APPAREL ENGINEERING

Industrial Engineering Methods for Apparel Industry

JK Akhil

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By

AKHIL JK

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Preface

The idea behind this book is emerged from the author's need for a suitable textbook for the Apparel Engineering to support the lecture at India's Leading Vocational College's to solve the difficulty in availability of right materials for the subject. Most of the Industrial Engineering sessions were been taken using the Mechanical Engineering theories converted to industry, also from the need of industrial Engineers who are working in industries. It need a lot of books to use for the Apparel Engineering session to be taken. Hope this book will serve as a single reference to the newly aroused session in the Fashion

industry and also introducing the term “Apparel Engineering” to the world for the first time.

Apparel Engineering is a term to explain the industrial engineering activities to be used in Apparel Production process, this will include methods to reduce Man, Machine and Material wastage in the Apparel Production process, it includes selection of right tools and machines, training to the operators for quality and fast production , material management, ergonomics to use in apparel industry, methods development and advanced production planning and development of method study and Workstudy applications in production process, Line balancing to product handling.

The whole booklet is capsuled to easy knowledge by reducing long theories. Maximum real time data from industry are used to generate and explain the calculations so that the methods can easily be adapted to industries by their industrial Engineers.

Using own original compiled teaching materials, and with the support of many current practitioners within the fashion production industry, it was set out to develop the structured book for reference to the Apparel Engineers and other academicians in the Fashion Production industry. All material contained in this book, other than where specifically referenced, comes from original sources or research from various resources and industry practicing methods. The calculations and methods explained here are guidelines and it cannot be guaranteed success all times, as the Apparel Engineering is situation based and changes according to product, machines, place and operators conditions, but most of the theory can be applied in major situations after doing a proper research of the situation applicability. A proper study about your industry based on the explained situations may be necessary while applying these methods in the running production floor.

I would like to personally thank all those people who have helped make writing of this book possible.
Dedicated to All Apparel Engineers of the world Reg,
Akhil JK

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1 Introductions

Garment Engineering
Garment engineering is the systematic study of identifying technical wastages during the garment manufacturing process and take corrective steps to remove the waste to improve productivity.

It is most confused with industrial engineering, garment engineering methods are designed to suit the needs of an apparel industry as it is a combination of designs, machine, fabric, trims and human efforts. The application of garment engineering can be started from the design room till retail market. Whereas Industrial Engineering is deliberately applicable in the production floor only. Garment engineers also use industrial engineering tools in the production floor hence making it as a part of garment engineering in certain departments only. Industrial engineering is developed based on the mechanical production procedures and in most cases these are used in RMG for setting machines and other, but in major cases the wrong usage creates excess burden in production loss and unexpected bottle necks.

Garment Engineering is developed from the thought of waste reduction is not only required in production where are a systematic method is also required in other departments. There are many methods in use at different departments but not yet standardized. This book tries to combine most of the methods used in in garment industry to reduce waste and to get maximum productivity and output in all departments starting from design room to retail shops. The methods are combinations of workplace engineering, Industrial Engineering, Visual merchandising, Retail Market planning, Pattern Engineering etc. to make this as the best reference .

What is waste?
The important question we have to deal is what is waste? Let us try to discuss in terms of Garment Engineering, There are three type of waste arising in the garment production,

1. Physical wastage
2. Technical wastage
3. Economic wastage

Physical waste are those waste generated in the form of fabric, thread, trims etc. these waste are countable and generally controlled in any garment industry because it is noticeable.

Technical waste age generally calculated as the waste of human effort, Machine waste, time wasted etc. when we calculate for a garment industry the technical waste comes more than 60% of the total waste, and this is generally not monitored.

Both technical and physical waste will generate economic waste which result in profit of the organization. An Apparel Engineer’s job is to reduce the technical and physical waste, he should more concentrate to reduce the technical waste.

History of Garment Industry.

Industrial revolution started in the 19th century, garment industry also began to evolve but it was in its immaturity and had no developed system for garment manufacturing. The

Indian clothing and apparel industry had its origin during the Second World War mainly for mass production of military uniforms. Technology has been gradually upgraded from the ancient pedal sewing machineries to most modern automatic sewing machines now a days. Now India is emerged as a strong destination of all types of apparel products with wide product and quantity range.

The apparel industry grew from these tailors/businessmen, as they built manufacturing factories for production, which pattern engineering accommodated. Pattern making was first taught to "designers". Paris was centre of the developments in style and creation in garments, many other countries copied from them. Garment industry has developed many new and time saving techniques, processes and machinery for the effective production today. The most important is the CAD/CAM which enables the designer, pattern maker, marker and grader to do their jobs precisely and effectively.

Application of Garment Engineering in RMG

The concepts of Garment Engineering are used in garment manufacturing to fulfil the following needs. 1. Monitoring Production Floor and to have better control over it
2. Improving process and method of working to increase factories overall performance 3. Standardize the garment manufacturing process and record for future

4. Reduce wastage in production and processing operations, the waste to reduce are Fabric, Machine time, Power consumption, Human fatigue, Workmen time wastages, Machine wastage, space utilization etc.

5. Proper Line balancing and product planning activities.
6. Maximum utilization of Man and Machine. Etc.

As garment engineering is a systematic questioning of all the operations that go together to make a garment,

To eliminate all unnecessary work: in the most jobs there are too much unnecessary works. Very often insufficient time and effort are given to the task of eliminating work, if a work can be done without the specific job, then it is unnecessary to spend money on an improved method.

There is no interruption, no delay whilst an improved method is developed, tested and installed, and there is no expensive training for the operator to be taught the new method.

Bearing all these things in mind, it is extremely important to examine the original method of doing the work a little longer to see whether any operation or movements can be eliminated completely or partially.

Combine Operations of Elements: Where ever possible, the garment engineer should combine operations, if he/ she is going to increase productivity. In many cases the division of the jobs into elements is taken too far, and the result is there is too much time lost between elements due handling of materials, and which leads to lack of balance between operations.

Change the Sequence of Operations: - in many cases, the sequence of operations in a job results from tradition, or from the methods of the original operator who started the job on an experimental basis. There has not been any improvement since that time, and most probably the supervisors or operators seldom needs a change from that, at that point, a

detailed investigation by a mind free from prejudice can make substantial increase in productivity by changing the order or sequence of operation.

Simplify the necessary operations: - in some situations the operator may be performing a task which is too complex and hence the productivity may be low, in this situation it is necessary to break the job down into smaller divisions which the operator can perform easily, and may need time to learn the new method or sometimes need to be trained to achieve the productivity high.

It is also necessary to examine the original method to see whether a job or fixture or some minor alterations to the workspace may simply help the operation. Many jobs where the process of location parts by hand is a highly skilled operation, can be made to semi-skilled or even unskilled, when a jig is used.

There are so many methods used to reduce these wastages, all tools and methods clubbed together is termed as Garment Engineering, there are Industrial Engineering, Quality Control, Pattern Engineering etc. are to be controlled. The Departments where the Garment Engineering Methods can be used are from the purchase to dispatch including every sessions and actions happening in the Garment Industry.

Know the Basic Terms

Fiber : - It is defined as one of the delicate, hair portions of the tissues of a plant or animal or other substances that are very small in diameter in relation to their length. A fiber is a material which is several hundred times as long as its thickness. A fiber must have 1:30 proportion in its thickness to length ratio.

Textile Fiber: - The essential requirements for Textile fibers to be spun into yarn include a length of at least 5 millimeters, flexibility, cohesiveness, and sufficient strength. Other important properties include elasticity, fineness, uniformity, durability, and luster will make a fiber into textile fiber. All fibers cannot used to make a textile product but now a day's most of the fibers are used to for the production of textile product the method of spinning them varies. The advance technology like SPT (sensory Perception Technology) allows us to spin or weave the minute particles like fragrance molecules to a fabric and directly to a 3D garment which is wearable.

Yarn: Yarn is a long continuous length of twisted or interlocked fibers, suitable for use in the production of textiles, sewing, crocheting, knitting, weaving, embroidery, and rope making.

Thread : - Thread is a type of yarn intended for sewing by hand or machine. Sewing threads may be finished with wax or other lubricants to withstand the stresses involved in sewing. Embroidery threads are yarns specifically designed for hand or machine embroidery.

Fabric : - Fabric is a flexible two dimensional material that is made by a network of natural or artificial fibers. The formation of fabric maybe interlacing (Weaving), interloping (Knitting), or inter meshing (as in knotting, punching etc.)

Cloth : - Cloth is a fabric which is wearable without doing any stitches or seams in it. Example sarees, dhotis, shawls etc. Ancient clothing methods are wearing cloth in different ways. Sometimes cloths are used in combination of dress or used alone.

Apparel : - Apparel is any clothing material made using any textile fabric/ material. Hence all garments are apparels but all apparels are not garments (e.g. CAPS, shoes etc. are apparels, shirts, trousers, etc. are garments)

Garment : - Garment is a three dimensional form made with fabrics, sewing is the major method used to construct the garments. All garments are apparels but all apparels are not garments. Garments are used as basic dressing items, there are many different types of garments according to fashion and its development. The fashion designers are designing the garments according to their ideas, themes and uses etc.

Spinning : - Spinning is generally used to denote the entire process of making yarn from the staple fiber. In most common production process fiber is prepared by opening, cleaning, carding, drawing, possibly combing and roving, then the strand of material is drawn down to the correct size and twisted to produce the yarn.

Weave : - method or pattern produced by interlacing yarns in weaving process. The basic weaves are plain, twill and satin weaves, most other weaves are the combinations or rearrangements of these weaves. For knitted garments it is called designs or knots, there are many structural as well as fabricated designs in use.

Weaving : - Weaving is the process of interlacing two or more sets of yarns or similar materials so that they cross each other at (usually) right angles. The warp yarns runs lengthwise and fillings in run from side to side.

Warp : - also known as end, is a yarn that runs lengthwise in a woven fabric, parallel to the selvages which interlaces with the filling yarns (picks) in different pattern to form different weaves or designs. Warp ends are held in parallel under tension in the loom and certain ones are raised or depressed, to form the “shed” before the insertion of each pick.

Weft : - in woven fabric, yarn that run from selvage to selvage at right angles to warp. It is also known as Woof, filling. Each yarn of a warp are called as a pick, shot, or pick. Weaving machines are classified according to the weft insertion methods and from handloom to rapier the rate of weft insertion varies from 20 picks per Minute to more than 500 picks per minute in advanced shuttle less looms like air jet, rapier etc.

Pattern: A guide for cutting one or more garments. It includes all the pieces needed to make a garment. A pattern for a garment style is graded by the ready-to-wear manufacturer or commercial pattern company to include the size range within a figure type. Patterns conform to standard measurements, but interpretation of the measurements for sizing in the ready-to wear market vary with each manufacturer and differ from commercial pattern standards. A set of pattern arranged together in a sheet of full length to enable a bulk cutting of garment is called as a Marker. Marker efficiency is the utilization of fabric.

Seam: A series of stitches joins two of more plies of material. The term seaming or stitching are also used to denote the processing of creating a seam. There are many methods used create a seam. The strength of the seam generally measured to calculate the strength of the garment. Generally the seam strength are kept nearer to the fabric strength. Details will be explained latter. Seam allowance is the distance or space provided for the seaming operations this will generally added to the original pattern according to the type of seam to be done.

Tec Pack: A Tec pack is an informative sheet (or file) which encompasses all of the garment specifications. The tech pack for the garments is created before embarking on the garment manufacturing process. The file contains all the details of any specific style and aspect of the garment. This document is usually prepared by the designer and finalized in consultation with the merchandisers, and then forwarded to bulk sampling department or to the production department for the reference and guide for bulk manufacturing. Once a tech pack for any style is developed, the production department should be able to proceed with the manufacturing process without having to refer back to the designer for any aspect of production.

All the details of the clothing being produced will be in the tech pack. The tech packs will include fabric requirements, trim requirements, grading, thread colors, etc. The merchandisers are thus able to go ahead and ensure that the required material as per the tech pack is made available to the production department, in the right quantities at the right time.

There are many other terms in use, each one will be explained respectively.

Sewing Machines

As this is an advanced study book, I am not going to start from the basics, we will start with the classification of sewing machines skipping the sewing machine parts, etc.
There are many methods of classification, the major are as follow

1. Classification based on Beds

a. Flat Bed
b. Raised Bed
c. Cylinder Bed
d. Post Bed
e. Feed of The arm

2. Classification based on stitch

a. Chain Stitch
b. Lock Stitch
c. Saddle Stitch etc.

3. Classification based on Feed systems

a. Drop Feed
b. Needle feed
c. Roller Feed
d. Unison feed
e. Differential feed etc.

4. Classification based on Drive a. Direct Drive
b. Belt Drive

There are other methods used by many like clutch drive or servo drive etc. the above are the base details required to be known by a garment engineer in detail. Let us see these one by one.

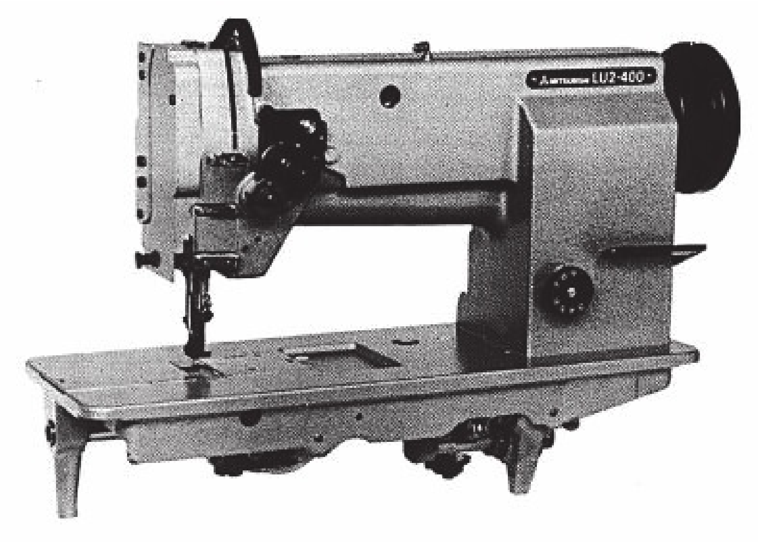
Type of Machine Beds.

Sewing machines are the main tools used in the apparel industry. In 1834 Sir. Isaac Singer

of UK invented the domestic sewing machine and in 19000 the Singer Company developed the industrial sewing machines. Sewing machines are designed in different ways depending on the kind of material, finish and seam. There are Light weight, Medium weight and Heavy duty machines used to sew, actually all these three are having minor differences. It uses different Presser foot, Feed Dog or feeding mechanism and Needles. It created different beds to the sewing machines for a machine is to give ease in sewing operation.

Bed is the portion of sewing machine where the sewing is effecting or sewing process actually takes place on the fabric. The area is with needle plate, throat plate, and nearby area of the sewing machine. This vary in position and shape according to the requirement of the machine to do the sewing application and specific seam to sew.

Flat Bed sewing Machines: The flat bed is used in the majority of sewing, where a large and open garment part can easily be stitched or handled under the needle. It provide suitable surface for each flat stitches and also facilitates the use of marker to control the position of parts. E.g. are JUKI DDL 8300, and most of the Single Needle lock Stitch Machines for plain seams.



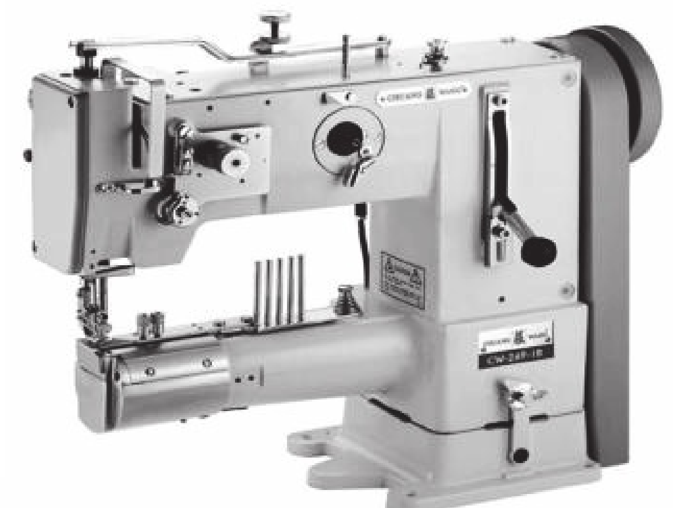
Raised Bed Sewing Machine: the feed portion usually little raised form the table. This is to enable easy handling of material. Normally overlock and surging machines has raised bed. Because the fabric or stitch are having elastic properties due to chain stitch formation, but in leather sewing.

Cylinder Bed Sewing Machines: these machines feature a narrow, horizontal column as opposed to a flat base. This allows fabric to pass around and under the column,. The diameter of the cylinder bed varies from 5cm to 16 cm. major applications are to attach cuffs, doing hems of sleeves of a knit T shirt, button sewing, bar tacking etc.

Feed of Arm: this is also a type of raised bed, the difference being the arm portion is little longer and vertical to the operator so that, the pieces will run through it, the workers to feed the material along the axis of a horizontal column. The design limits the diameter of the seam sewn to the diameter of the column, but can create continuous seam of fabric in a tubular shape. The major applications are shirt side seam finishing, and trouser in seam finishing etc.

Post Bed sewing machine: Post bed sewing machines have a vertical rectangular or round post rising up from the bed of the machine to where the needle and presserfoor meet (where the sewing occurs). Post bed machines are used for a wide variety of applications where product cannot fit on the regular flat or raised bed. The height of the post may vary from 10cm to 45cm according to the requirement. The major applications being attaching emblems in caps, boot making, leather shoe and bag sewing, glove making etc.

Cylinder Bed



Feed Mechanism.

Post Bed

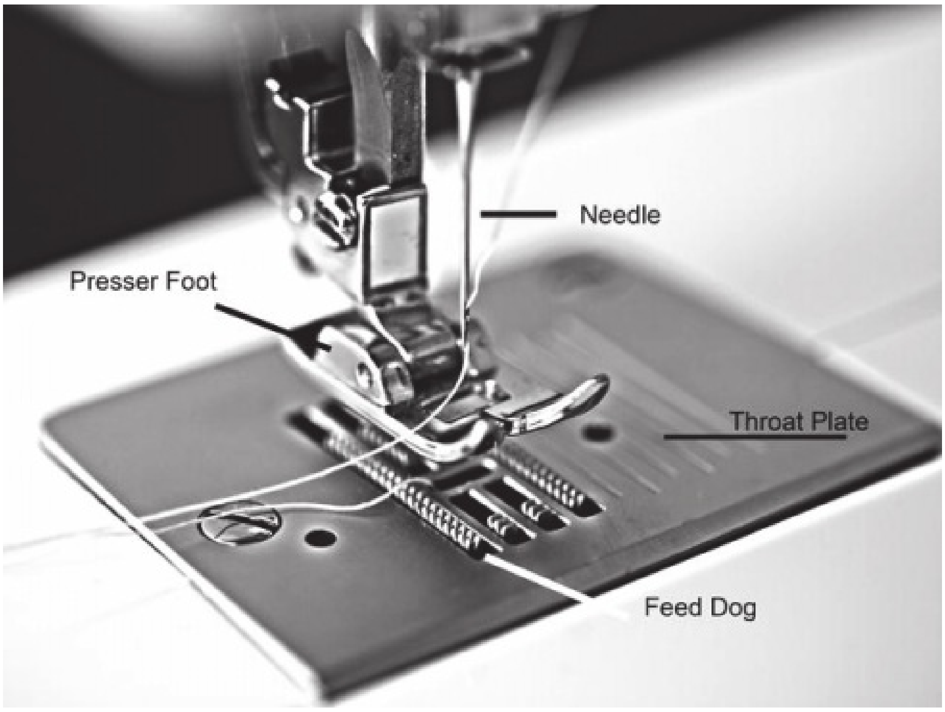
Off the Arm

Besides the basic motion of needles, loopers and bobbins, the material being sewn must move so that each cycle of needle motion involves a different part of the material. This motion is known as feed, and sewing machines have almost as many ways of feeding material as they do of forming stitches. For general categories, there are: drop feed, needle feed, walking foot, puller, and manual. Often, multiple types of feed are used on the same machine. Besides these general categories, there are also uncommon feed mechanisms used in specific applications like edge joining fur, making seams on caps, and blind stitching.

Elements of Feed Mechanism

Feed is one major control of a sewing machine in act. It is to control the length of the stitch while stitching. The feeding mechanism controls the amount of fabric fed by the feed dog during every sewing cycle of needle. The three main sewing machine parts which together constitute a drop feed mechanism are *Presser foot, throat plate and a feed dog.* These are also known as the basic elements of feed mechanism.

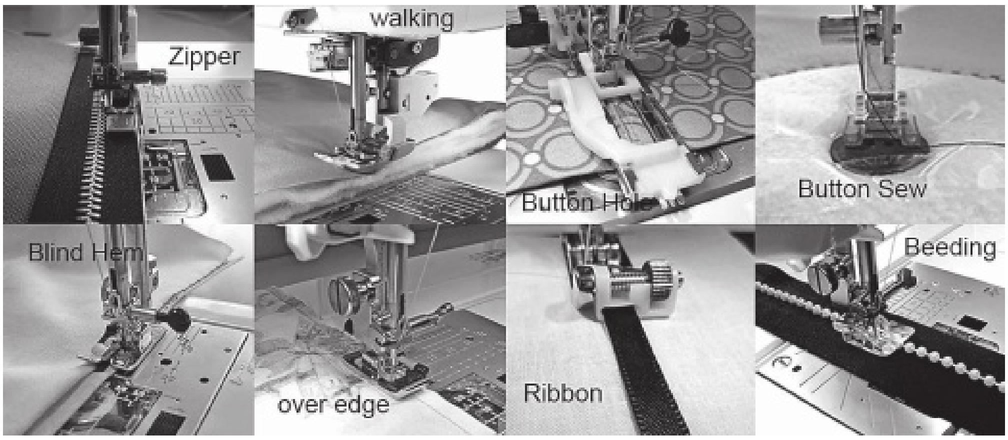
The material forwarding of the sewing operation is through feed action, and it is based on the friction forward act. The two layers of fabric are held in position by using the presser foot over the feeddog. While feed action of the fabric, the bottom layer is forwarded by the feeddog and the top layer, which is in pressure held by presserfoot, is also forwarded, the perfect pressure on presserfoot is necessary to move the fabric.



Presser Foot.

A presser foot is an attachment used with sewing machines to hold fabric flat as it is fed through the machine and stitched. Sewing machines have feed dogs in the bed of the machine to provide traction and move the fabric as it is fed through the machine, while the sewer provides extra support for the fabric by guiding it with one hand. A presser foot keeps the fabric flat so that it does not rise and fall with the needle and pucker as it is stitched. When especially thick work pieces are to be sewn, such as quilts, a specialized attachment called a walking foot is often used rather than a presser foot.

Presser feet are typically spring-hinged to provide some flexibility as the work piece moves beneath it. The most commonly used presser feet are the all-purpose foot and the zipper foot which come standard with most household machines. However, an array of specialized feet have also been designed for a number of uses. Among these are, blind hem foot, buttonhole foot, darning foot, gathering foot, tape attaching foot, narrow hem foot, open toe foot, overedge / overcast foot, piping/ cording foot, quarter-inch seam foot (6mm), quilting quarter-inch seam foot, roller foot, satin stitch or decorative stitch foot, straight stitch foot, pintuck foot etc. some of them are shown in fig.



A walking foot, also known an even feed presser foot, has built-in feed dogs at its base, and is helpful when sewing multiple layers of fabric. The foot's feed dogs move the upper

layer of fabric at the same rate as the machine's feed dogs advance the lower layer.

A walking foot can be used for any type of sewing but is especially helpful for straight line machine quilting, sewing binding around the edges of a quilt, and when sewing any other project that's made with multiple layers or heavy cloth, such as rag quilt projects and denim quilts.

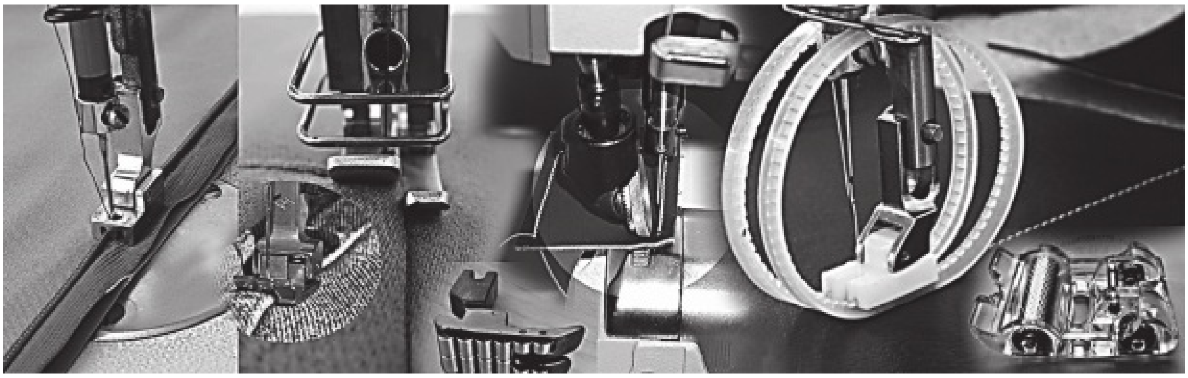
These modifications to the original presser foot are made to reduce the ply shift during the specific operations. Garment engineer will always use a right presser foot or develop or modify the current ones to improve productivity of the operation. There are many type of modifications made to the presser foots, some common are,

1. Hinging Presser foot: - The most standard presserfoot with spring mounted in the rear, so that its front part is up. This corresponds well to materials and ensure smooth feeding at overlapped sessions. 2. Fixed Presserfoot: - exclusively used for 2 or 3 fold piping to assure the stability of folding is good. 3. Compensating Presserfoot: - this is an edge guide presserfoot exclusively used for edge and ¼" stitches. There are three types of it, left, right and both side compensating.

4. Sliding presserfoot: - presserfoot moves forward and backward by means of up or down of the feeddog. It is effective to reduce uneven material feeding. Mainly used in leather sewing and as in button sew, bartack etc.

5. Roller presserfoot: - This is used for leather sewing. A rotating roller synchronized with bottom feed instead of presser sole is located on side of the needle entry. It presses and feeds material to be sewn.

6. Ring Roller Presserfoot: - nylon rings attached to the both sides of the presserfoot which rotates in synchronization with bottom feed, and feeds the materials. This is used to reduce ply shift while sewing fine fabrics.



Feed Dog

Feed dogs are the critical component of a "drop feed" sewing machine. It is used to control the motion of fabric. A set of feed dogs typically resembles two or three short, thin metal bars, crosscut with diagonal teeth, which move back and forth in slots in a sewing machine's needle plate. Their purpose is to pull ("feed") the fabric through the machine, in discrete steps, in-between stitches.

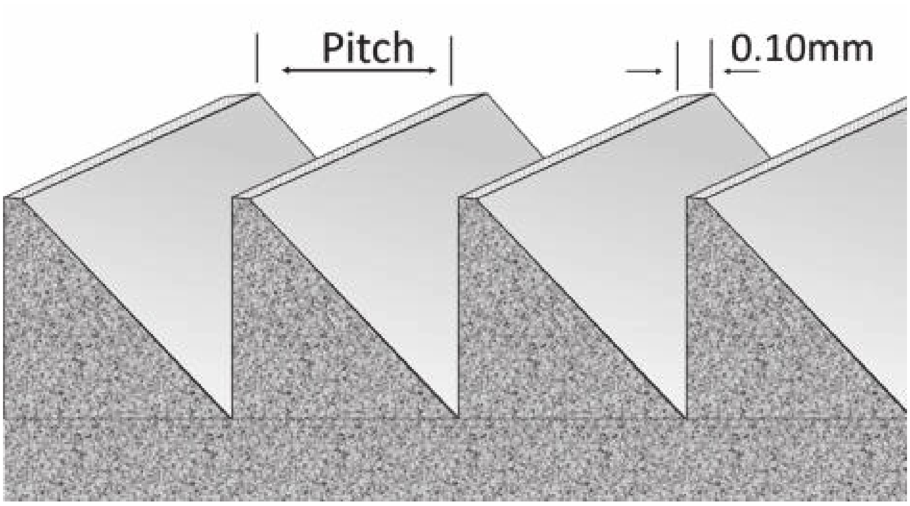
This arrangement is called "drop feed" in reference to the way the dogs drop below the needle plate when returning for the next stroke. Allen B. Wilson invented it during the time period 1850 to 1854, while also developing the rotary hook. Wilson called it a "four-

motion feed", in reference to the four movements the dogs perform during one full stitch: up into the fabric, back to pull the fabric along to the next stitch, down out of the fabric and below the needle plate, and then forward to return to the starting position.

Virtually all drop-feed sewing machines can vary their stitch length; this is typically controlled by a lever or dial on the front of the machine. They are usually also capable of pulling the fabric backwards, to form a backstitch.

The feeddog contain saw tooth which are like a sw. The distance from tooth to tooth is called as tooth "pitch", normally measured in millimeters. The structure of the face side of the feeddog is zigzag and it contains teeth. There are mainly three types of feeddogs

1. Saw toothed feeddog



2. Upright Toothed feeddog
3. Diamond toothed feed dog

Forward- down- backward-up; these four steps of the feeddog helps the machine to pull the fabric while stitching.

The tooth of the feeddog when raises through the opening in the throat plate and engages the under surface of the fabric. It takes the fabric along towards the back of the machine and then drops it below the throat plate before commencing the whole cycle again. The up-down directional movement of the needle is to be synchronized accordingly with the four step elliptical motion of the feeddog to pull the fabric only when the needle is not in contact with the fabric.

In a sewing machine the number of feeddog, its position, length, shape and nature of tooth surface etc. can be varied at any situation based on the application requirement. The

rationale behind this is, when a single row or short length of the feeddog provides very less surface contact and reduces friction between the material and the feeddog, it create a problem of fabric slippage during sewing either of the sides instead of passing in a straight line.

In an overlock machine, the feeddog is mainly to the left of the needle drop point as it trims and sews to the right, also there is a chaining off finger on the throat plate over which the loops are formed as stitch. The teeth on the surface are slightly slanted towards the direction of feeding.

For sewing light to medium weight fabrics the teeth pitch of 1.3mm to 1.6mm is normal. On a very light fabric sagging can occur between the teeth and pucker can appear after sewing as a result. Fine teethed feeddogs with a pitch of 1.0mm to 1.25mm can be used to prevent this. On heavy weight fabrics, a certain amount of sagging is required for satisfactory feeding in order to keep both the plies together. In this case, coarser feeddogs of 2.5mm or above teeth pitch may be needed. Based on the fabric type and requirements rubber coated feeddogs with no sharp teeth can also be used for very delicate materials like soft leather or soft fabrics.

Feeddogs should not have sharp edges at the top, to avoid damage to the material and to reduce thread breakages, so the teeth are slightly grinded at the top to reduce the sharp edges. If the width of the top surface at the top of the tooth is 0.1mm or more, then it need to reduce the feed force or else there is a chance for uneven stitch on material slip may result.

Throat plate / Needle plate

Sewing machine throat plate is a metal plate beneath the presserfoot. The plate has holes and slots, the holes are to allow needle to pass through during its downward movement on stitching cycle and the slots or groves allow the feeddog to raise and move during its cycle operation. The needle/ throat plate is to hold the material from stuck in machine parts and to ease a free movement through the stitching cycle effectively. The main function of a throat plate is to provide a smooth, flat surface over which the fabric passes as successive stitches are formed. The groves and holes are to match the feeddog.

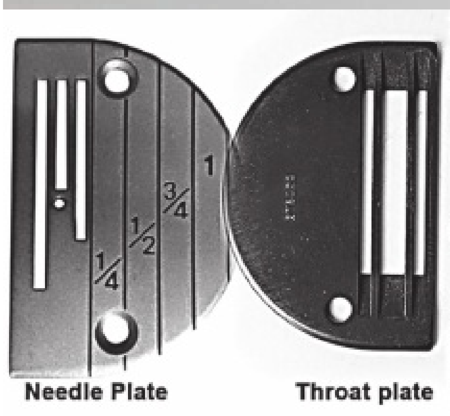
The sewing machine throat plate can look different depending on the type of sewing machine they are designed to fit. Usually throat plates for normal use are marked with small groves ¼ inches apart on the

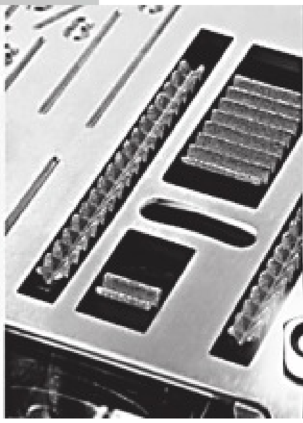
Fine Fabric 1.0 to 1.25mm Medium Fabrics 1.3 to 1.6mm Medium Heavy 1.75 to2.0mm Heavy Weight 2.5mm or above

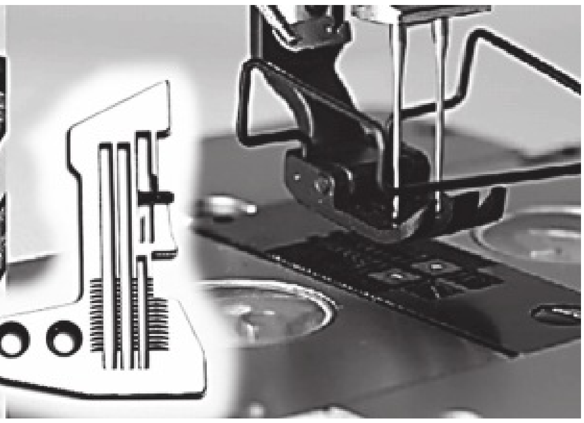
right side to use as guidelines for sewing.

The needle hole for a straight sew regular machine are round in shape and it should only be about 30% larger than the needle size. If the needle hole is large the fabric may be pushed into the hole while needle penetrates it, this problem is known as “FLAGGING” and results missed stitches and yarn breaks often. Fabric flagging is a machine related issue, the throat plate aperture may enlarge due wear and tear also. This can also happen when the needle size is changed and if the throat plate is not changed accordingly. And throat plates must be changed at the given intervals.

In zigzag machines a vertical grove instead of a hole is used to pass the needle, it is because of the movement of the needle. The needle holes or groves are used in straight line stitching, the shape and selection is purely based on the stitch formation and mode of needle movement. The throat plate of an over lock machine is having looping fingers to help the serger to make loops on the right end.







Feed Mechanisms in Sewing Machines.

Besides the basic motion of needles, loopers and bobbins, the material being sewn must move so that each cycle of needle motion involves a different part of the material. This motion is known as feed, and sewing machines have almost as many ways of feeding material as they do of forming stitches. For general categories, there are: drop feed, needle

feed, walking foot, puller, and manual. Often, multiple types of feed are used on the same machine. Besides these general categories, there are also uncommon feed mechanisms used in specific applications like edge joining fur, making seam. The different types of feed mechanisms used in sewing machines are,

Drop feed

The drop feed mechanism is used by almost all household machines and involves a mechanism below the sewing surface of the machine. When the needle is withdrawn from the material being sewn, a set of “feed dogs” is pushed up through slots in the machine surface, then dragged horizontally past the needle. The dogs are serrated to grip the material, and a “presser foot” is used to keep the material in contact with the dogs. At the end of their horizontal motion, the dogs are lowered again and returned to their original position while the needle makes its next pass through the material.

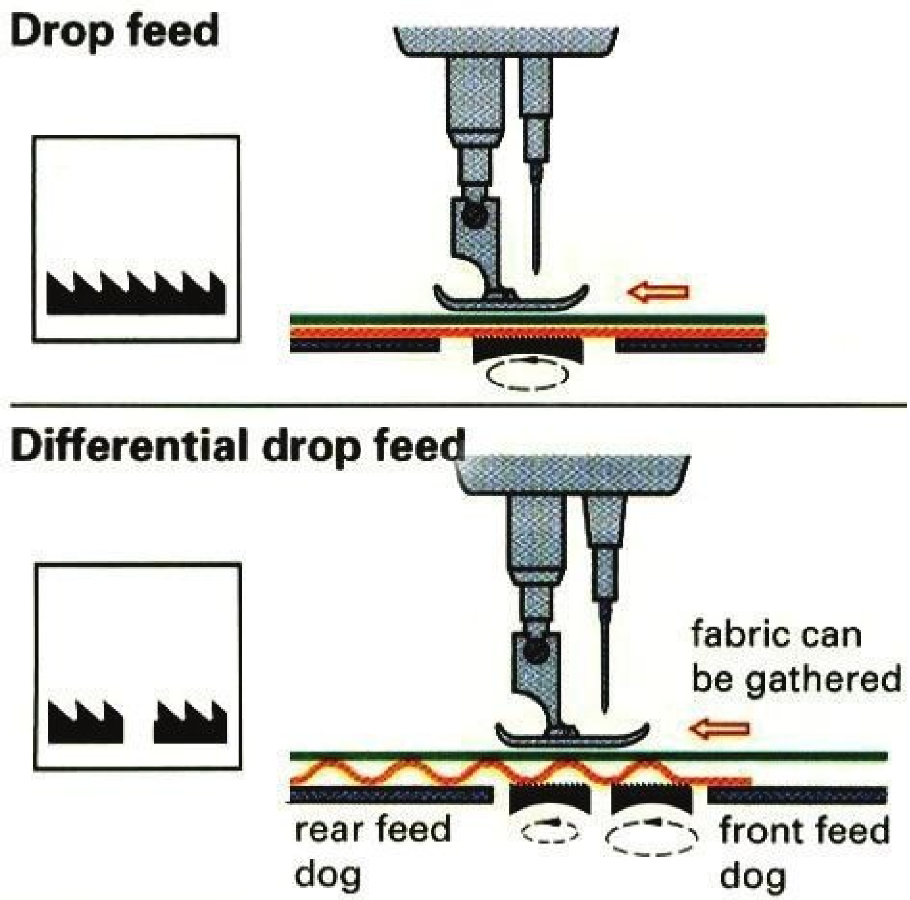
While the needle is in the material, there is no feed action. Almost all household machines and the majority of industrial machines use drop feed.
The main problem caused in drop feed is PLY SHIFTING, this is because when two plies fabrics are sewn- lower ply moves forward by the help of feed dog but foot. So two plies of fabric cannot move forward at the same speed. As a result lower ply is more fed than upper ply. This is called ply shifting/differential feeding pucker/feeding pucker.
Sometimes roping is occurred during making of hem due to ply shifting. To avoid such defects in drop feed it is necessary to have good presserfoot, Needle and Feed dog alignment. A right selection of all the elements is also necessary.

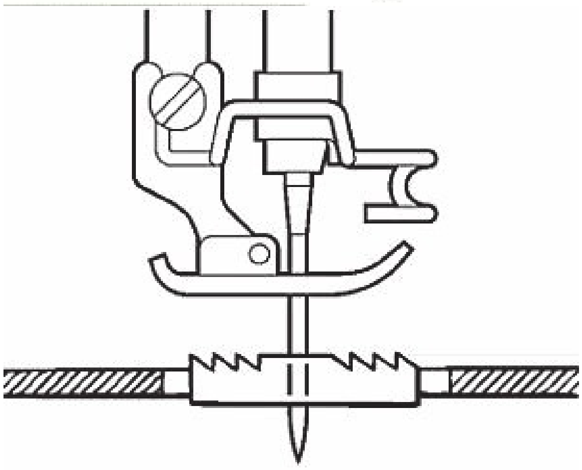
Differential feed is a variation of drop feed with two independent sets of dogs, one before and one after the needle. By changing their relative motions, these sets of dogs can be used to stretch or compress the material in the vicinity of the needle. This is extremely useful when sewing stretchy material, and overlock machines (heavily used for such materials) frequently have differential feed. For more clear, when the speed of the front feed dog is higher than the back feed dog. “The bottom ply is pulled by the back feed dog but this will overcome by the greater speed of the front feed dog. So less possibility of shifting”. When the speed of the front feed dog is less “we get lacy effect because the feeding speed in greater than the delivery speed”. Stretching & gathering of fabric can be done by this system.

Needle feed / walking Needle

A needle feed, used only in industrial machines, moves the material while the needle is in the material. In fact, the needle may be the primary feeding force. Some implementations of needle feed rock the axis of needle motion back and forth, while other implementations keep the axis vertical while moving it forward and back. In both cases, there is no feed action while the needle is out of the material. Needle feed is often used in conjunction with a modified drop feed, and is very common on industrial two needle machines. Household machines do not use needle feed as a general rule.

Upper pivot needle feed.





o The needle bar, which carries the needle, is held in a frame, and its motion is pivoted from a point on the frame farthest from (or far from) the needle.

o The needle will enter the goods at a leading angle from the centerline of needle travel, and will exit the goods at a trailing angle from the centerline of needle travel. In other words, the needle enters the goods at a certain angle and exits at a different angle. This would seem to disrupt the material and the stitching process, but in practice it does not.

Central pivot needle feed.
o The needle bar, which carries the needle, is held in a frame, and its motion is pivoted from a point near the middle of the frame.

o The needle will enter the goods at a greater leading angle from the centerline of needle travel than with the upper pivot system described above, and will exit the goods at an equally great trailing angle from the centerline of needle travel that it entered with. In

other words, the needle enters the goods at a certain angle and exits at a different angle. This would seem to disrupt the material and the stitching process, but in practice it does not, except with thicker or heavier goods.

○ There is less momentum of the needle bar frame in motion than with the upper pivot system, and higher stitching speeds can be reached.
Parallel drive needle feed.
○ The needle bar, which carries the needle, is held in a frame, and its motion is always parallel in relation to its prior and successive movements. It remains perpendicular to the material at all

times. For example, if the needle enters the goods at 90 degrees to the materials' surface, the needle will remain at 90 degrees through its travel, and will exit at the same 90 degree angle. ○ It is the type of needle feed suitable for stitching the heaviest and thickest of materials.
○ The mechanism involved in a parallel drive makes for a more expensive unit and will generally have a slower stitching speed.

Top Feed

Top feed is characterized by a mechanical foot, rollers attached to foot, feet with teeth or friction surface or rollers that transport or assist in the transport of material is normally often a foot working in unison with a drop feed. Top feed has a directional movement in which material is fed. The foot or rollers may push downward into the material to capture the material between the other feed components such as bed, feed dog etc.

The general arrangement of top feed system is that the presser foot in two sessions, one holding the fabric in position while the other having teeth on lower side which moves the fabric, this motion is like walking in such a way that the top ply is taken along positively while the needle is out of the material. There are different types of top feed

Vibrating Presserfoot is a foot with teeth or friction surface that transports or assists. It has a vibrating motion forward with the feeding process and backwards with the return stroke. This will be paired with the presserfoot or may be the only top feed. a vibrating presserfoot is usually incorporated with a lifting motion on the backward stroke. This allows the foot to clear the material and to drop relatively straight down on to any raised or uneven portion of the material without interference.

Alternating Presserfoot is a pair of feet that alternately presses against the material while one of it is pressing against or feeding the material and other foot is raised to clear off the material. The position then alters. One foot is typically a vibrating presser foot but both functions will alter intermittently or can work only raising and lowering to hold the material in position.

A **walking foot** replaces the stationary presser foot with one that moves along with whatever other feed mechanisms the machine already has. As the walking foot moves, it shifts the work piece along with it. It is most useful for sewing heavy materials where needle feed is mechanically inadequate, for spongy or cushioned materials where lifting the foot out of contact with the material helps in the feeding action, and for sewing many layers together where a drop feed will cause the lower layers to shift out of position with the upper layers.

Jump Foots are vibrating presser feet where backward and forward motions are not driven, but spring loaded. This is usually incorporated with a lifting motion on the return stroke. This is the most conventional form of top feed.

Clamp feeds having clamps from above the material and pressing downward, effectively holding the material between itself and the machine bed or a clamp or clamps above and below the material holding the material firmly. The clap or clamp sets are driven by linkages which moves during sewing. This is used in unison with other feed systems to get effect seams produced.

Combination Feed
For special requirements of quality of sewing we may use combination feeds, generally it is the combination of different feed mechanisms together.

Top and Bottom Feed combination : - a combination of any top feed and a feed dog or drop feed is used as one method. Also *Compound Feed* is a combination of needle feed and drop feed are the two different combination feeds in act.

Unison Feed is a term used in two different ways, one application of this term is its application any two or more feed used together and the second is to describe the uncommon feed system of a vibrating presserfoot or alternating foot along with needle feed and a drop feed or feed dog working in combination but operating from an one piece frame. The frame extends from the presserfoot or needle feed mechanism through the machine casting to the drop feed or feed dog.

Puller feed

Some factory machines and a few household machines are set up with an auxiliary puller feed, which grips the material being sewn (usually from behind the needles) and pulls it

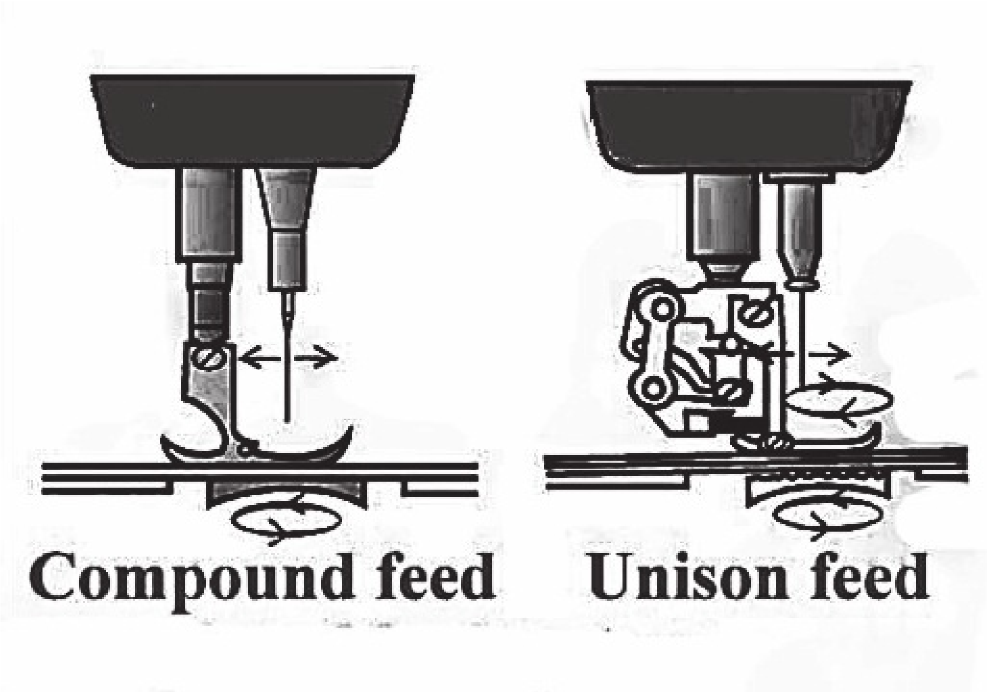
with a force and reliability usually not possible with other types of feed. Puller feeds are seldom built directly into the basic sewing machine. Their action must be synchronized with the needle and feed action built into the machine to avoid damaging the machine. Pullers are also limited to straight seams, or very nearly so. Despite their additional cost and limitations, pulling feeds are very useful when making large heavy items like tents and vehicle covers.

A rotary wheel will have a movement in the direction of feed. It incorporates a friction surface or clamping surface that feeds or assists in feeding the goods. It has either an intermittent motion or a continuous motion. Continuous motion wheel feed must work in unison with a needle feed.

There are Upper and lower wheel feed. Wheel feed system where an upper and lower wheel are both driven. The material is fed between the wheels. There is positive feeding pressure both the top and bottom of the material at the same time.

Manual feed

A manual feed is used primarily in freehand embroidery, quilting, and shoe repair. With manual feed, the stitch length and direction is controlled entirely by the motion of the material being sewn. Frequently some form of hoop or stabilizing material is used with fabric to keep the material under proper tension and aid in moving it around. Most household machines can be set for manual feed by disengaging the drop feed dogs. Most industrial machines cannot be used for manual feed without actually removing the feed dogs.



Material Flow, Process Flow, Plant Layout, Process Charts, Space requirements, Factory Layout

2 Facility Layout and Material Handling

Factory is a place where all the industrial activities are housed. After the selection of the factory site, it is necessary to construct a building. There are two types of building according to location. In many cases the govt. or local authority may provide us with a standard industry building to operate with, in that cases we have to allocate various departments of the company in the roof, so that all will give maximum function with minimum response time. While in the second case we can design the factory building by allocating the departments as we need. It should be noted that, though the problem of factory and plant layouts arises only after the building facilities have been made available, they are considered along with the construction of the factory building. Certain specific requirements of the administrative departments and the characteristics of the production process and plant services have a direct bearing on the construction of the factory building. Thus for an effective productivity both factory building and factory layout are considered simultaneously. The architectural design and the exterior view of the factory is considered with the technical requirement of various departments. The emphasis is given to the technical aspects rather than the aesthetic considerations.
The difference between factory layout and plant layout should be noted sensibly. The factory layout is a broad consideration and it decides about the housing of all the activities inside the factory, generally the activities can be divided into two groups;

1) Office Area: - in which the administrative departments should be accommodated.
2) Plant Area: - where the Production department and Service departments should be accommodated.

We can differentiate Service department to two,
Technical service: - Like receiving departments, store-room, stock room, tool rooms, inspection department, powerhouse, material handling department, packing and shipping etc.
Personal Service: - like parking area, security rooms, canteen rooms, recreation rooms, toilets etc. In relation to factory layout, plant layout is a narrow consideration and concentrates on the arrangement of production and service departments along with the location and sequence of machines and equipment.

Perfect plant layout.
A plant layout is the overall arrangement of the production process, like store room, cutting room, production room, finishing, packing, shipment, employee service and all other fixtures required for helping the production in the factory. It should be so that by compiling the production and service sessions and to provide for the most effective utilization of men, material and machines organizing the process. This is the master design for coordinating all operations performed inside the factory. A good layout is one which allows materials rapidly and directly for processing. This reduces transport, handling, clerical and other costs reduced per unit. It should have a reduced space requirements and will reduce idle man and machine time.
The objectives of a perfect plant layout will be striving to achieve the following,

1) Minimized material handling
2) Elimination of bottle-necks through plant capacity balancing

3) High material turnover through shorter operating cycle.
4) Effective utilization of installed capacity so that ROI (return of investment will be maximum)
5) Effective utilization of space usage (reduced cubic space of factory area)
6) Reduced idle time and hence effective manpower utilization.
7) Elimination, improvement or confinement of objectionable (vibrating or noisy etc.) operations
8) Elimination or reduction of physical efforts required of operative workers.
9) Can avoid industrial accidents
10) Better working conditions for employees like lightening, ventilation, noise reduction and reduced or no vibrations etc. and hence reducing some amount of fatigue (tiredness)
11) Better customer service through good quality in cheap priced and can have good delivery promises
Factors affecting Plant Layout choice
The selection of plant layout is made according to,

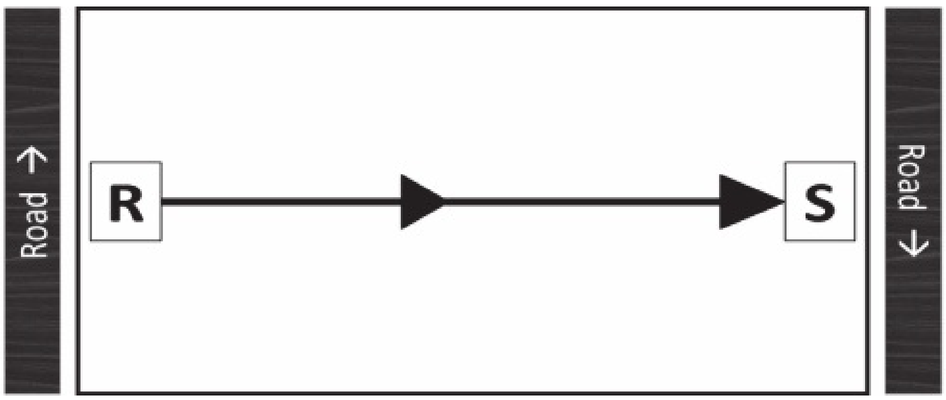
1) *Type of Production*: - the layouts will be different for a garment unit to an accessory unit.
2) *Production System:* - the plant layout for a make through will be different form unit production.
3) *Scale of production:* - differs in a large-scale to small scale organizations, the main difference will be in the material handling departments on these.
4) *Type of machines:* the use of single purpose and multipurpose machines substantially affects the plant layout. Also there may be some machines needs special attentions such as an embroidery machine need separate rooms if used in multiple heads while a single head uses can be used in the same room provided it has required conditions met.
5) *Type of building and facilities:* the layouts we prepare for a single story and multi-story will be different, same as if we have a pre- designed standard industry building will differ from a specific designed industry building.
6) *Total available floor area:* the allocation of space, machines, stores etc. will be made on the basis of the available floor area only. Sometimes we need to provide overhead spaces or platforms to make use of to create or meet more space requirements.
7) *Need of future expansion:* if the company plans future growth and there are possibility then we will design the floor considering future expansion requirements.
8) *Material handling department:* The plant layout is closely related to the material handling service and it has a critical effect on the arrangement of production process. It is because the production industry is mainly related to the material handling, high handling time means reduced capacity.

Material flow system.

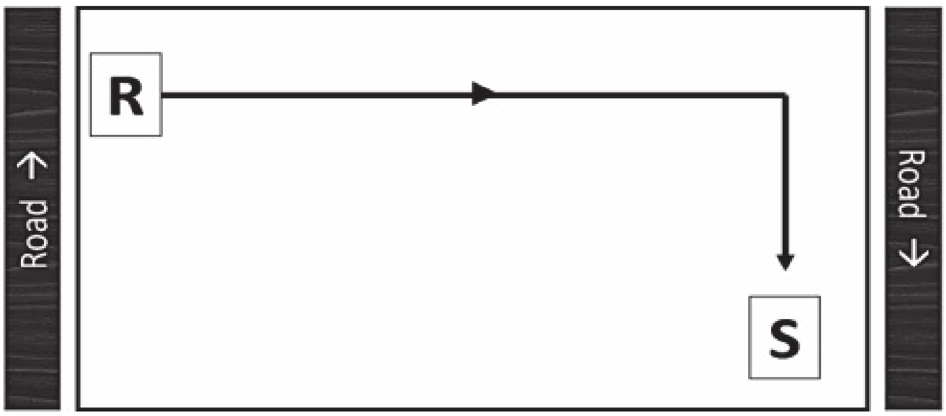
Man, machines and materials are the three basic inputs in the manufacturing process. Generally men and machines tend to remain static while the materials move from one work station to another for the purpose of processing. The raw materials pass through various paths till they are converted to finished product. The pattern of movement of materials inside the plant area is arranged under different type of floor systems. The pattern of material flow is important because to minimize the flow of materials is necessary. The pattern of flow of the materials is largely decided by the type of layout.

In the product layout the material flow is smooth and short, while in the process layout it is long and involves many complexities. The flow pattern is closely related to the type of the material handling, type of materials and the cost of material handling. It also need to consider the requirement of temporary storing, spots of bottlenecks or rushing. The operating cycle period has a close relation with the flow pattern of materials. The flow pattern of materials is to reduce the bottlenecks rushing, back-tracking and ensure good supervision and quality control. It also helps in minimizing the material handling cost, effective utilization of plant capacity, reduction in the operation cycle and results increase in returns on investment.
The material flow systems are broadly divided into two on the basis of the nature of the availability of floor space as Horizontal system and vertical system.

H orizontalSystemofmateialflow: - This systems are devised majorly in a single story building when a flat floor area is used. The starting point is the “receiving” of raw materials and the terminal point is the “Shipment” for finished goods. In-between these points, the materials move from one workstation to another for the purpose of processing. The horizontal flow system is generally denoted using the alphabets. There are I, L, U, S, O, IU, IS and IO systems used.
“I” Type Flow



“L” Type Flow

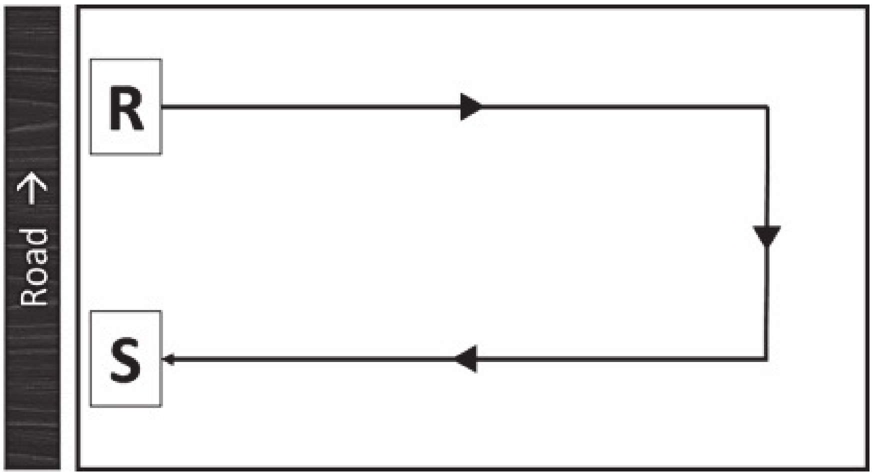


Shortest Route
Must have roads on both sides
Plant area has long length but short width Difficulty in returning empty containers
Absence of rushing of outside transportation Unsuitable for longer production lines.

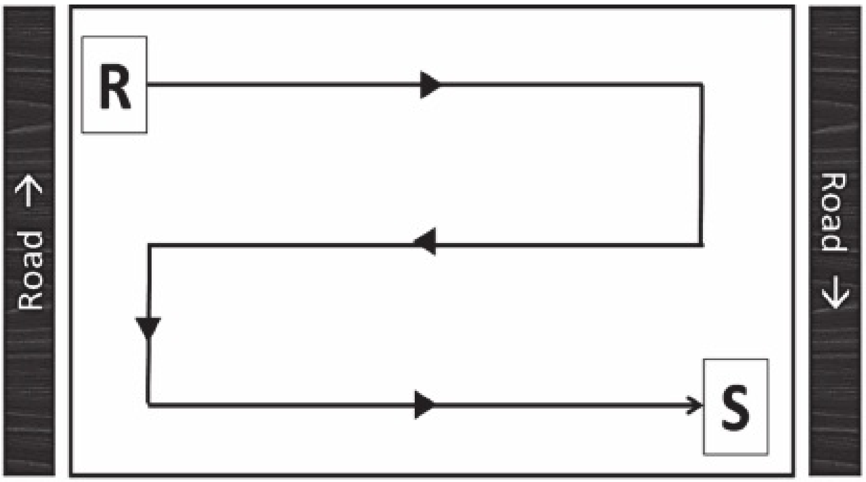
Shortest Route
Must have roads on both sides
Plant area has long length but short width Difficulty in returning empty containers

Absence of rushing of outside transportation Unsuitable for longer production lines.

"U" Type Flow

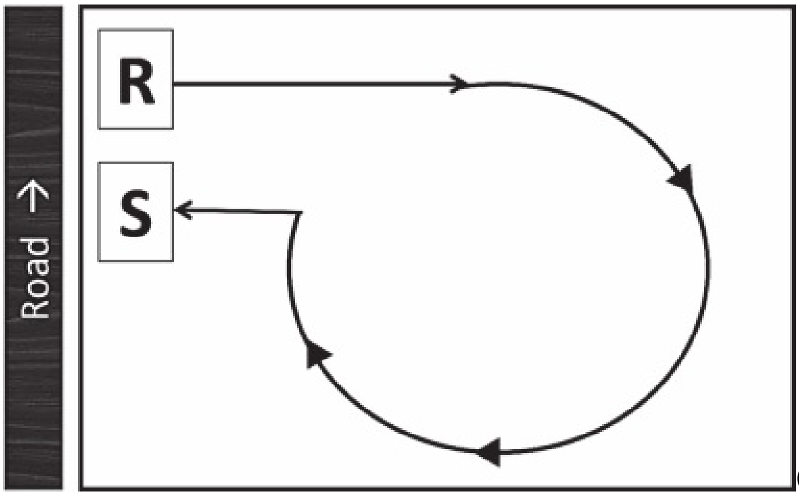


"S" Type Flow

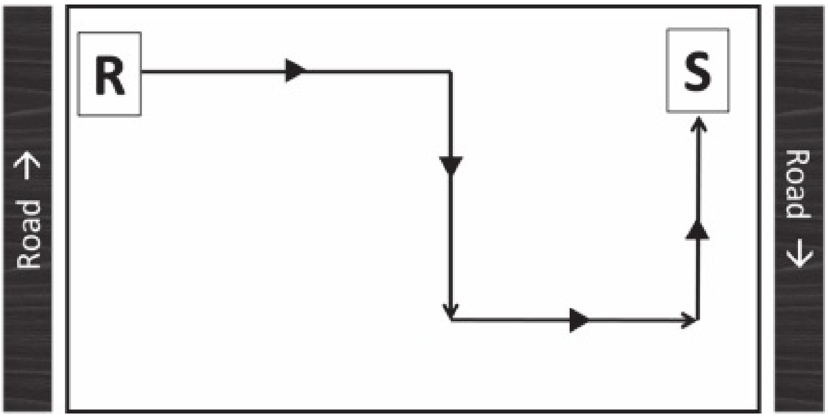


One side road is required
Less difficulty in returning empty containers Possibility of rushing outside transportation
Suitable for longer production lines
Require square like floor space

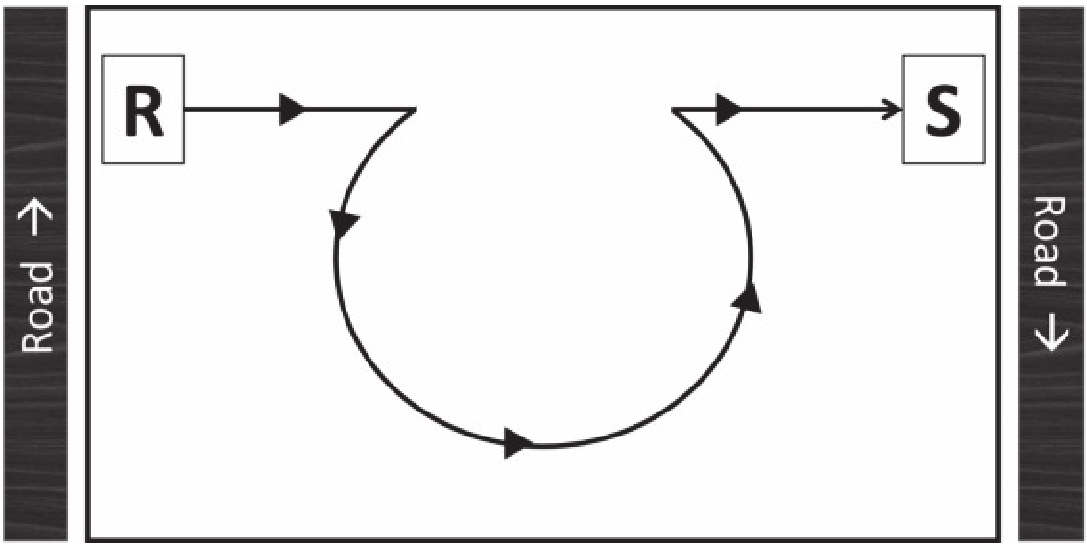
Require roads on both sides
Absence of rushing of outside transportation Require square like floor space
Difficulty in returning empty containers Suitable for longer production line.
"O" Type flow



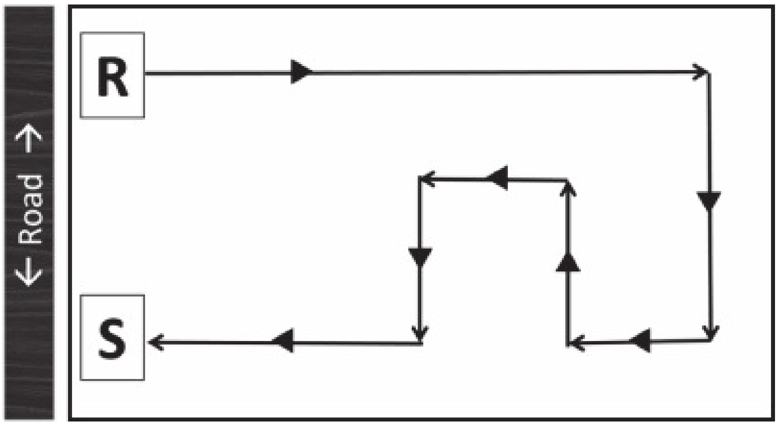
Combination of “I” and “U” Flow



Combination of “I” and “O”
One side road facility is required Heavy rush of outside transportation Ease of returning empty containers Require square floor space
Suitable for longer production line.

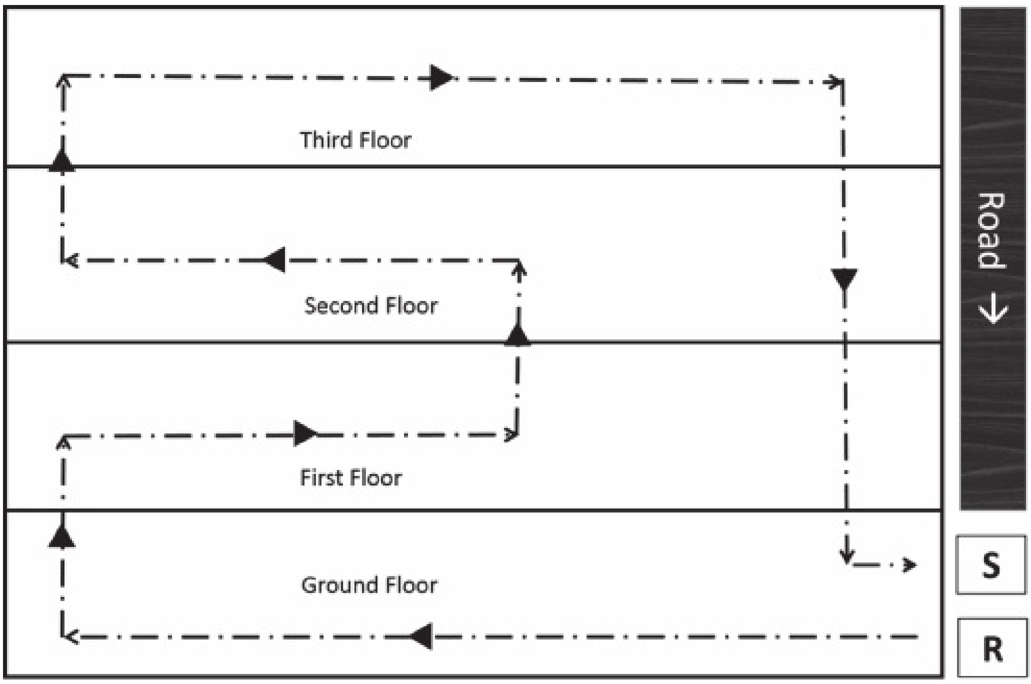


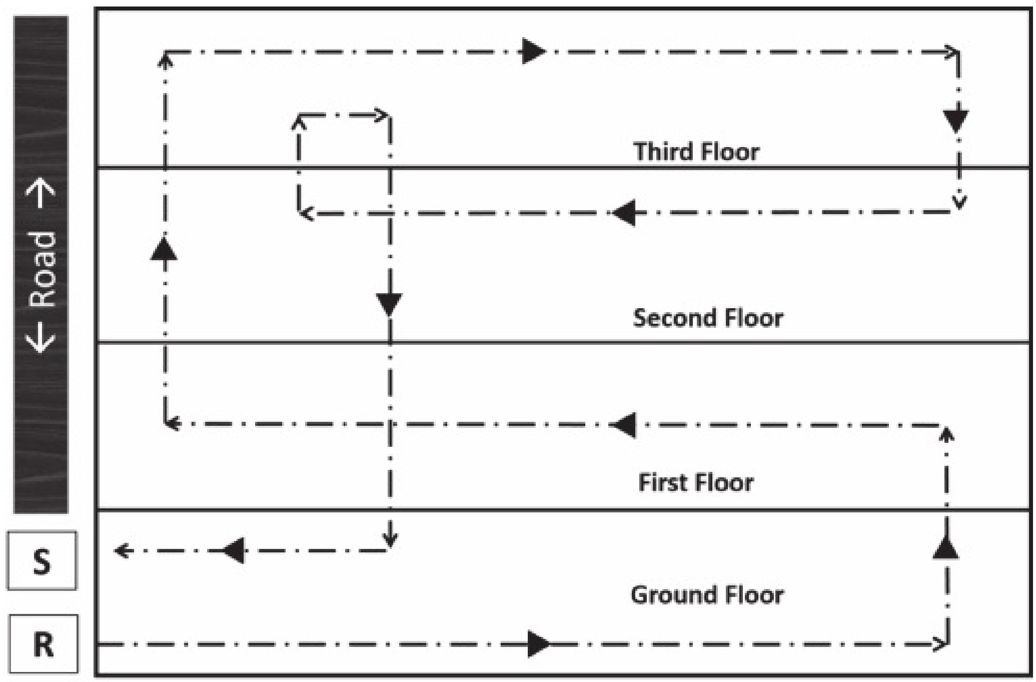
Combination of “I” and “S” Flow



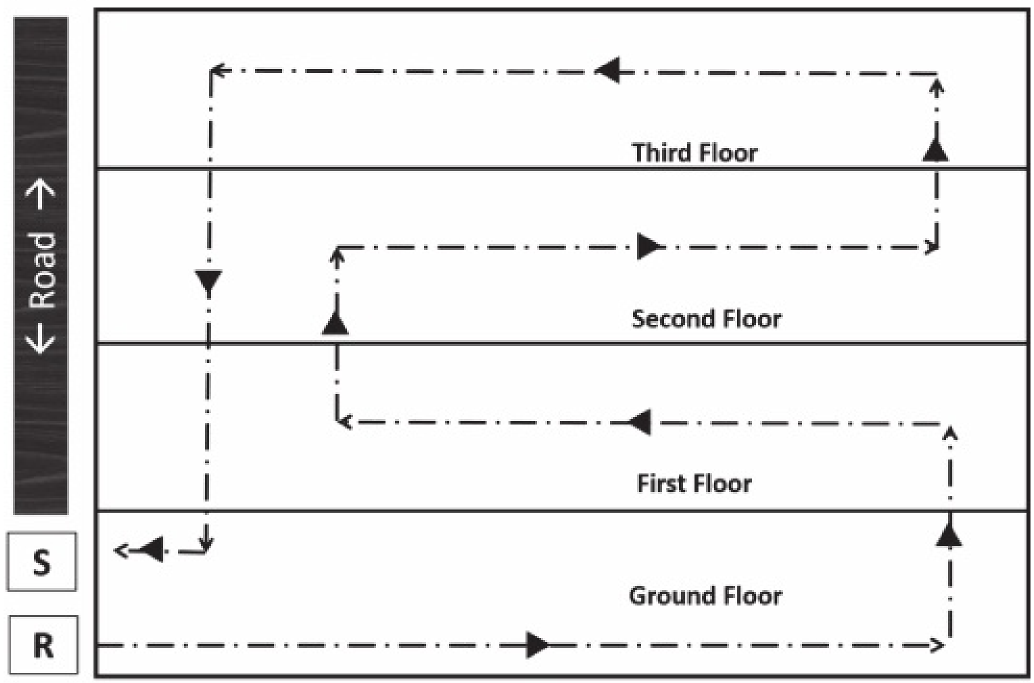
All combination flow structure have the combined characteristic properties and requirements of both the methods. Selection of these is purely based on the total floor area, and number of operations to be carried out and machine or operator requirement to reduce bottle necks.

VerticalSystemofmaterialflow : - this method arises in case of multi-story buildings. Multi story buildings are used where limited land area is available and processing is done on light materials with the help of light machines. The advantage of gravity flow can be tapped, however, it first requires availability of materials at the top floor.
Certain important vertical flow system diagrams are under,

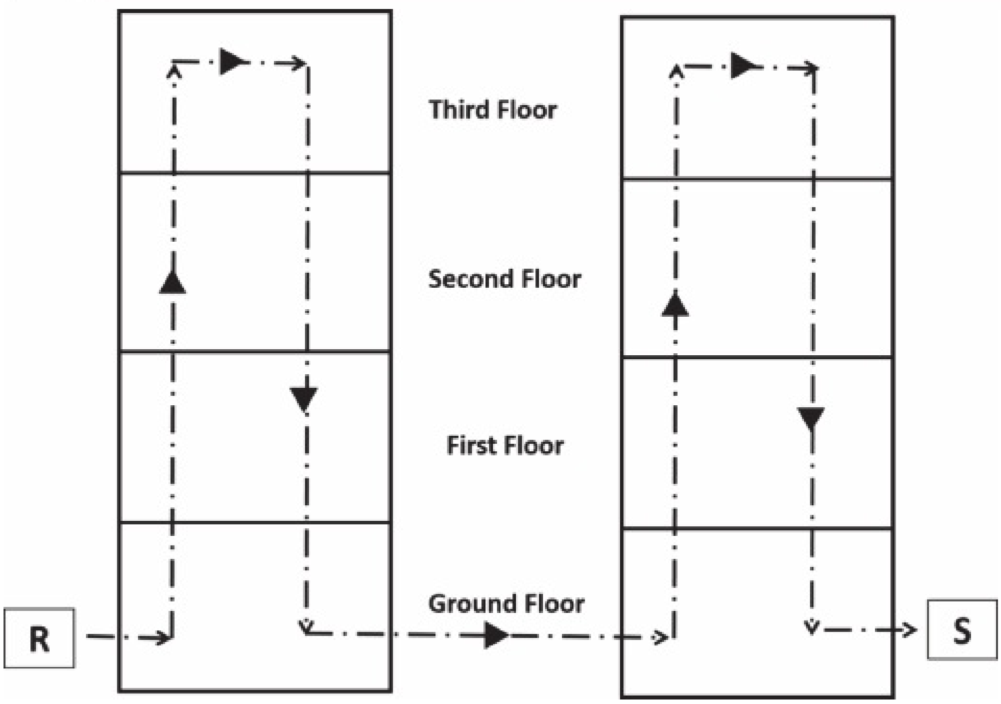




Road
Third Floor
Second Floor
First Floor
Ground Floor
S
R

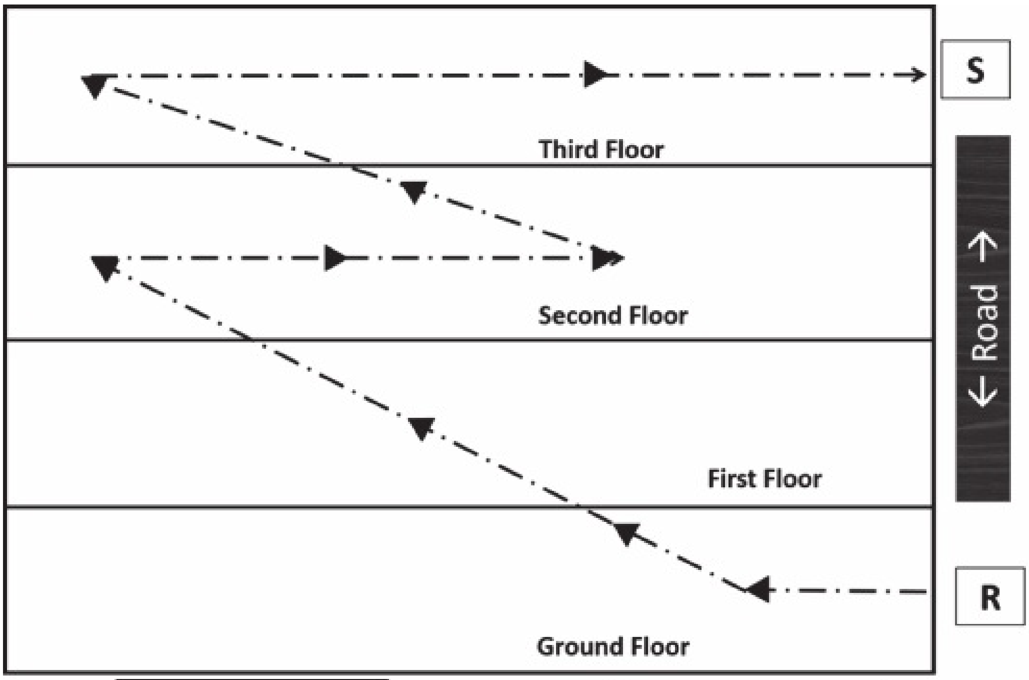


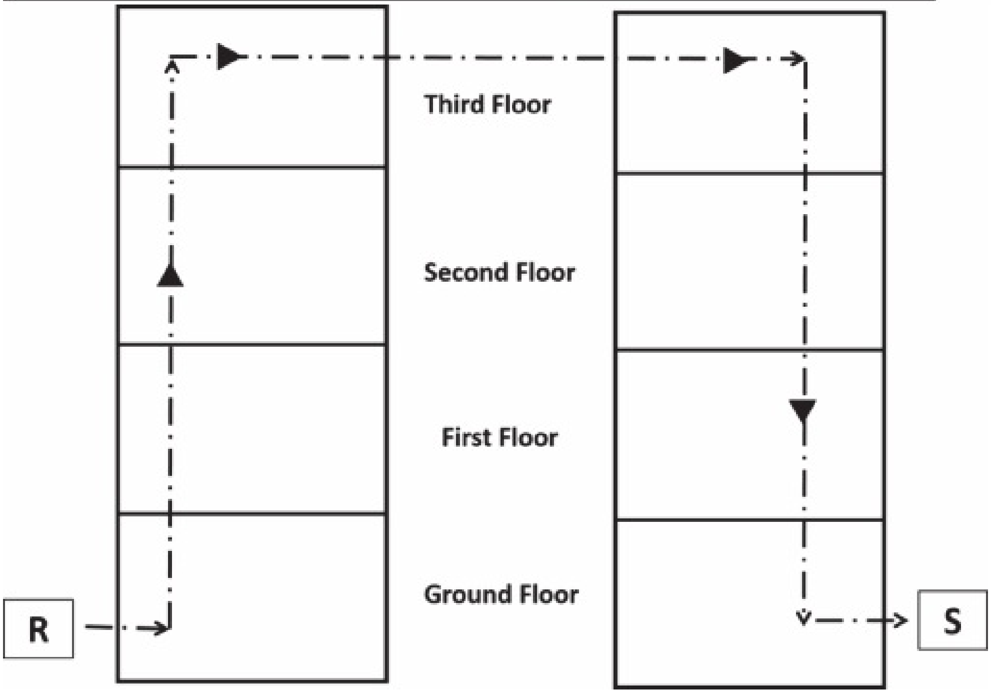
Road
Third Floor
Second Floor
First Floor
Ground Floor
S
R



Third Floor
Second Floor
First Floor
Ground Floor
R
S

Type of Plant Layouts





Plant layout is the most effective physical arrangement, either existing or in plans of industrial facilities i.e. arrangement of machines, processing equipment and service departments to achieve greatest coordination and efficiency of 4 M's (Men, Materials, Machines and Methods) in a plant. Layout problems are fundamental to every type of organization/enterprise and are experienced in all kinds of concerns/undertakings. The adequacy of layout affects the efficiency of subsequent operations. It is an important pre-requisite for efficient operations and also has a great deal in common with many problems. Once the site of the plant has been decided, the next important problem before the management of the enterprise is to plan suitable layout for the plant.
According to James Lundy, "Layout identically involves the allocation of space and the arrangement of equipment in such a manner that overall operating costs are minimized".
In the words of Mallick and Gandreau, "Plant layout is a floor plan for determining and arranging the designed machinery and equipment of a plant, whether established or

contemplated, in the best place, to permit the quickest flow of material, at the lowest cost and with the minimum handling in processing the product, from the receipt of raw material to the shipment of finished product".

According to Apple, "Plant layout is planning the path each component/ part of the product is to follow through the plant, coordinating the various parts so that the manufacturing processes may be carried out in the most economical manner, then preparing drawing or other representation of the arrangement and finally seeing that the plan is properly put into effect." (Plant Layout and Material by Apple). In the words of Sansonneti and Malilick (Factory management Vol. 103) "It is planning the right equipment, coupled with right place, to permit the processing of a product unit in the most effective manner, through the shortest possible distance and in the shortest possible time." The last definition seems to be most appropriate.

Many situations give rise to the problem of plant layout. Two plants having similar operations may not have identical layout. This may be due to size of the plant, nature of the process and management's caliber. The necessity of plant layout may be feel and the problem may arise when.

i. There are design changes in the product.
ii. There is an expansion of the enterprise.

iii. There is proposed variation in the size of the departments.
iv. Some new product is to be added to the existing line.
v. Some new department is to be added to enterprise and there is reallocation of the existing department.
vi. A new plant is to be set up.

The possibility of attaining the best possible layout is directly proportional to following factors: *The Weight, Volume or Mobility of the Product:*- If the final product is quite heavy or difficult to handle involving costly material handling equipment or a large amount of labour, important consideration will be to amount the product minimum possible e.g. boiler, turbines, locomotive industries and hip building companies etc. *Complexity of the Final Product:* If the product is made up of a very large number of components and parts i.e. large number of people may be employed for handling the movement of these parts from shop to shop or from machine to machine or one assembly point to another e.g. automobile industry. *The Length of the Process in relation to Handling Time*:- If the material handling time represents an appreciable proportion of the total time of manufacturing, any reduction in handling time of the product may result in great productivity improvement of the industrial unit e.g. Steam Turbine Industry. *The Extent to which the Process Tends towards Mass Production:* With the use of automatic machines in industries for adopting mass production system of manufacturing the volume of production will increase. In view of high production output, larger percentage of manual labour will be engaged in transporting the output unless the layout is good.

The following are the popular type of plant layouts,

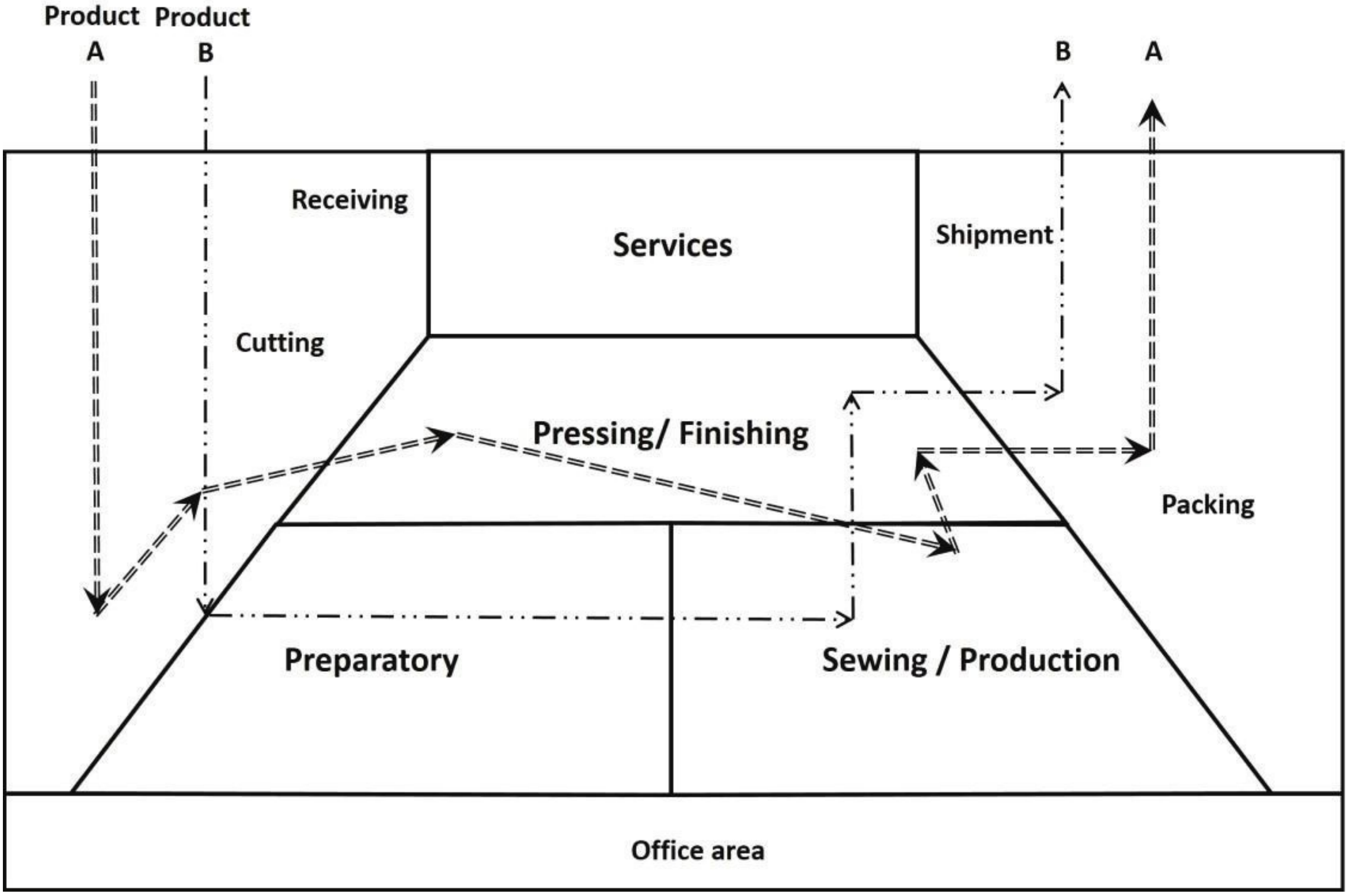
1. Process layout
2. Product layout
3. Combined Layout
4. Static product layout or Project layout
5. Cellular layout

6. Job Shop Layout

For the better productivity by limited resource, before doing the construction of the building it is required to do the detailed study and preparation of the plant layout so that minimum machines only need to purchase, with minimum manpower, space requirements maximum output can be gained from a right and proper prepared layout.

Process Layout

All machines performing similar type of operations are grouped at one location in the process layout. It is also known as “the functional layout” e.g. all sewing machines, pressing machines etc. in the garment industry will be clustered in their like groups. The sequential arrangement of the machine group is generally, but not necessarily, made on the basis of labour operation. In this layout the process rather than a product has the dominating role. The product is given secondary consideration and is moved for the purpose of operations to the process section with like machines stationed at a particular point. This type of process is more suitable to job order type of production. In such production the operations differ from product to product. So it is desirable to arrange the machines on the basis of process rather than on products.
For example a small scale garment industry with about 20 to 40 machines, who are working for the pivot brands and local orders, may have to go with different style changes frequently and there may be product change from shirt to trouser or from kids to adults etc. In such situation the machines has to arranged in according to the process such as Single Needle, double needle, button hole, bar tack, over lock etc. are treated as different process and will be allocated separately. It is because to utilize them for producing different styles in same time, so that product A and product B can be loaded in to the same industry simultaneously by calculating the production process. This will reduce idle machines and operators. A typical example is shown below,



The main advantages are,

It eliminate the duplication of machines to its maximum and enables the optimum use of installed capacity.
It facilitates the flexibility in production. The production capacity is not arranged in rigid sequence and fixed rated capacity with line balancing.
The breakdown of one machine does not interrupt the entire production flow.
Specialization in supervision becomes possible as the departments are working on separate operations.
Individual incentive schemes can be developed.

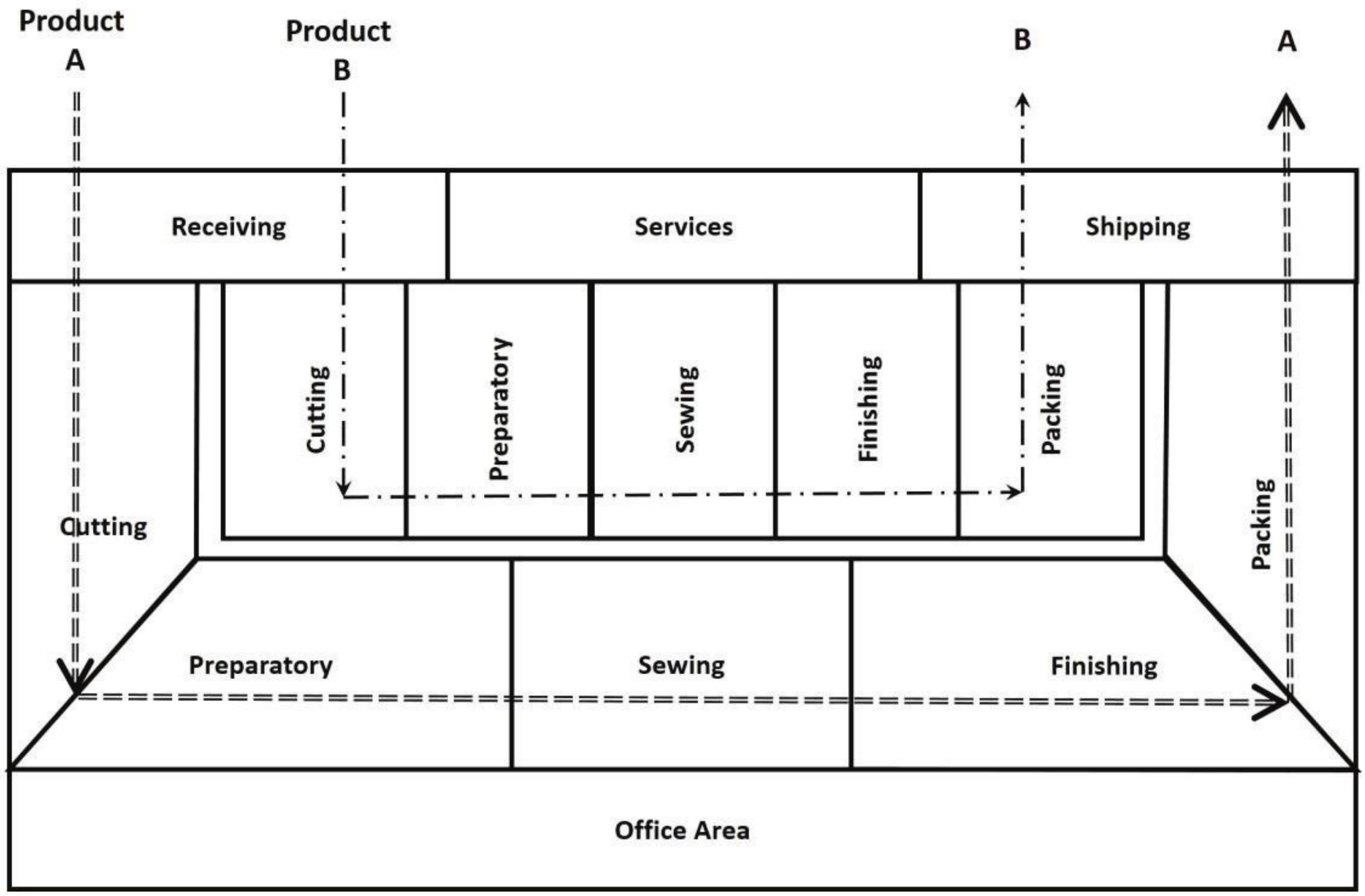
Also the following are the main disadvantages of process layout.

Due to lack of straight line sequence of production, it is impossible to maintain the line balancing in production. Hence the problems of bottleneck, waiting and idle capacity arise. The cost of material handling increases due to long routing and back tracking between the processes.
The processing time is prolonged which reduces the inventory turnover and increase the investments in inventories.
The inspection cost increases. Due to frequent changes in the machine set-up, inspection is required at each stage of process.
The cost of supervision increases due to specialist supervisors and more number of supervisors are required at each process unit.
Production planning and control becomes difficult due to complexities arising in routing, scheduling, dispatching and follow-up.
It is not possible to implement the group incentive schemes on the basis of quantity of

products manufactured.
More space is required for internal storing, reservoir of material and provision for the expansion of particular process section on requirement.

Product Layout

In product layout, the machines are arranged in the sequence as required by the particular product. All machines as required to balance the particular product line are arranged in a sequential line but it may not necessarily in the straight line. In this type of layout the product is given the primary importance and the process machine must remain present at a point where the product needs its service, as a secondary importance. Product line is more suitable for continuous flow production with few items of production. It does not require frequent changes in machine set-up. The typical arrangement of product layout is as in the figure,



The major advantages of a product line are,
Reduced material handling cost due to straight line production flow.

Mechanism of material handling is possible due to handling between fixed points. Better line balancing is possible to reduce bottlenecks and idle capacity.
Shorter operating cycle due to shorter and speedier movement of materials. Maximum utilization of machine and labour capacity through developing proper balance between them.
Effective control over production with reduced supervision by supervisors.
Reduced inspection points will give effective quality control.
More effective production planning and control due easier routing, scheduling, dispatching and follow-ups.
Maximum use of space due to straight production flow and reduced need of inter storing.

The disadvantages of product layout are,

Duplication of machines and equipment necessitates in the increased investment. And may have idle capacity if running with a low quantity order.
The system is highly inflexible as the production flow is regulated straight line through sequence and fixed rated capacity.
The breakdown of any one machine in a line interrupts the entire production flow.
Specialization supervision is not possible.
As the entire production is the result of joint efforts of all operators in the line, it is difficult to implement individual incentive schemes.

Mixed or Combined Layout

Pure product of process layout is not found in practice generally. Only a proper compromise reaping the benefits of both the layout is possible to some extent. Combined layouts are developed as, Product layout for the main product with a process layout for joint or by-product tapping the idle capacity of product layout along with marginal investment required in process layout.
To diversify the production with view to tap the idle capacity of the product layout.
Product with complete negative correlation with the product line can make the use of maximum idle capacity of the product layout.
In the product layout, some process may be segregated from the product-line, which may require special treatments and repetitive performance.

Static Product layout or Project Layout

The manufacturing operation require movement of men, machines and materials. Generally few inputs tend to be static while the others are moving. In the product and process layouts generally the machines have fixed installations and operators are having static workstations. It is only the materials move from operation to operation for the purpose of processing. But where the product is large in size and heavy in weight, such as ships etc. it tends to be static. In such production systems the product remain static and the machine and men move performing the operations on the product.

Cellular or Group Layout

To bring element of flexibility into manufacturing systems and the updating in technology for material handling etc. and batch size variations and differing operations due short run styles, the Flexible Manufacturing System (FMS) are designed. It was first installed in 1968 at England. This was more suitable for electronic assembly.
FMS is a mixture of traditional with modern computerized automations which essentially consists of a set of machines performing operations linked up with material handling systems. The grouping into cells enable the performance of similar type of functions for a group of products.

In garment industry where we use Eton® system of production is an example for cellular layout. It is necessary to optimize the host factors to have and ideal layout. The major clusters of factors affecting the layout are,

1. Manpower factors
2. Machinery factors
3. Movement factors
4. Material factors
5. Waiting factors
6. Service factors
7. Factory building factors
8. Change in production related factors etc.

For each factory it is first necessary to list out these key factors and prepare the layout so as to satisfy all of these makes a perfect layout.

Layout Design Procedure

The layout design moves from ideal to what is practical under the limitations given. The plan as a whole is made first, and details are added afterwards. The requirement of material is central to al layout planning. The process and machinery may need modifications in the light of different factors affecting the layout plan. The following are the steps followed in general for a layout preparation

1. Determine the objectives and limitations
2. Collect the input data and study the activities involved. The input data may be about sales forecasts, production forecasts, work study, existing layouts, charts etc.
3. Determine the flow of materials and activity relationships and prepare a relationship diagram. It should be subjective to space available and space required. Probably termed as a space relationship diagram.
4. The prepared space relationship diagram is modified in the light of various considerations and practical limitations.
5. Prepare as many different layouts for the specific location and carefully study each one of them and then evaluate critically to finalize.

In order to design a good layout, we require quantitative and qualitative data about various factors affecting the plan like product attributes, output volume, component parts etc. are required. Data required is collected on a continuous basis through techniques like industrial engineering methods, quality control, market researches, time and motion study etc. and record the various materials process, flow sequences, space requirement and availability etc.

Process Charts.

The most commonly used process charts are, Operation Process Chart and Flow Process Chart. The use of following symbols are recommended by the American Society of Mechanical Engineers (ASME), to simplify the construction and interpretation of process charts.

These symbols are used to represent steps in the procedure or manufacturing process in the process charts.
When necessary the operation activity can be subjected to a more detailed analysis. The distinction is then made between *Make Ready* and *Put Away* Operations. These deal with the preparation of material, plant or equipment to enable the "Do" Operations or "Inspection" to be performed and with the placing aside or clearing up after the "do" operations or "inspection".

Symbol	Activity	Predominant result
○	Operations	Produces, accomplishes, further process
⇨	Transport	Travel, material movement
▽	Storage	Holds, keeps or retains
D	Delay	Interfere or delay
□	Inspection	Verifies quality or quantity

"Do Operations" are the actual performance of the work on the material or work with plant and equipment. The "do" operation symbols can be shaded to facilitate subsequent examination in order of the importance to the overall process.

The process chart is generally used to record the activities that occur during a manufacturing or servicing job, there are several types of process charts in use, and they are divided mainly as two. 1) Those which are used to record process sequence (i.e. series of events in order in which they occur) but do not depict the events to time scale, they are

- Operation Process charts (Outline Process Chart)
- Flow Process charts (Man/ Material/ Machine)
- Operator Charts (Two handed process charts)

2) second one are those which record events in the sequence in which they occur on a time scale so that the interaction of related events can be more easily studied, there are
- Multiple activity charts
- SIMO Charts

Specify the following as a must for future references,
a) Type of Chart

b) Job concerned and whether it is the present or proposed method
c) Date of survey and name of observer
d) Where the chart ends and where it started
e) If present method record the actual output and efficiency

Include the following,
f) Adequate and accurate description of all activities on the right hand side of the symbol concerned g) Number each activity for identification purpose by placing the numeral within the symbol. h) Each class of symbol is to be numbered in its own sequence.

i) Numbering begins on the main line of activities which is always placed on the right hand side or center of the chart.

j) The numbering sequence continues until there is a junction with a subsidiary line, when it jumps to the top of this subsidiary and proceeds downward from there. When combined symbols are used, the first number applies to the outer symbol.

k) Date, concerning time, distance, weight or quantity are may be shown on the left hand side of the symbol it refers to.
l) A summary of activities is shown at the bottom left hand side of the chart
m) Use the same scale of breakdown in the analysis of activities so that the comparison of present and proposed methods will not be distorted by appearance.
n) Neatness and clarity in the layout of the chart helps to simplify the process of critical examination.

Operation ProcessChart: - An operation process chart provides the chronological sequence of all operations and inspections that occur in a manufacturing or business process. It also shows materials used and the time taken by operator for different elements of work. Generally a process chart is made for full assembly, that is, it shows all the operations and inspections that occur from the arrival of raw material to the packaging of the finished product.

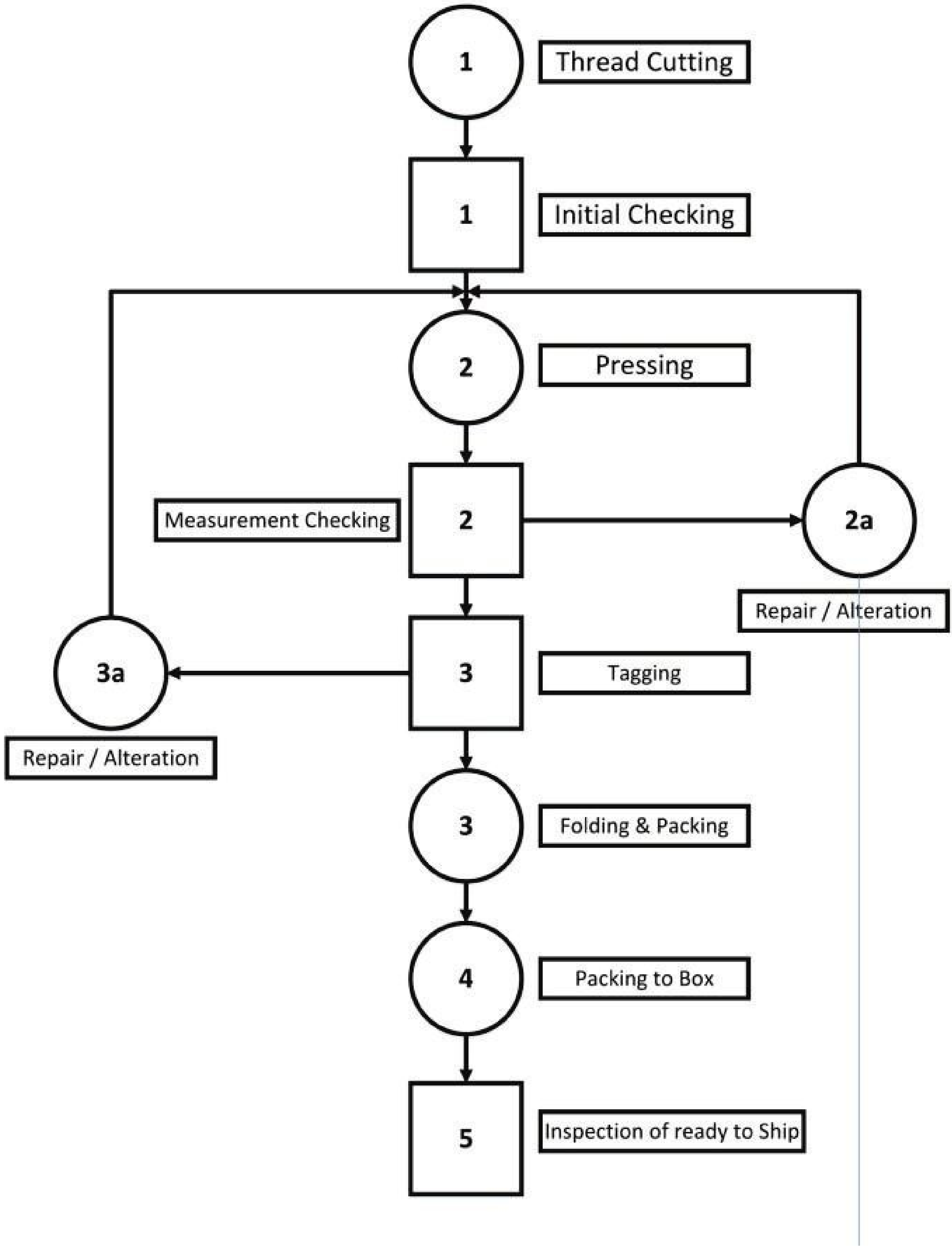
Operation Process Chart: Finishing of Shirt
Method : present Location : AQB
Charted : JK Beginning: Thread Cutting

Date : 1-1-2016

Ending : Ready Ship

Inspection 4

Operation 6



FlowProcessChart: - A flow process chart is used for recording greater detail than is possible in an operation process chart. It is made for each component of an assembly rather than for the whole assembly.

A flow process chart shows a complete process in terms of all the elements of work. There are two main types of flow charts: product or material type, and the operator type. The product type records the details of the events that occur to a product or material, while the

operator flow chart details how a person performs an operational sequence.

An important and valuable feature of this chart is its recording of non-productive hidden costs, such as delays, temporary storages, unnecessary inspections, and unnecessary long distances traveled. When the time spent on these nonproductive activities is highlighted, analyst can take steps to minimize it and thus reduce costs.

a) Man Type b) Material Type c) Equipment Type :- How the Equipment is Used

The example shown below is a process chart prepared Material Type, here the operations, movement's etc. of the material will be measured and recorded, and it is to note that this chart will give a complete idea of material movement, its time of movement, and delay etc.
:- Recodes what the worker Does :- What Happens to the Material

FLOW PROCESS CHART -		~~MAN~~ / MATERIAL / ~~EQUIPMENT~~ TYPE			
CHART No	7	SHEET No 01 / 1	SUMMARY		
SUBJ CHARTED Used bus Engine			ACTIVITY	PRESENT	PROPOSED	SAVING
ACTIVITY ENGINE STRIPPING, CLEANING & DEGREASING			Operation O	4		
			Transport ⇨	19		
			Delay ◗	3		
			Inspection □	2		
METHOD	PRESENT / PROPOSED		Storage ▽	1		
OPERATORS	A,B C,D	CLOCK No 1234, 1524	Distance (m)	237.5		
			Time (Man-Min)	0		
CHARTED BY.	Akhil		Cost Labour			
			Cost Material			
Chart Date	01-01-2016		TOTAL			

DESCRIPTION	O	⇨	□	◗	▽	QTY	Distance (m)	Time (Min)	Remarks
Stored in old Engine Store					x				
Engine Pick Up		x							
Transported to next Crane		x					24		
unloaded to Floor		x							
Picked Up		x							
Transported to Stripping Bay		x					30		
Unloaded to Floor		x							
Engine Stripped	x								
Main components Cleaned and layed out	x								
Components inspected for wear			x						
inspection report written			x						
Parts carried to degreesing basket		x					4.5		
Loaded for degreasing		x							
de greased	x								
lifted out of degreaser		x							
Transported away from degreeser		x					6		
unloaded to ground		x							
to cool				x					
transported to Cleaning benches		x					12		
All partes cleaninig completely	x								
All cleaned parts placed in one box		x					9		
awaiting transport				x					
All parts except cylinder block and heads loaded on trolly		x							
transported to engine inspection section		x					76		
parts unloaded and arranged on inspection table		x							
Cylinder Block and head loaded on trolley		x							
Transported to engine inspection section		x					76		
Unloaded to groud		x							
Stored Temporarily awaiting inspection				x					
	4	19	2	3	1	0	237.5	0	

The same method is used to record Man type and equipment type based on the requirement, but while doing a running line modification for production improvement it is required to prepare all the three modes for the better result.

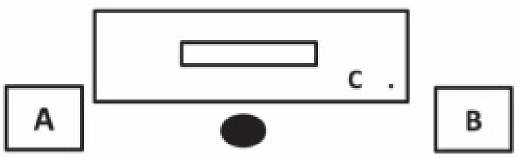
O peratorProcessChart: **-**It is also called Left Hand – Right Hand chart and shows the activities of hands of the operator while performing a task. It uses four elements of hand work: Operation, Delay (Wait), Move and Hold. Its main advantage lies in highlighting un-productive elements such as unnecessary delay and hold so that analyst can take measures to eliminate or shorten them.

In the two handed process chart the symbols are used in a slightly different way, because

of the motion variation and easy marking, is used to represent HOLD and**D** is used to show that the particular hand is idle at that time. Constructing the chart usually starts by recording activities of the hand that does the most work, then putting the symbols for the other hand in their right places. Mostly the movements being recorded are small and fast, so to start at the top, with the earliest activity and work downwards is preferable method of recording. Also a video can be used for more accurate plot of the chart, so that it can be played in a slower speed to identify the exact movements.

TWO HANDED FLOW CHART (OPERATOR CHART)

Operation:	Set the Fly with top Stitch		Date:	30-12-2016
Chart Begins:	Hands picking the bundle from stack		Chart By:	Akhil
Chart Ends:	tie bundle of cut pieces			
Machine	SNLS (UBT)		Attachemnt	1/16" Compensating Foot
SPI			SAM	

Simple Layout of Operation	Details of operation:
	Set the Trouser fly with zipper at left side, using the template for top stitch. A- Bundle of Cut pieces B-Finished Product C-Fly with Zipper

	LEFT HAND	RIGHT HAND
1	Put a bundle of front cut pieces at position	Put a bundle of front cut pieces at position
2	Untie the rope	Untie the rope
3		Get and put down the fly with zipper at position C
4	Get and put down a piece of front cut piece on the m/c table	Get and put down a piece of front cut piece on the m/c table
5		Get the fly with zipper from the position C
6	Put and align the fly facing with zipper at the front rise	Put and align the fly facing with zipper at the front rise
7	Sew the fly facing from front rise / Hold in position	Align the fly to keep in position
8	Get the front piece behind the compensating foot	Get the front piece behind the compensating foot
9	Press and open the seam of the front rise	Press and open the seam of the front rise
10	Fold the fly facing behind the front piece	Fold the fly facing behind the front piece
11	Sewing 1/16" edge stitch from front rise/ Hold in	Sewing 1/16" edge stitch from front rise/ Align
12	Get the front piece behind the compensating foot	Get the front piece behind the compensating foot
13		Get the template from position C
14	Get and smooth over the front rise	Align the template at front rise at edge
15	Put the front plate with template beneath the Foot	Put the front plate with template beneath the Foot
16	Top Stich / Hold the pieces with template	Top stitch / Align and hold the piece with template
17	Draw out 1/2" and put the front pannel beneath the presser foot	Draw out 1/2" and put the front pannel beneath the presser foot
18	Top stitching 1/4" - Hold the pieces	top stitch / Align and hold the pieces
19	Take the front piece from presser foot	Take the front piece from presser foot
20	Deposit the front piece on basket	Deposit the front piece on basket
21	Repeat the process from 4 to 20	Repeat the process from 4 to 20
22	fold twice for the front pannel	fold twice for the front pannel
23	take the rope and make a knot	take the rope and make a knot
24	tie bundle of pants cut pieces	tie bundle of pants cut pieces

this two handed flow chart is prepared without symbols, and is commonly used for the first reference of complex operations, and to plot the operations, then another one will be prepared as below, or may the same can be used with symbols for further references.

TWO HANDED FLOW CHART (OPERATOR CHART)

Operation:	Dismantling of an Electric Plug			Date:	30-12-2016
Chart Begins:	Hands empty, plg top on carton			Chart By:	Akhil
Chart Ends:	hands empty, plug top dismantled				
Equipments	Scre driver		Attachemnt		
			SAM		

No.		LEFT HAND	No.		RIGHT HAND
1	D	Delay	1	⇨	To Carton on Bench
			1	O	To Pick up Carton
1	⇨	To Meet Right Hand	2	⇨	To Meet Left Hand
1	O	Grasp Carton			
1	▽	Hold Carton	2	O	Open Lid and grasp plug
2	⇨	Draw off carton and toss aside			
3	⇨	To meet plug at right hand	3	⇨	Plug to Left Hand
2	O	Grasp plug and rotate to disassemply position	3	O	Release Plug
2	▽	Hold Plug	4	⇨	To scre driver on bench
			4	O	Pick up scre driver
			5	⇨	Screw driver to plug
			5	O	Remove - unscrew cover retaining screw
			6	⇨	Lay scre driver on bench
			7	⇨	Empty hand to plug top
4	⇨	Draw off cover- Lay aside on bench	1	▽	Hold Plug top
5	⇨	To plug	8	⇨	Plug to meet left hand
3	O	Grasp plug - rotate to disassembly position	6	O	Release plug
3	▽	Hold Plug	9	⇨	To scre driver on bench
			7	O	Pick up scre driver
			10	⇨	Screw driver to plug
			8	O	Unscrew -"E" Terminal Screw & Let fall to bench
			9	O	Unscrew -"P" Terminal Screw & Let fall to bench
			10	O	Unscrew -"N" Terminal Screw & Let fall to bench
6	⇨	Plug to box on bench	11	⇨	Lay scre driver on bench
4	O	Aside box to tray	1	D	Delay

SUMMARY

Left Hand				Right Hand		
O	Operation	4		O	Operation	10
⇨	Transposrt	6		⇨	Transposrt	11
□	Inspection	0		□	Inspection	0
D	Delay	1		D	Delay	1
▽	Hold	3		▽	Hold	1

This is the common form of a two handed Process chart recording the activities of the operator to analyze.

M ultipleActivityChart: -Worker-Machine process chart and gang process chart fall in the category of multiple activity charts. A worker-machine chart is used for recording and analyzing the working relationship between operator and machine on which he works. It is drawn to time scale. Analysis of the chart can help in better utilization of both worker and machine time. The possibility of one worker attending more than one machine is also sought from the use of this chart.

A gang process chart is similar to worker-machine chart, and is used when several workers operate one machine. The chart helps in exploring the possibility of reducing both the operator time and idle machine time.

The multiple activity chart is used whenever it is necessary to consider on the same document the activities of a subject in relation to one or more others. By allotting separate bars, placed against a common time scale, to represent the activities of each worker or machine during the process, the multiple activity chart shows clearly periods on ineffective time within the process. This makes the avoidance of such time by rearrangement of work to a much easier task while considering cost aspects.

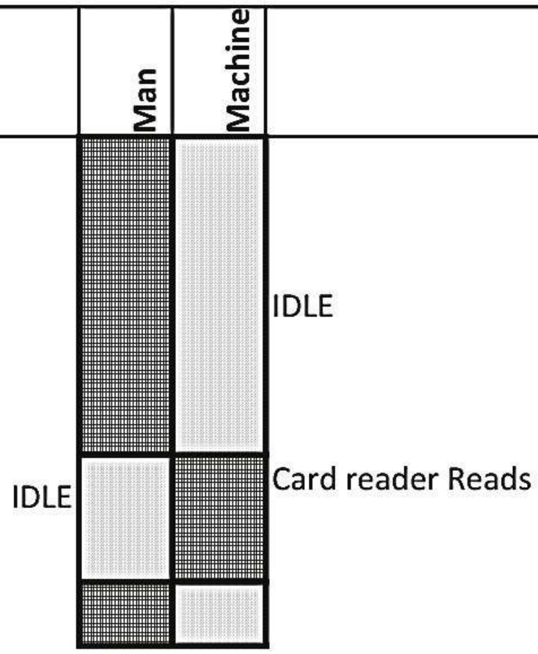
This chart is useful while utilizing an expensive machine or equipment and while organizing team work. It enables complex process to be recorded in a simple way for study leisure.

MULTIPLE ACTIVITY CHART

PRODUCT: PUNCHED CARDS

PROCESS: Reading a bundle of Cards in a Card Reader

Time (S)	Activity
0	0
3	Remove Rubber Strap
5	Picks up weight from Hopper
7	Places Cards in Hopper
9	Replace Weight over Cards
12	Pushes Start button
20	Picks up Card stack from out stacker
23	Replaces Rubber strap on cards



SUMMARY

	MAN		Machine	
	Time (S0	%	Time (S)	%
Work	15	65.22	15	65.22
Idle	8	34.78	8	34.78

Worker and machine activities are normally recorded by shading the respective bars. Direct or prerecorded timings can ensure the chart effective. Activates are plotted against the time scale and a summary of the present or proposed methods with their percentile should be made for easy analyzing. A sample is shown as on the above.

SimultaneousMotionCycle(SIMO)Chart:A Simo chart is another Left-Hand Right-Hand chart with the difference that it is drawn to time scale and in terms of basic motions called therbligs. SIMO Charts are often based on film analysis used to record on a common time scale the therbligs or groups of therbligs performed by different parts of the body of one or more workers.

SIMO Chart is the micro motion form of the man type flow process chart, because they are used primarily for operations of short duration, often performed with extreme rapidity, it is generally necessary to compile them from films made of the operation which can be stopped at any point or projected in slow motion. It is recorded by a “wink counter” placed in such a position that it can be seen rotating during the filming in olden days. Now due to digital film we can use software for counting frames passed, or time elapsed instead of

wink counters. Investigation in this degree of detail is only justified when the saving resulted from improved method will contribute the cost of work involved.

SIMO CHART

No & Name: Operation:
Operator:
Operation No: Film No:
Chart No:
Date:
Chart done by:

Left Hand Description$^{\text{Time in}}$ Right Hand Description$_{2,000/m}$

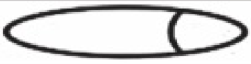
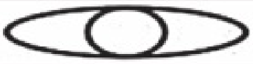
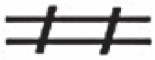
TherbligsExplained:it is the named by Mr. Frank B Gilberth to each of the specific divisions of movement, according to purpose. These therbligs cover movements, or reason for the absence of movement. Each therbligs has specific Colour, symbol, and letter for easy recording purpose. After the ASTM's Addition of 'HOLD' in the 1940's there are eighteen therbligs.

In its simplest form, therbligs symbols can be used in place of process chart symbols, to produce a therbligs chart. This can serve the same purpose as the flow process chart or two handed process chart. And although it may seem that greater details can be portrayed in this way, the absence of a time scale makes this advantage uncertain. Mostly we does the recorded movie analyzing to prepare the therbligs chart. Now a days either a wink counter or a micro chronometer (decimal minutes) are used to record the time. When, the therbligs symbols are shown in the figure.

Movement and Flow Activities.

The process flow charts shows the sequence and nature of movements, but it does not show clearly the paths of movement. There are often desirable features such as back-tracking, congestion and unnecessary long movements. To record these undesirable features, representation of the working area in the form of flow diagrams, string diagrams or two and three dimensional models may be used.

These methods helps to reduce problems in plant layout and design effectively and to demonstrate the improved method to both workers and management, as it is essential.

SYMBOL	Name	Description	Colour	Pencil
	SEARCH	Locate and article	BLACK	67
	FIND	Mental reaction at the end of search	GREY	69
	SELECT	Selection from Number	Light GREY	70
	GRASP	Taking Hold	Red	19
	HOLD	Prolonged Grasp	Gold Ochre	58
	TRANSPORT – LOADED	Moving an Article	Green	45
	POSITION	Placing in a definite location	Blue	29
	ASSEMBLE	Putting parts together	Violet	25
	USE	Causing a device to perform its function	Purple	22
	DISASSEMBLE	Separating Parts	Light Violet	26
	INSPECT	Examine or Test	Burnt Ochre	60
	PRE POSITION	Placing an article ready for use	Pale Blue	39
	RELEASE LOAD	Release an article	Carmine red	14
	TRANSPORT – EMPTY	Movement of a body member	Olive Green	51
	REST	Pause to overcome fatigue	Orange	10
	UNAVOIDABLE DELAY	Idle-Outside person's control	Yellow	6
	AVOIDABLE DELAY	Idle-Within person's control	Lemon Yellow	1
	PLAN	Mental Process before action	Brown	55

FlowDiagr ams:They are drawings, substantially to scale with working area, showing the location of various activities identified and numbered according to sequence and is associated with a particular flow process chart either man, material or equipment type.

The routes followed in transport are shown by joining the symbols in sequence by a line which represents the path of movement of the concerned subject. The subject may be machine movement, or man movement with material or material movement only as per the requirement.

There are two methods used to prepare the flow diagrams, Elevation flow diagram and ThreeDimensional flow diagrams.

As distances moved on a vertical plane or in a horizontal plane, flow diagrams are prepared to show the elevation as well as plan of the area where the movement occurring

is plotted. When object covers several floor levels or through different areas of the factory, a three dimensional flow diagram is more useful. The flow diagrams gives layout of workplace and the travel routes of workers, material or equipment.

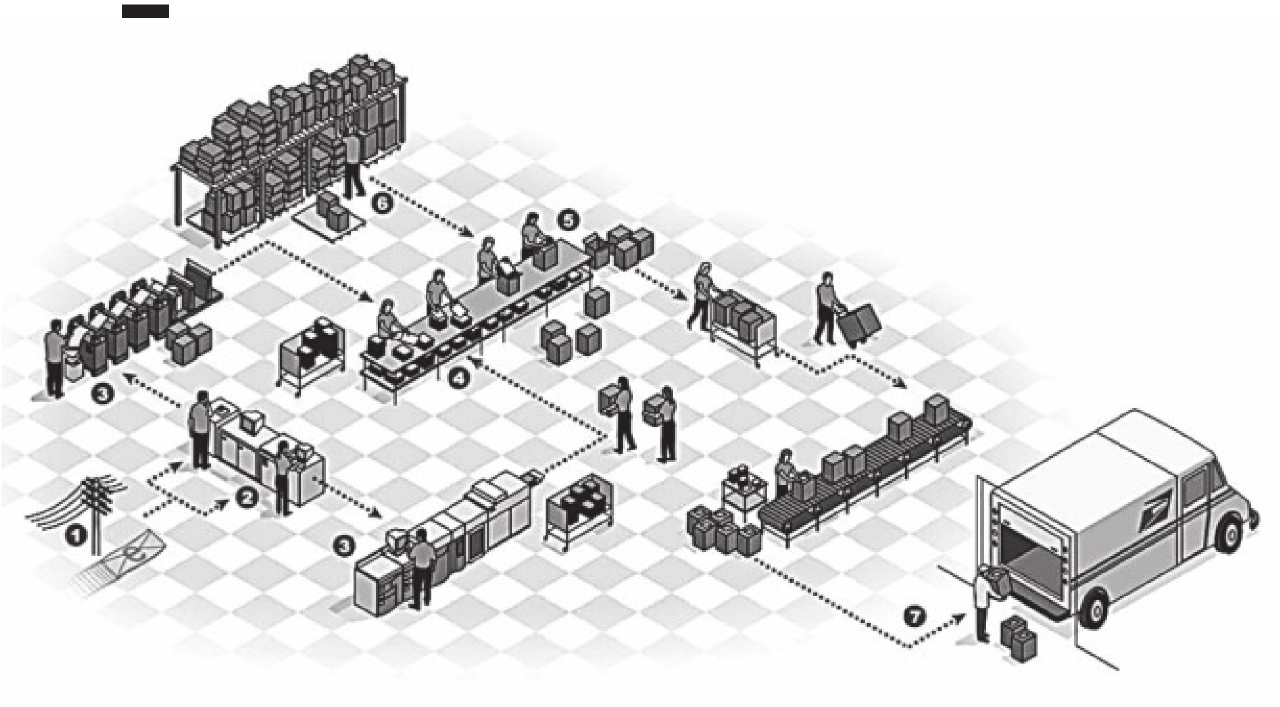
A

B 2

1

C

D



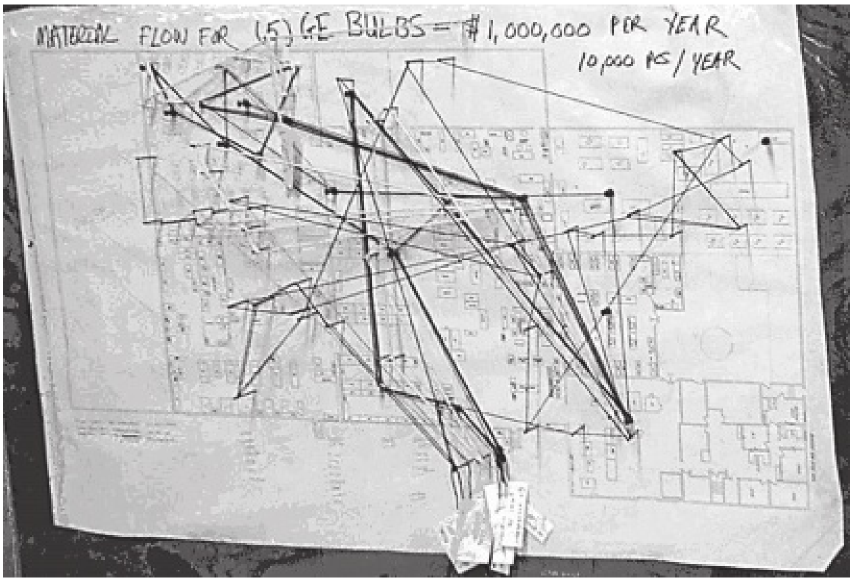
StringDiagram:the string diagram is a scale layout drawing on which a length of string is used to record the pattern of movement of a worker, or equipment working within a limited area during a certain period of time. It is defined as the scale model on which thread is used to trace the path or movement of man and materials during a specified sequence of events. As a thread is used to measure distance, it is necessary that the diagram should be drawn up to scale.

The basic construction steps are at first step is to make a study of the movements of various resources of the task. Then prepare scale layout of the shop area and mark various features such as machinery, work stations, stores etc. care should be taken to include all building features such as walls, and doorways, block plans of machines and other equipment installed in vicinity of the route and in scale. Then mark and insert panel pins at all workstations between which journeys are made after attaching it on a board. More pegs/pins may be stretched in between the facilities to trace more or less the actual path followed by men and materials.

A strong un-stretchable often colored string is then tied to the starting point pin and then by reference to the study taken round each of the other terminals in order and sequence of movement. Use different colored strings for different man of material movements to find

out journeys between any numbers of pins. Since thread is used instead of draw lines, there is no risk that obliteration will occur. Then remove the string after the path being photographed and measure to calculate the distance or length of the movement.

The major uses of string diagram are,
It represents the record of an existing set of conditions and thus helps the method engineer in visualizing the actual situation. It indicates complex movements, back tracking, congestion, bottle necks and over and underutilized paths on the shop floor. It is an aid for comparison between layouts or methods of doing a job as far as the distance moved are involved. It helps in tracking existing paths of movement for incorporating necessary modification, if any. It is prefixed when movements are not regular as far as frequency and distance moved are concerned. String diagram indicates the pattern of movements and thus helps in deciding the most economical routes to perform a particular operation.



To summarize, the principal use of a string diagram are to investigate movement in the following circumstances:
1) When a tram is working
2) When one worker is tending several machines
3) In process where several sub-assemblies have to be moved to another assembly
4) Where the process necessitates the worker moving from one work place to another.
5) For testing the relative values of different layouts.
And also to decide how the material or man to have their movement in the floor. Sometimes a slight changes of work stations may also be decided using this chart.

Tr avelChart: -in certain instances when it is required to examine complex inter-departmental or intersection materials movement, the flow diagram becomes a maze of lines and difficult to follow. In particular the flow diagram is not suitable when quantitative factors as distance, weight and frequency of movement have to be studied. It is also called as From-To-Charts or cross charts, since it depicts the entire materials flow amongst the departments taken as source and destination. The travel chart is of significant help in product layout. It shows the material interface between departments. The higher the interface, closer the departments are placed to avoid unnecessary material handling.

To Raw Dept. Dept. Dept. Inspection Finished material #1 #2 #3 &QC Goods StoreFrom Store

Raw material $_{8000\ 2000}$Store

Dept. #1 4000 2000 1000 1000
Dept. #2 3000 3000
Dept. #3 500 500 4000 5000
Inspection &QC 1000 M_{ij} 8000

Finished Goods
Store

Mij is in kilograms
The entries in the chart are scattered on both the sides of the diagonal. A to B and B to A travel requirements may be different. The travel charts have the following merits.

1) Useful tool of materials movement analysis
2) Useful to locate activities,
3) Alternative flows and layouts could be compared
4) Relationship of activities in terms of volume of movement become clear
5) Shows quantitative relationship.

ActivityrelationshipChart (RELCharts):- a relationship chart (REL) is a central technique in a Systematic Layout Planning (SLP). The activity relationship diagram converts vowel-letter ratings on the relationship chart to a graphic visualization of desired closeness among activity areas. In the space relationship diagram, each activity area is drawn to scale, thus showing the relative size (and sometimes the shape) of each area, as well as its best-related position. A relationship chart may be constructed as follows,
List all departments on the relationship chart. Conduct interviews or surveys with persons from each department listed on the relationship chart. Then define the criteria for assigning closeness and itemize and record the criteria as the reason for relationship values. And then establish the relationship values and the reason for the value for all pairs of departments. It is important to allow everyone having input to the development of a relationship chart to evaluate and discuss changes in the chart. An example is show as,

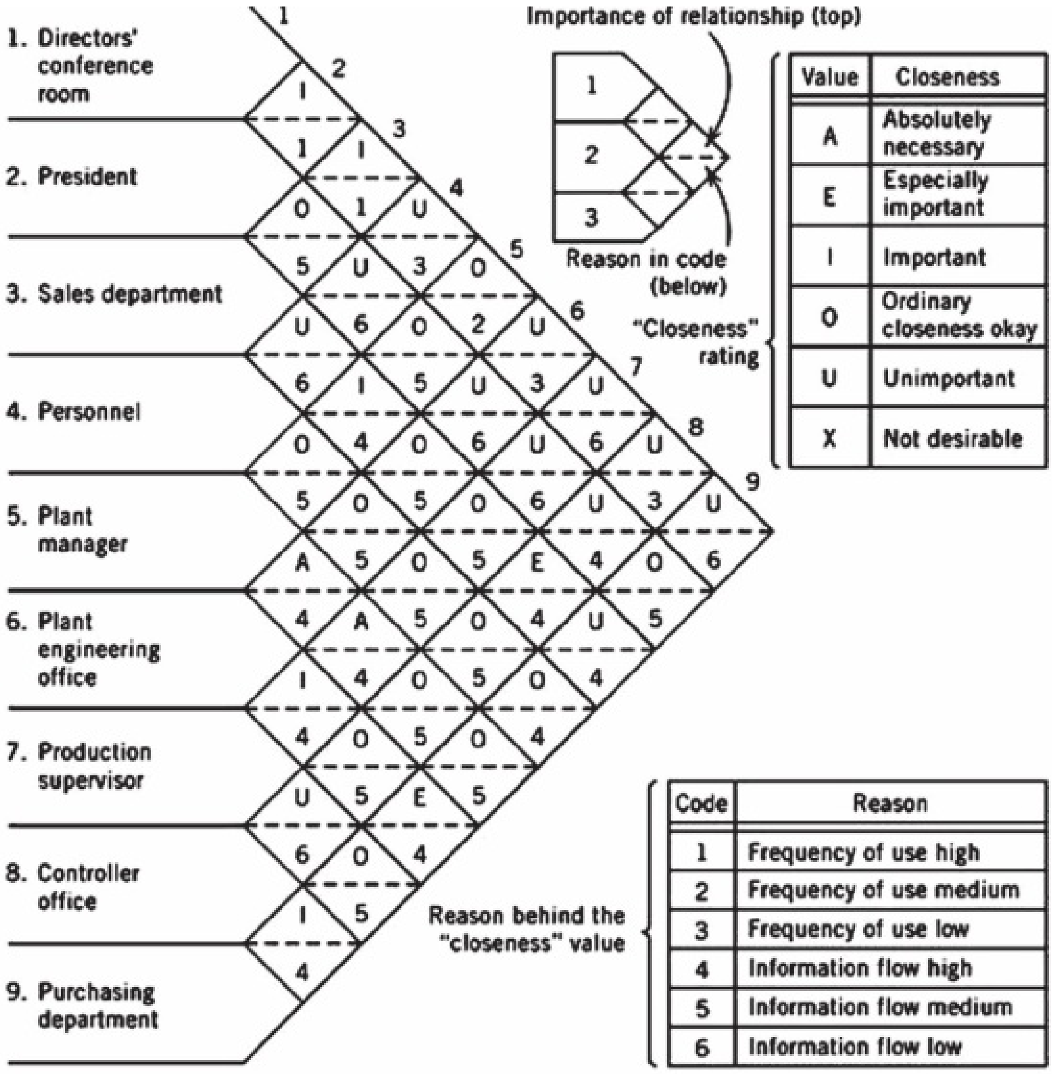
A = absolutely necessary E = especially important I = important
O = ordinary closeness U = unimportant
X = undesirable

An *Activity Relationship Diagram* is developed from information in the activity relation chart. Essentially the relationship diagram is a block diagram of the various areas to be placed into the layout.

The departments are shown linked together by a number of lines. The total number of lines joining departments reflects the strength of the relationship between the departments. E.g., four joining lines indicate a need to have two departments located close together, whereas one line indicates a low priority on placing the departments adjacent to each other.

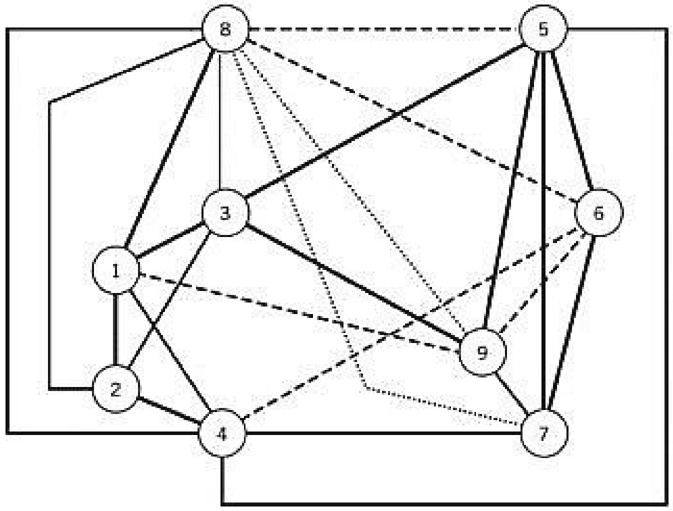
The next step is to combine the relationship diagram with departmental space requirements to form a Space Relationship Diagram. Here, the blocks are scaled to reflect space needs while still maintaining the same relative placement in the layout.
A Block Plan represents the final layout based on activity relationship information. If the

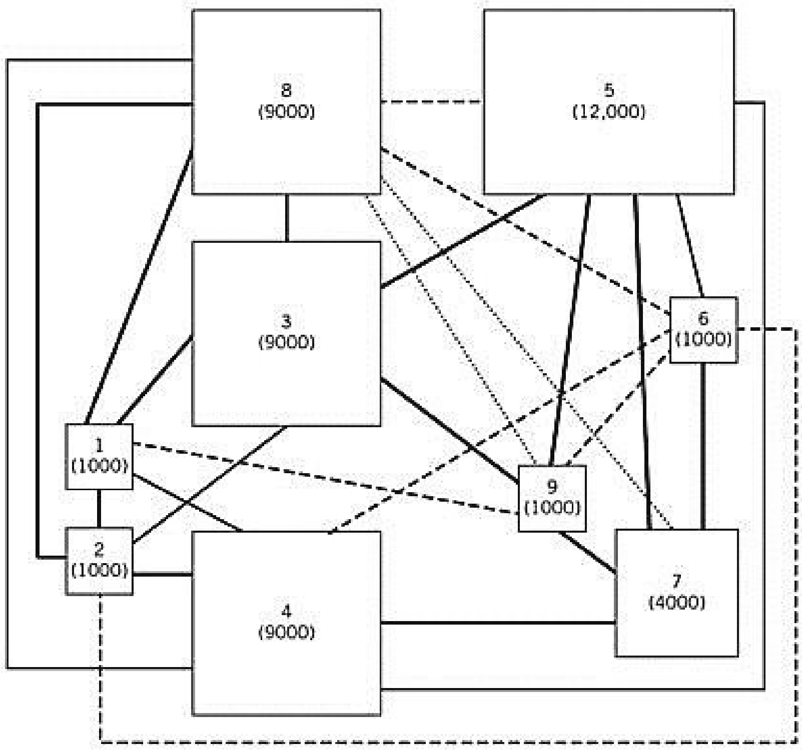
layout is for an existing facility, the block plan may have to be modified to fit the building. In the case of a new facility, the shape of the building will confirm to layout requirements.



It is important to do proper and detailed analysis while preparing the REL chart. If, instead of the facilities planner synthesizing the relationship among departments as described above, the department heads are allowed to assign the closeness relationships with other departments to reduce the conflicts. The relationship values between the departments A and B are to be the same as those of B to A. it is important to emphasize the difference between relationship values U(unimportant) and X (undesirable). Two departments can be place adjacent to each other with a relationship value U, but they cannot be placed adjacent to each other with a relationship value X.

From facilities planning perspective activity relations are often translated into proximity requirements. For example, if two activities have a strong positive relationship, then it is highly desirable that they be located close together.





Space Requirement.

Plant layout primarily deals with the allocation of the total floor, rather cubic area among various production and service departments along with their specified stationing inside the plant area. The most difficult determination is the amount of space required in the facility. The design year of a facility is to be for a 5 to 10 year span in future. Considerable uncertainty generally exist concerning the impact of technology in most industries, changing the product mix, demand levels are the major challenges while planning an apparel industry. The second challenge is the task of projecting *True Space Requirements* for the uncertain future.

To further complicate matters, there exists the “Parkinson’s Law”. Loosely translated in the context of facilities planning. It states that things will expand to fill all available capacity sooner than you plan, hence, even though the facility might be constructed with sufficient space for future, when the future arrives, there will be no space available for it!

In determining the space requirement for warehouse activities, inventory levels, storage units, methods and strategies, equipment and requirement s must be considered in detail.

In manufacturing and office environments, space requirements must be determined first to the individual workstations for each and then departmental requirements based on the collection of workstations. For example the workstation requirement for a Pattern maker and that of a sample tailor are not equal, the pattern maker needs a large sized table with sufficient racks where as a sample tailor with sufficient machine and siting spaces. According to James Lundy "Overall plant areas are generally about 150 to 200 sq. feet per employee for a light manufacturing operations, 500 sq. feet for medium manufacturing and as high as 1000 sq. feet for process industries.

Factory and Departmental Layout

The layout of the factory is of major importance as it affects the flow of material and processes, labour efficiency, supervision and control, use of equipment, use of space, expansion possibilities, and factory appearance. When properly executed it prevents waste of time` unnecessary effort, and loss of money due to useless movement and travel of work in progress. It increases workers efficiency and satisfaction as it frees them from taking unnecessary steps or making needless motions and permits them to direct their energy into productive efforts. It assists management in maintaining or improving the established quality of the product, in meeting delivery schedules and thus in establishing better relationships with customers. It prevents the needless duplication of machinery and equipment, and this keeps the capital investment at a minimum. It conserves floor space, thus reducing the investment in plant and increases the efficiency of operation. It makes provision for expansion and for temporary contraction to take care of fluctuations in market demand. It provides and orderly plant arrangement, that is pleasing to look at and a safe place in which to work.

Within the working career of an Industrial Engineer, it is highly unlikely that the opportunity to plan the layout of the complete factory will arise, but he/she may be required to re-organize manufacturing sections within the present factory. If we follow the basic guidelines of Method Study, we can adapt these to suit the criteria of a successful factory layout. Although the choice of selecting the particular area of the factory that we are organizing may well be done for us, the next stage is the recording of all of the information we will need.

Record: The first criteria is going to be the physical details about the floor space available. Although the measurements of the space available may well be obtained from the architects plan, or by taking measurements, it is important to remember that the available space may be reduced by factors such as entrances and exits from the floor, columns and obstacles of a permanent nature, so that the available space may be considerably less than the area measured. We can term this the available working area. Secondly we will need to control all the information about the particular types of machines we will be using and the number of machines required to meet our production requirements. The physical size of the machines will have to be recorded and also the amount for floor space required for the machine and for the operator to be able to position themselves comfortably behind it, and the space required between machines.

Thirdly, we must record all of the particulars about the garments that are being made. The sequence of operations and how we intend to move garments through the progressive stages of assembly. This will necessitate assessing what type of transportation system we intend using, if any, or the size of baskets or trolleys, if we use them. Work in progress

will also be another factor that will affect the available working area and it is necessary to determine at an early stage, what our quantities of work in progress will be, so that adequate space can be made for storage.
Next we will need to know the number of operators, supervisors and service hands who are going to work in the area, as they must be provided with adequate access into and out of the factory, toilet and canteen facilities and office communication, for the indirect workers and staff. Record the services required for the machines and people in the factory, how much electricity is required for lighting and power, how much water and compressed air, if needed. These factors may well have a major influence on the layout of a lot of machinery, as the availability of power points and steam, for example, are not as maneuverable as the machinery. Record the actual requirements of the building. These will to a great extent be covered by the "Factories Act".
To summarize on the recording aspects, it is apparent from the influences that the processes have on plant layout, it is necessary that a thorough production analysis must be made of the garments and the operations required, to determine the most advantageous for departments and machinery. To this end the flow of work must be known, the process through which the garments must pass be determined, the sequence of operations be established and the required machinery and equipment be selected.

Therefore the information required to be known before planning can be listed as follows:

1. The total workable floor area available,
2. The operations required to manufacture the garments,
3. The sequence of operations,
4. The machinery and equipment required,
5. How the garments are going to be handled,
6. The number of operators and staff required,
7. What type and amount of services required.

Examine: Once all of the facts previously discussed have been gathered, they must then be carefully examined. This is done to ensure that nothing that affects the layout has been missed; remember it will be too late once the plan is drawn, and also to see what factors have an interrelationship, ie, can we position machines where we want, irrespective of where the power source is, or does the location of the pressing section depend on where we can locate or steam pipes.
Develop: The next stage in the layout of our factory is to develop and draw the actual plan. It is imperative that we ensure that each department has adequate space for its needs, and an allocation of space to meet any possible expansion in the future. To enable us to meet any possible expansion in the future. To enable us to do this we must prepare a block plan. This is a plan of the actual allocation of floor space to each department, and the relationship of the departments to each other prior to the detailed planning of each section. In the block plan we must ensure that adequate gangways and passages have been left for the flow of work and people, and where possible one department feeds to the next, thereby helping the work flow from department to department.
The next stage is the detailed planning of each department and the positioning of the machinery, tables and equipment etc. that are to be used. Although we now have a detailed scale plan of the factory, a lot of factors still have to be considered before we can draw in the positions of the machinery. Scale templates, preferably of stiff cardboard, should be

made and positioned onto the plan where they are required, use Pre-stick to position the templates. The Factory or Production Manager should be involved as ultimately they are the people responsible for the running of the factory. The mechanic should also be consulted as he/she will have the technical competence to give advice on power supply etc. The supervisors of the departments should be involved, they have to run their sections on a day to day basis. It must always be remembered that the installation of the layout is a disrupting time for employees. When the installation plans are nearing completion, invite employees to come in and see the layout, and identify each department or work station, so that the workers can see where they are going to be situated and invite their comments or opinions. The final step in developing the plans is to make a timetable of the moves and a schedule of how the change is to be implemented.
Install: The next stage is the implementation of the plan. Now the plan has been drawn, the Engineer will usually only act as adviser or coordinator, as the mechanics or maintenance department will be the ones involved in the physical moving of the equipment is positioned exactly where it is intended. This can be helped by marking the floor and machinery with chalk. This is a useful guide for the maintenance crew to position things correctly. NB: It is important to note that only one person should direct a move. If more than one person is giving instructions, confusion will occur.

Section Layout

A previously stated it is very rare the opportunity will arise for an Industrial Engineer to plan the layout of a whole factory. It is highly likely though that he/she will be called upon to reorganize a particular section within the factory to accommodate a style change for example. The rules governing Section Layout are the same as those for the Factory Layout, but on a more detailed scale.
Once again we need to record all the relevant information, firstly about the actual product we will be making:

1. How many styles,
3. Number of components,
5. Size of bundles,
7. What future changes. 2. Production rate,
4. Number and sequence of operations, 6. Any special trimmings,

Secondly about the equipment that we will be using:
1. How many machines required,
3. Power supplies,
5. Spare machines,
7. Lighting,
2. What type of machines 4. Compressed air or steam, 6. Specialized machinery, 8. Future changes or additions.

Lastly we need to record the space available, and again calculate the workable floor space available by taking into account:
1. Gangways, 2. Pillars,
3. Exits and entries, 4. Space between machines.

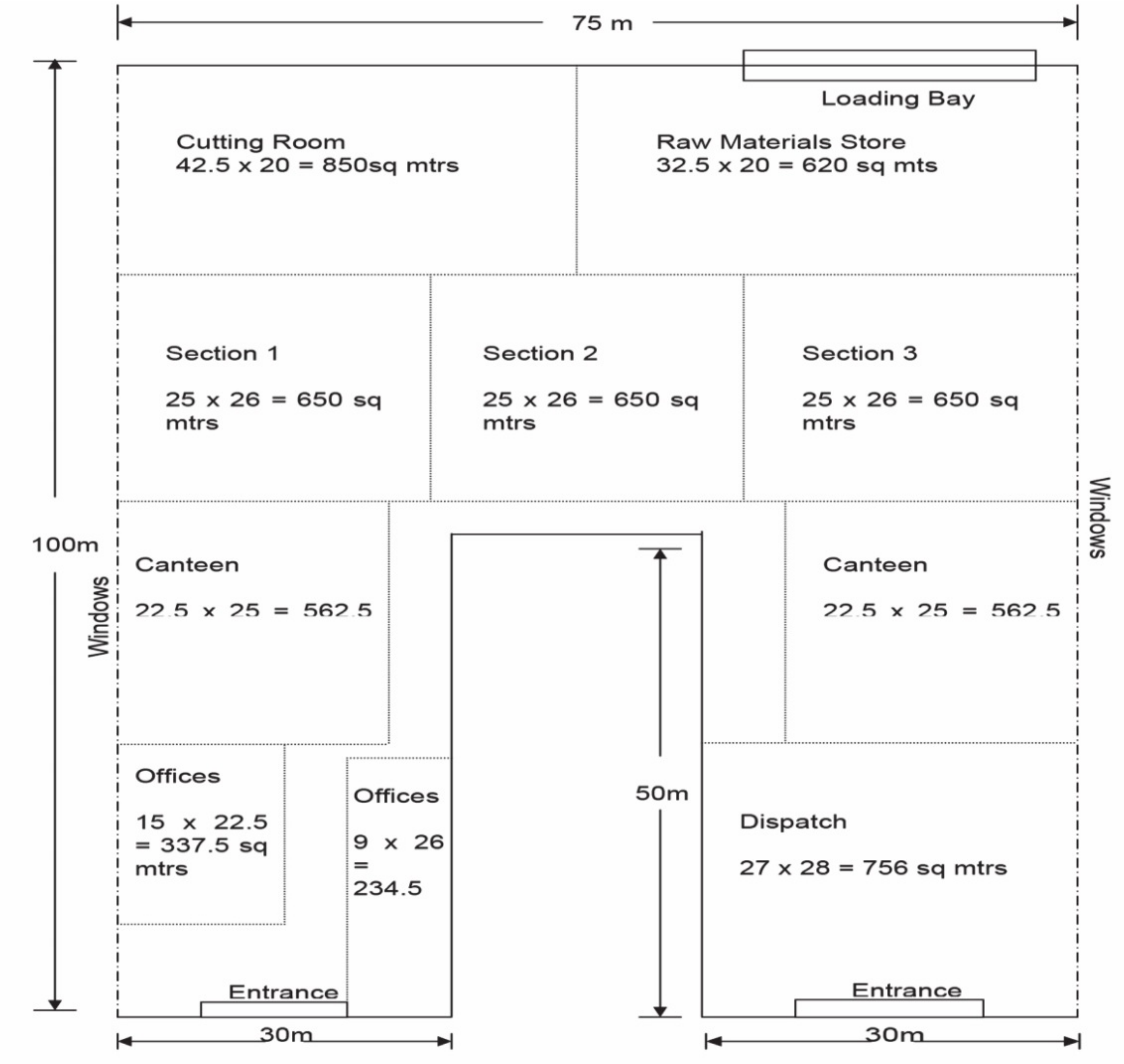
Now we need to develop the plan again. Using templates of the machines is an ideal way for preparation before actually drawing the plan. It must be decided from the start what

type of production system we are going to use. This could be; Make through, Straight line or conveyor system, Conventional Bundle Units (CBU), Progressive Bundle Units (PBU), And if we need tables for matching points how many and of what dimensions. The Production systems in detail will be explained latter sessions.

Install: The implementation of the plan again follows the same rules and procedures as that of the factory only on a smaller scale. Are the managers, supervisors, mechanics, etc., completely familiarized with the change over? Have the machines been marked to where they have to be positioned, and is the power supply available and adequate. When marking machines it is a good idea to number the machines and the floor position. It is important that the operator's chair, cushion and work box and any other items which the operator may use, so that when he/she gets to their work place everything is available for them. This minimizes the effect of moving and helps them to settle more quickly.

Maintain: The maintenance of Section Layout can concern itself with ensuring that all the machines are working properly and, vitally important, is the work flowing from operation to operation as required, are the work in progress levels correct and has the new layout created any unforeseen bottlenecks or disruptions. Work should not be moved to operators. Operators should be moved to the work. This will enable supervisors to see where the work in progress is, and will ensure simpler supervision. It is important to establish a good aesthetic look to a layout, people work better and more efficiently in a well ordered and clean layout.
Example: consider the condition that we are working on a rented building and recently we have purchased a new building and we have to shift the current factory to the next. We have calculated the current space utilization percentage of the factory and the same to be followed to the new one. The data are,

1) Cutting room - 12.59% 2) Raw Material Store - 9.6%
3) 3 Sections each of - 9.6% 4) Canteen - 8.33%
5) Finishing Department - 8.67% 6) Dispatch - 11.2%
7) Offices -8.5% 8) Gangways - 12.31%



Finishi

The below shown is a 2 basic plant layout based on the data,
Calculated as Total Area = 75x 100 = 7500 sq. feet, and its proportionate allocation of each department with respective to its REL strength are allocated.
It is inevitable to prepare the blue prints and models of the plant layout before the actual laying function begins. The location of the machines, equipment and plant facilities is the result of trial and error method. Templates or models represent the actual space requirement for each machine or service department along with its sequential relations.
The popular method of plant layout are, Square layout, Template layout or Two-dimensional layout, Model Layout or three Dimensional Layout etc.
Square Layout is the preliminary layout of the plant. It indicates the total square feet floor area and its allocation among various work stations and the plant facilities on the basis of some appropriate scale. It simply indicates the location of workstation, plant facility and flow patterns of materials. This is the basis for the other two layouts.
Template Layout is the most common method of presenting the plant layout. They are two

dimensional and consider the height of the floor area, generally, cardboard, hard board, colored papers, tapes etc. are used in presenting the building walls, workstations, plant facilities etc. a template is generally prepared to a scale ¼ inch equal to one foot. They are characterized by their transparency. It is cheaper to model layout, it is possible to produce duplicate copies thereof, has clear reading and interpretation. Model layout or three dimensional model are made using models of plant and equipment with their appropriate scale. Generally model layouts are prepared to the same scale as template layout. They are most expensive and very rarely used. These are easy models to explain and provides visual aid and has clean possibility of overhead workstation modeling.
ADLEP (Automated layout Design Program) and CORELAP (Computerized Relationship Layout Designing) are REL based computer programs and CRAFT (Computerized relative Allocation of Facilities planning) minimizes linear function of movements amongst departments and is an improvement program. Also there are lot other software based on these methods GSD, PROSMV etc. have advanced features attached to the core software to do the layout planning.

Material Handling

Material handling is a necessary and significant component of any productive activity. It is something that goes on in every plant all the time. In a manufacturing firm, the raw materials are obtained from the suppliers are stored in the store room. They are issued to production department and are moved inside the plant area from one process to another for the production operations till they became finished products ready to dispatch. For a garment industry, when we consider the total cost, it is about 60% to 80% cost are spent for the fabric itself, and it is moved till the dispatch room through many stages. Very reduction in movement is reduction in cost of manufacturing, hence a proper study should be made before adapting any system.
Material handling means providing the right amount of the right material, in the right condition, at the right place, at the right time, in the right position and for the right cost, by using the right method. It is simply picking up, moving, and lying down of materials through manufacture. It applies to the movement of raw materials, parts in process, finished goods, packing materials, and disposal of scraps. In general, hundreds and thousands tons of materials are handled daily requiring the use of large amount of manpower while the movement of materials takes place from one processing area to another or from one department to another department of the plant. The cost of material handling contributes significantly to the total cost of manufacturing.
In the modern era of competition, this has acquired greater importance due to growing need for reducing the manufacturing cost. The importance of material handling function is greater in those industries where the ratio of handling cost to the processing cost is large. Today material handling is rightly considered as one of the most potentially lucrative areas for reduction of costs. A properly designed and integrated material handling system provides tremendous cost saving opportunities and customer services improvement potential.
It’s a well-known theory: Sewing factories spend 80 percent of their time handling product vs. 20 percent of time sewing, pressing or finishing. If the theory holds true, that means there are only six minutes of productive, value-added work in a 30-minute garment. The other 24 minutes are unproductive, spent moving and manipulating material so that the

productive work can be carried out.
Consider this breakdown of the steps involved in closing of two side seams:

“Material handling is the movement and storage of material at the lowest possible cost through the use of proper method and equipment”

Pick up first part, pick up second part and position two parts together at beginning of seam, place to needle. Sew seam in three bursts (three bursts required to reposition fabric as one sews along the seam). Reposition two pieces together for second seam, place to needle. Sew seam in three bursts (again three bursts to allow for repositioning as one sews). Fold, set aside and book work.

It’s a very simple operation, but immediately one sees that the only productive part is the actual sewing, not the repositioning during the seam, not the picking up and placing of the fabrics to the needle, not the folding and setting aside and not the booking of the work.

Methods of materials handling can substantially increase the ineffective time. For instance, it is not productive to have employees or supervisors whose responsibility it is to move work around to different parts of the factory. Likewise, folding and unfolding work between operations is not productive. Tying up and untying bundles also is a waste of time. Yet many companies continue to perform these activities, which cost money, and therefore drain profitability. They also take time, thus hampering a company’s ability to respond quickly to customer needs and market requirements.
If moving work from one workstation to another is unproductive, the storage of work between operations is even worse. No income can be obtained from that work until it is finished and reaches the customer.

Increasing global competition is forcing manufacturers around the world to look seriously at their methods of production in the quest for ways to turn good quality merchandise rapidly. They are seeking flexible methods that will enable them to react to consumer demands and maintain low work-in-process (WIP) levels. To be able to swiftly change styles in a quick-turn manufacturing environment, companies must embrace market-oriented production. It is vital to master simultaneous handling of different production processes and parallel channeling of styles. From a financial perspective, this business model focuses holistic attention on the cost of delays and the amount of working capital tied up in WIP and stock. In traditional production models, there tends to be more of an isolated focus on labor costs. In their push to be more flexible, some companies are moving toward Toyota Sewing System-style (TSS) quick response methods. In a TSS environment, operators work in teams to finish sewing a single garment, moving between machines and operations and manually passing the garment on to the next operator immediately when she is free to process it. This method results in no WIP between operations, and the operators’ work immediately results in a finished garment.
A 60-minute garment produced by a TSS team should take 60 minutes to move through the TSS sewing unit. For comparison, a 10-minute garment, with a week’s WIP in the sewing room, could take a week to complete.

Another approach to eliminating wasted time and excessive WIP buildup is the use of unit production systems (UPS). These systems eliminate the need for operators to bundle goods or collect or dispose of work, and garments are ergonomically delivered to the

operator’s needle point, ready for sewing. Studies indicate that UPS can change an 80/20 handling to production ratio to 60/40 or better.

It is a good idea to generate work flow and factory floor layout diagrams in analyzing your needs and objectives for a new materials handling system. Your analysis should take into consideration the product mix, fabric types, order size and quality level your factory is making and expects to make in the foreseeable future. Times have changed from when one line could be set up to make one product for eternity. Flexibility is now paramount. Many companies that set up overhead rail systems without bypasses have had to rethink their situations just as much as companies that are still using large bundle trucks to move materials.

Materials Handling Solutions Available

All sorts, shapes and sizes of trucks, bins and boxes from numerous non-clothing industry-specific suppliers. Boxes can be self-stacking or used in combination with temporary storage racking. Trolleys can ease transportation.

A wide variety of sewing room trucks, trolleys and mobile rails with add-on shelves, small-part baskets, etc. Design of these products depends on the type of product to be manufactured. Many incorporate clamps to secure the work in a position to enable machining processes to be carried out with a minimum of handling. Care must be taken in the choice of trucks and trolleys to ensure the wheels are designed not to become clogged with thread, dust and lint from the shop floor.

Numerous different designs of clamps and clips, which can be incorporated into off-the-shelf solutions or in-house developments. The fabric and garment type will dictate what sort of clamp/clip is used, depending on the fabrics or garment’s weight, delicateness, slipperiness and tendency to tear or stretch. Often trials will be required of several types to determine the most suitable.

Floor-mounted conveyors using the live storage, flow line or carousel principle. These conveyors can be powered or manually moveable.

Numerous types of manual overhead hanging systems for progressing single garments, bundles or a combination of both. Although garment parts are normally attached in a hanging position using clamps, some systems cater to flat garments by using a hanging basket for some or all of the process. Although many off-the-shelf systems are available, many companies develop their own in-house solutions, either independently or with the assistance of independent consultants or companies specializing in materials handling.

Different solutions may well be used in different areas of the factory, depending on the product and process. For example, pre-assembly areas may work in lay height, main assembly areas in bundles and finishing departments in singles, each requiring a different method of handling. Whatever solution is chosen, great care must be given to careful planning of the installation and implementation, with adequate and correct training given to all personnel involved. Once the system is up and running, its use must be correctly maintained. Also, operators, supervisors and management alike must not slip back into old methods and habits, or introduce new elements unless there is a good reason for doing so.

Overhead handling systems can ease bottlenecks, some overhead material handling systems used in garment industry are,

Switchtrack: Switchtrack was designed by production engineers for production managers

who wanted to increase output on garment assembly lines and maintain flexibility for style changes. As a manual system, Switchtrack is maintenance free and requires no spare parts, lubrication or electrical power. As with all new systems, it does require initial training, which is provided as part of the installation package. Switchtrack also provides free assistance in layout planning.

Switchtrack uses an overhead aluminum profile suspended on a strong steel frame to carry a chain through the assembly line. The chain, with a series of clips to hold the components, then delivers the work to the operator. The work is delivered at a height that enables the operator to present the main body of the garment to the needle point without the need to remove it from the chain. Any small parts for attachment to the garment can be easily removed from the clip with one hand for sewing to the main component. When the sewing operation is complete, the operator pushes the chain forward for the next operator. As the next operation is not always in layout sequence, the flick of a switch can divert the chain to a bypass facility. This allows flexibility on the line and eliminates potential bottlenecks.

Switchtrack reports that benefits such as the elimination of the need for bundle handling, sorting by numbers and handling pieces that will be attached by someone else add up to productivity improvements of 15 percent to 20 percent. The company reports the system can reduce throughput time by as much as 80 percent, thanks in part to a reduction in rework, better control of workflow and easier access for random inspections. Switchtrack production engineers can introduce new working practices to help maintain high levels of productivity, resulting in a return on investment of less than one year, the firm reports.

Peter Ward : - During the past three years U.K.-based Peter Ward has developed a manual overhead sewing production line (patent pending) and during the latter half of 2003, has been installing it in factories in Morocco, Indonesia, India and Madagascar. The line has two rails, one giving the option to bypass to keep the work flowing. The company points to the following advantages of the system: a special ball clamp unit designed to hold the material is very quick to load and unload and does not mark the material; the carrier is suitable for most garments; and the carrier rotates and can be moved up and down, allowing easy movement from one garment to another. As with other systems, realtime production control may be introduced.

Some comparative studies show a 15 percent increase in output among companies using the Peter Ward system, which like Switchtrack, is a manual system. In addition to sewing rooms, Ward has designed and installed many handling systems in finishing and pressing areas both in the United Kingdom and abroad, especially in Sri Lanka.

Salpomec Ltd.: Salpomec, a supplier of slide tube garment handling systems, specializes in developing and producing garment production, handling, transport and warehousing systems under the name Magic Tube. The Magic Tube enables the movement of garments and their parts without traditional wheeled trolleys or complex technical solutions. The systems are in use in more than 20 countries and in more than 200 companies throughout Europe, the United States and Asia. Salpomec reports that its system supports the kind of production that is based on fast throughput and minimal inventory on site. It reports that its systems are designed to be ergonomic and comfortable for the worker.

The cost of a production system includes not only the conveying system price but also the technical elements required to operate it, such as lights, electrical outlets, pressured air, steam and waste removal. Much savings can be had when the same structure can be utilized for all of these elements as in the case of Salpomec's Magic Tube. The production line solution can be designed as a double-line system with fixed or moveable workstations. It can be fitted on I, U or S shapes, and can be floor, wall or ceiling

supported.
Salpomec's system can accommodate cutting room flow and the need to ship to and from subcontractors. The system can adapt to the needs of cell, small group or whole section production of bundles or units, and special operations can be integrated into the system. Different sizes of clips and clamps are used in hanging cut pieces, garment parts and completed garments onto the Salpomec system's baskets and sliding units. Large pieces are hung by clamp and smaller pieces by clip. The basic principle of the Magic Tube production system is that the bundle, garment pieces and/or garment should not be taken off of the sliding unit, clip or clamp, unless absolutely necessary. If a work stage forces detachment from the basket or the frame, most often the clip or clamp can still be left attached to the bundle or product, again saving handling time.
The Magic Tube production system can enable an increase of 15 percent to 20 percent of overall production in a short time, Salpomec reports.

Eton Systems: - Eton Systems is a supplier of automated UPS, focusing on the sewn products industry. Its headquarters are in Sweden, and the company operates with direct subsidiaries and agents worldwide. Eton UPS is designed to automate materials flow through the production process and minimize materials handling for each sewing operator at his/her workstation. It also incorporates real-time production control, collecting both labor cost and WIP information at the workstation. Users may sort products by different criteria, such as size or color. Production quality can be traced automatically through the manufacturing process.
The Eton system for apparel industries is a flexible material handling system designed to eliminate manual transportation and minimize handling. It increases productivity radically, ensures an optimal working flow and provides time for adding value to your products. Technically the system consists of overhead conveyors with individually addressable product carriers, automatically finding its way to the correct operation. It is monitored by a computer providing all necessary data for measuring and

managing the process optimally. Furthermore, the
system is highly flexible and can rapidly be modified to changes in the production line or the need for expansion.
Eton’s software interfaces with other software, such as systems tracking import and export information. The system also can automatically influence payroll based on productivity data.
The Eton system’s Skills History logs measure the competence of operators. Supervisors can access information regarding which operators can perform what operations and who is best suited to transfer to achieve the optimal balancing of the system/manufacturing process.
Eton’s latest development is a Web-based interface, called the Digital Zone, which enables customers to view production via the Internet from remote locations.
While considering the main objectives of material handling, the primary objective of a material handling system is to reduce the unit cost of production and the other subordinate objectives are:

1. Reduce manufacturing cycle time
2. Reduce delays, and damage
3. Promote safety and improve working conditions
4. Maintain or improve product quality
5. Promote productivity
i. Material should flow in a straight line
ii. Material should move as short a distance as possible
iii. Use gravity
iv. Move more material at one time
v. Automate material handling
6. Promote increased use of facilities
i. Promote the use of building cube
ii. Purchase versatile equipment
iii. Develop a preventive maintenance program
iv. Maximize the equipment utilization etc.
7. Reduce tare weight
8. Control inventory

Ultimately the total cost of material handling must decrease, it is mostly in the,
1) Cost of the material handling equipment, both fixed and operating cost calculated as the cost of equipment divided by the number of units of material handled over the working life of the equipment. 2) Cost of Labour - both direct and indirect associated cost calculated in terms of cost per year unit of material handled
3) Cost of Maintenance of equipment's, damages, lost orders and expanding expenses, also calculated in terms of cost of material handled.
After calculating the industry requirements, where we want to automate (partial of complete production and process line), and its cost, etc. and then a comparison chart of the requirement and return on investment graphs comparison is to be made in detail before installing any new system to a running production line. But while planning a new line it can be planned on ROI time scale based. Now a days Etone® are most used system for its extended applicability and other features etc. where we go for a complete line automation.
Limitations of automated material handling systems: - A good management practice is to weigh benefits against the limitations or disadvantages before contemplating any change. Material handling systems also have consequences that may be distinctly negative. These are:

Additional investment
Lack of flexibility
Vulnerability to downtime whenever there is breakdown
Additional maintenance staff and cost
Cost of auxiliary equipment.
Space and other requirements:

The above limitations or drawbacks of adopting mechanized handling equipment have been identified not to discourage the use of modern handling equipment but to emphasize that a judicious balance of the total benefits and limitations is required before an economically sound decision is made.

Economics of Material Handling

The American Society of Mechanical Engineers (ASME) had developed certain formulas for estimating the economics that are possible with the application of certain equipment to material handling problem. The following factors in the handling cost are taken into account are,

1) A = Percentage allowance on investment
2) B = Percentage allowance for insurance, taxes etc.
3) C = Percentage allowance for maintenance
4) D = Percentage allowance for depreciation and obsolescence
5) E = Yearly cost of power, supplies and others in Dollars
6) S = Yearly saving in direct labour cost in dollars
7) T = Yearly saving in fixed charges, operating charges or burden in dollars
8) U = Yearly saving or earning through increased production in dollars
9) X = percentage of year during which equipment is used
10) I = Initial cost of equipment

Make through, Section, PBS, Synchro, QRS, Modular …

3 Production Systems

A production system comprises both the technological elements (machines and tools) and organizational behavior (division of labor and information flow). Businesses need to design their own production systems this then becomes the focus of analysis, modeling and decision making (also called “configuring” a production system)
A first possible distinction in production systems (technological classification) is between continuous process production and discrete part production (manufacturing).

1) *Process Production* means that the product undergoes physical-chemical transformations and lacks assembly operations, therefore the original raw materials can’t easily be obtained from the final product, examples include: paper, cement, nylon and petroleum products.

2) *Part Production* (e.g. cars and ovens) comprises both fabrication systems and assembly systems. In the first category we find job shops, manufacturing cells, flexible manufacturing systems and transfer lines, in the assembly category we have fixed position systems, assembly lines and assembly shops (both manual and/or automated operations).
Another possible classification is one based on Lead Time (manufacturing lead time vs delivery lead time) Engineer to Order (ETO, Purchase to Order (PTO), Make to Order (MTO), Assemble to Order (ATO), and Make to Stock (MTS). According to this classification different kinds of systems will have different customer order decoupling points (CODP), meaning that Work in Progress (WIP) cycle stock levels are practically nonexistent regarding operations located after the CODP.
Work in process, work in progress, (WIP) goods in process, or in-process inventory are a company’s partially finished goods waiting for completion and eventual sale or the value of these items. These items are either just being fabricated or waiting for further processing in a queue or a buffer storage. The lesser WIP means lesser the material in production.
Most of the production systems employed in clothing factories are derived from manual or mechanical systems. Each production system has its own specific operational characteristics. Some general category of production systems followed in apparel production are as follows,

Make Through Garment System

This is essentially the traditional method of production where one operator assembles the entire garment. In tailoring shops and in some couture, it is common for a tailor to perform nearly every operation required to make the garment, including machining, hand work and pressing.

With this production system the operator would be given a bundle of cut work and would proceed to sew it according to his or her own method of work. Essentially, the labour required by this system must be highly skilled and versatile, a combination which is becoming exceedingly rare and increasingly expensive. This type of system is effective when a very large variety of garments have to be produced in extremely small quantities. A typical application would be in the sewing room of a boutique, which produces its own merchandise.

Advantages
Highly flexible for fashion changes Required little organization
Required little supervision
Job satisfaction
Quick throughput time
Low work in progress
Absenteeism not a problem
Disadvantages

Required very skilled and experience operators and lots of training.
Inefficient workers work to suit themselves.

Little use of work aids.
Productivity is low due to lack of specialization of operation and equipment.
Costs are excessive.
Low operator performance due to variety of operations handled individually

Whole Garment Production System There are two types of Whole Garment Production Systems, Complete whole garment and Departmental whole garment. In the whole garment system one individual makes the entire garment from cutting the cloth to sewing and pressing the garment. The garment is ready for dispatch once the operator completes the final operation. This type of system is used in a few places, which are engaged in custom-wholesale. They are normally high priced and exclusively made for a particular customer. They are limited in number and distribution; normally about 10-20 garments are made.
The departmental whole garment system is also used by custom wholesale manufacturers as well as high price or better dress manufacturers. In the departmental whole garment system one individual does all the work with the equipment allocated to a department. For example, one person does all the cutting work in cutting department, second person does all the sewing work in sewing department, and the third person does the pressing and packing work. The workers in this system may use more than one equipment to complete their respective job.
Advantages

1. This system is more effective when a very large variety of garments have to be produced in extremely small quantities.

2. In Individual piece rate system the operators will do with full involvement: To finish more pieces, to earn more money.
3. Operator will be specialized in his own working area.
4. As the pay depends upon the complication of the operation, the operator will try to finish the complicated operation also without any difficulties.
5. The Work in Progress (WIP) is reduced, at a time one cut garment to one operator and so the amount as inventory is reduced.
Disadvantages

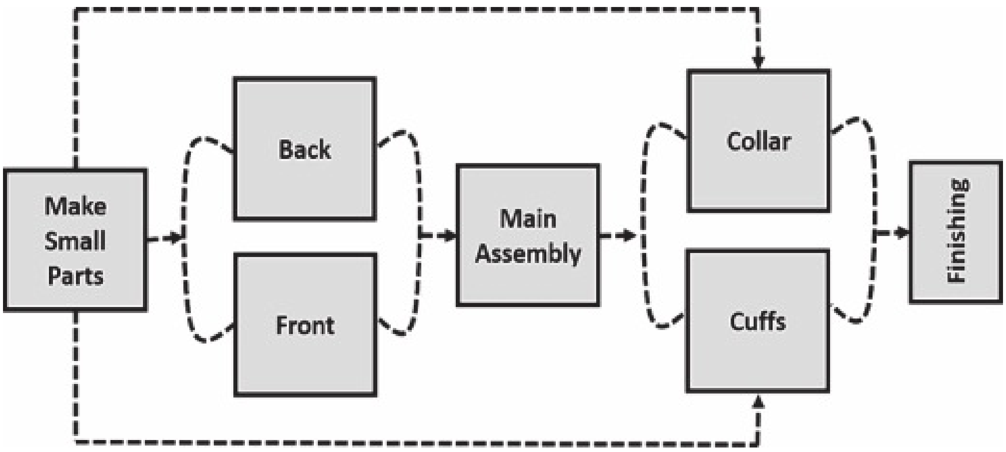
1. Highly skilled laborers are to be used, so the cost of labour is high.
2. The operator is more concerned on the number of pieces finished rather than the quality of work.

3. Productivity is less due to lack of specialization.
4. For long run/bulk quantity of same style is not effective in this system.

Section or Process System - Group System
This is a development of the making through system, with the difference that the operators specialize in one major component and sew it from beginning to end. For example, an operator specializing in fronts would assemble the front, set the pockets, etc. and perform all the operations required to finish that particular component. The sewing room would have a number of sections, each containing versatile operators capable of performing all the operations required for a specific component. The sections are built according to the average garment produced, and include:

o Pre-assembling (the preparation of small parts)
o Component making (front, Back etc.)
o Main assembly (closing, setting collars and

sleeves, etc.)
o Pre Finishing Works (lining, Labeling etc.)
o Finishing operations (buttonholes, blind
stitching, etc.)



All in all, this is a very efficient system for producing a variety of styles in reasonable quantities. Mostly this is suitable for less operations with specified or customized machines are in use.
Advantages

1. As the labour of all levels, i.e., semi-skilled, skilled, trainee can be used in this system, the labour cost is less compared with individual system.
2. Productivity is higher compared to individual system, because of the use of special machine and all types of labour.
3. This system is very efficient for producing a variety of styles in reasonable quantities.
4. Automation and specialization can be done.
5. Absenteeism and machine breakdown problems will not cause serious problems.

Disadvantages

1. All the levels of operators are involved in the work, so the quality of garment should be strictly maintained.
2. Even though productivity is high still the highly skilled operators are required to

perform simple operation within the section.
3. Group of people involved in each section and so we require more WIP, which increases the inventory cost.
4. As this is not a bundling system, there are more chances to mix up of lost, shade variation, sizes, so quality and production will be affected.

Progressive Bundle System - Batch System

The progressive bundle system (PBS) of apparel garments production gets its name from the bundles of garment parts that are moved sequentially from operation to operation. This bundle system, often referred to as the traditional garments production system, has been widely used by garments manufacturers for several decades and still is today. The AAMA Technical Advisory Committee (1993) reported that 80 percent of the apparel manufacturers used the bundle system of garments production. They also predicted that use of bundle systems for garments production would decrease as firms seek more flexibility in their production systems.

Bundles system of apparel production consist of garment parts needed to complete a specific operation or garment component. For example, an operation bundle for pocket setting might include shirt fronts and pockets that are to be attached with garments. Bundle sizes may range from two to a hundred parts. Some firms operate with a standard bundle size of particular garments, while other firms vary bundle sizes according to cutting orders, fabric shading, size of the pieces in the bundle, and the operation that is to be completed. Some firms use a dozen or multiples of a dozen of garments because their sales are in dozens. Bundles of garments are assembled in the cutting room where cut parts are matched up with corresponding parts and bundle tickets.

Bundles of cut parts are transported to the sewing room in the garments and given to the garments operator scheduled to complete the garments production operation. One garments operator is expected to perform the same operation on all the pieces in the bundle, retie the bundle, process coupon, and set it aside until it is picked up and moved to the next operation of garments production. A progressive bundle system of garments production may require a high volume of work in process cause of the number of units in the bundles and the large buffer of backup that is needed to ensure a continuous work flow for all operators in garments.

The progressive bundle system of garments production may be used with a skill center or line layout depending on the order that bundles are advanced through garments production. Each style may have different processing requirements and thus different routing. Routing identifies the basic operations, sequence of garments production, and the skill centers where those garments operations are to be performed. Some garments operations are common to many styles, and at those operations, work may build up waiting to be processed.

The principles of this system are:

○ The various sections are positioned according to main operation sequence, with each section having a layout according to the sequence of operations required to produce a particular component.

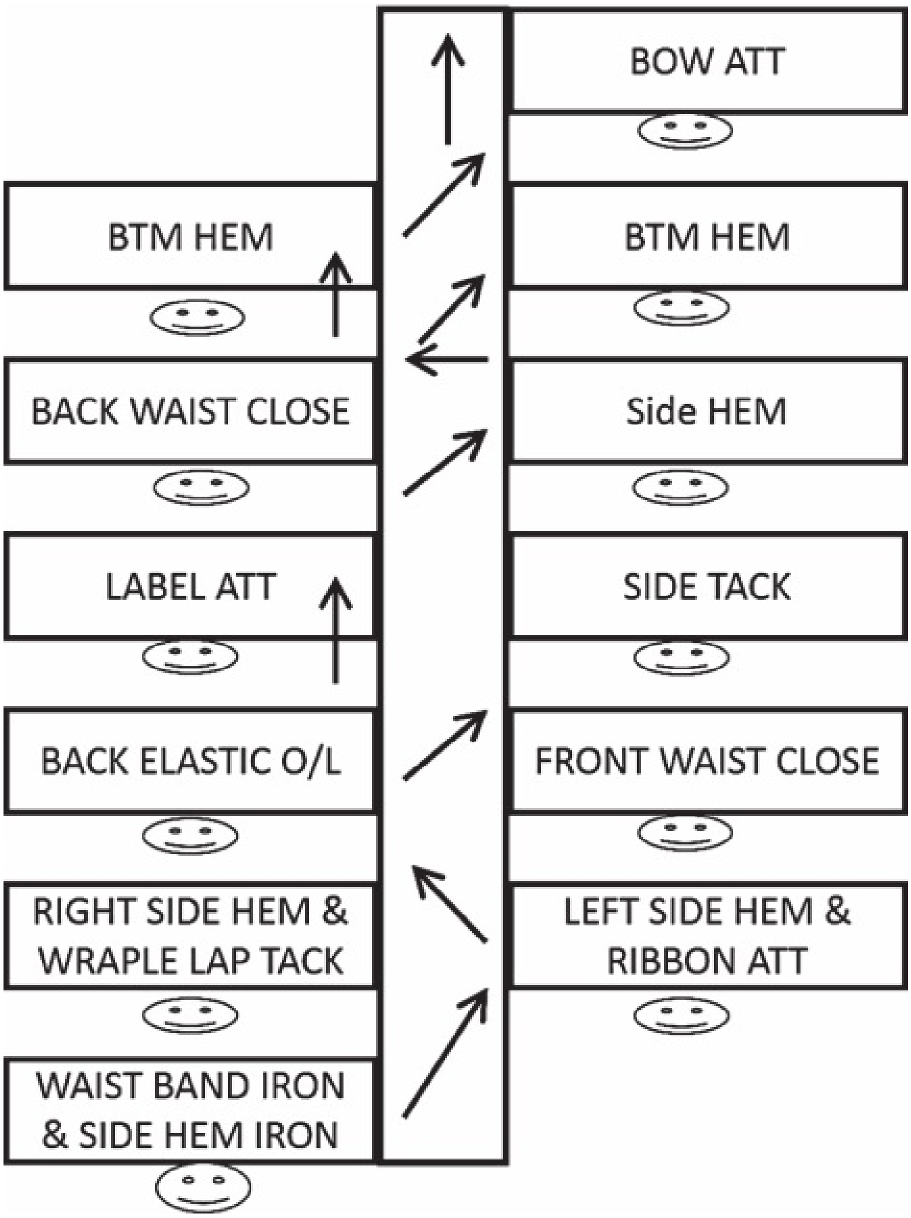
○ The amount of machinery for each operation would be determined by the output required.

○ A work store is positioned at the start and end of every section of these buffers is used to

store work received from a preceding operation, and to hold work completed by that section.
○ Due to these work stores or buffers, each section is not directly dependent on the preceding section, but can absorb slight variations in output via the stocks held within the section.
The progressive bundle system, while being somewhat unwieldy in operation and requiring large quantities
of work in progress (WIP), is probably one of the most stable systems as regards output. Unless there is
serious absenteeism or prolonged special machine breakdowns, most of the usual hold-ups can be
absorbed because of the amounts of work in progress.
Balancing and the changeover to new styles are also somewhat simplified, due to the amount of work held
in reverse. When properly managed, the progressive bundle system is versatile and efficient.

Advantages

1. Labors of all levels, i.e., unskilled, skilled, semi-skilled are involved in this system where the operations are broken into small simple operation. Hence the cost of labour is very low.
2. Here the quantity of each component is checked during the individual operation itself, hence more quality control is possible.
3. The components are moved in bundles from one operation to next operation, so there is less chance for confusion like, lot mix-up, shade variation, size variation, etc.
4. Specialization and rhythm of operation increase productivity.
5. As the WIP is high in this system, this is stable system. Because of the buffer, the breakdown, absenteeism, balancing of line, change of style can be easily managed.
6. An effective production control system and quality control system can be implemented such as, Time study, method study techniques, Operator training program. Use of material handling equipment, such as center table, chute, conveyor, trolley, bins, etc.
7. Bundle tracking is possible, so identifying and solving the problems becomes easy



The success of a bundle production system of garments manufacturing may depend on how the production system is set up and used in a plant. This production system may allow better utilization of specialized garments production machines, as output from one special purpose automated garments machine may be able to supply several garments machine operators for the next operation. Small bundles of garments allow faster throughput unless there are bottlenecks and extensive waiting between operations.

Disadvantages

1. Balancing the line is difficult and this problem can solved by an efficient supervisor.
2. Proper maintenance of equipment and machinery is needed.
3. Proper planning requires for each batch and for each style, which takes a lot of time.
4. Improper planning causes labour turnover, poor quality, less production, etc.
5. Increase in WIP in each section increases the inventory cost.
6. Planned and proper layout should be made to make the system effective, ie, smooth flow of material.
7. Variety of styles & less quantity are not effective in this system.
8. Shuttle operators and utility operators needed in every batch to balance the line effectively. The progressive bundle system of garments production is driven by cost efficiency for individual garments operations. Garments operators perform the same

operation on a continuing basis, which allows them to increase their speed and productivity. Operators of garments who are compensated by piece rates become extremely efficient at one garments operation and may not be willing to learn a new garments operation because it reduces their efficiency and earnings. Individual operators that work in a progressive bundle system of garments production are independent of other operators and the final product. Slow processing, absenteeism, and equipment failure may also cause major bottlenecks within the system. Large quantities of work in process are often characteristic of this type of garments production system. This may lead to longer throughput time, poor quality concealed by bundles of garments, large inventory, extra handling, and difficulty in controlling inventory of garments industry.

Straight-line or 'Synchro' System

As its name suggests, this system is based on a synchronized flow of work through each stage of producing a garment. Time-synchronization is the most important factor of this system because the flow of work cannot be synchronized if there are considerable variations in the standard times allowed for all the operations performed on the line.

For example, if one operation has a value of 1.5 minutes SAM, then all the other operations in the line must have the same, or a very close, value. The manipulation required to balance the standard time for each operator can sometimes lead to illogical combinations of whole or part operations which are not always conducive to the overall efficiency of individual operators.

The Synchro system by its very nature is rigid and particularly vulnerable to absenteeism and machine breakdowns. At all times reserve operators and machines must be available to fill the gaps. In addition, this system requires a sufficient volume of the same type of garment to keep the line in continuous operation.

Advantages

1. It's very rigid in nature, & particularly vulnerable to absenteeism & machine breakdowns
2. Line balance is very important here labour or high skills are required, to maintain the line balance
3. the productivity is very high, because of regular pace of operations
4. work in progress will be very short
5. layout is very simple as in a straight line

Disadvantages:-

1. The system is very rigid
2. The absenteeism & breakdown of machine will be serious issue
3. All the time reserve operators & machines should be kept for this process
4. The SAM should me within the minimal range, hence not suitable for complex garments.

Unit Production System (UPS)

A unit production system (UPS) of garments production is a type of line layout that uses an overhead transporter system to move garment components from work station to work station for assembly. All the parts for a single garment are advanced through the production line together by means of a hanging carrier that travels along an overhead conveyor. The overhead rail garments production system consists of the main conveyor and accumulating rails for each work station of garments. The overhead conveyor operates

much like a railroad track. Carriers are moved along the main conveyor and switched to an accumulating rail at the work station where an operation is to be performed. At the completion of an operation the operator presses a button, and the carrier moves on to the next operation.

Most unit production systems of garments production are linked to a computer control center that routes and tracks production and provides up-to-the-minute data for management decisions. The automatic control of work flow sorts work, balances the line, and reduces claims of favoritism in bundle distribution in garments production. Electronic data collection provides payroll and inventory data, immediate tracking of styles, and costing and performance data for prompt decisions.

Processing begins at a staging area in the sewing room of garments. Cut parts for one unit of a single style are grouped and loaded directly from the staging area to a hanging carrier. Loading is carefully planned so minimal handling is required to deliver garment parts in precisely the order and manner that they will be sewn. When possible, garments operations are completed without removing the parts from the carrier. Varied sizes and types of hanging carriers are available for different types of garments products. Automated garments handling replaces the traditional garments production system of bundling, tying and untying, and manually moving garment parts. Unit production systems eliminate most of the lifting and turning needed to handle bundles and garment parts.

The need for bundle tickets and processing operator coupons is also eliminated when an integrated computer system monitors the work of each garments operator. Individual bar codes or electronic devices are embedded in the carriers and read by a bar code scanner at each workstation and control points in garments factory. Any data that are needed for sorting and processing such as style number, color shade, and lot can be included.

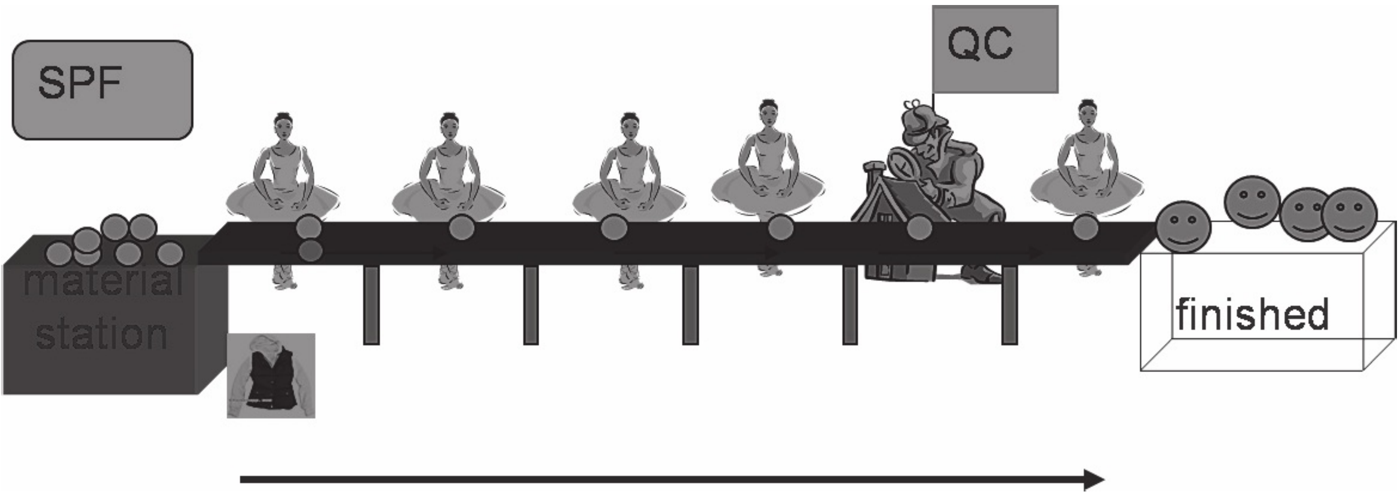
Integrated garments production systems have on-line terminals located at each work station to collect data on each operation. Each garment operator may advance completed units, reroute units that need repair or processing to a different station of garments, and check their efficiencies and earnings. Garments operator may signal for more inventory or call for a supervisor if assistance is needed. The terminals at each station enables central control center to track each unit at any given moment and provide garments management with data to make immediate decisions on routing and scheduling.

Garments operators of the UPS control center can determine sequences of orders and colors to keep operators supplied with work and to minimize change in equipment, operations, and thread colors. A unit garments production system can control multiple routes and simultaneous production of multiple styles without restructuring production lines in garments. The control center may perform routing and automatic balancing of work flow, which reduces bottlenecks and work stoppages. Each operator as well as the control center is able to monitor individual work history. Data can be collected on the amount of time an garments operator works, time spent on each individual unit, number of units completed, the operator who worked on each unit, and the piece rate earned for each unit in garments. The system of garments production will calculate the earnings per hour, per day, and the efficiency rate of each garments operator.

As a mechanical system this has been in use for many years, but a major advance was made in 1983 when computers were first used to plan, control and direct the flow of work through the system. The essential features of this type of system are:

1. The unit of production is a single garment and not bundles.

2. The garment components are automatically transported from workstation to work station according to a pre-determined sequence.
3. The work stations are so constructed that the components are presented as close as possible to the operator's left hand in order to reduce the amount of movement required to grasp and position and component to be sewn.
The operational principles are, all the components for one garment are loaded into a carrier at a workstation specially designed for this purpose. The carrier itself is divided into sections, with each section having a quick-release clamp, which prevents the components from falling out during movement through the system. When a batch of garments has been loaded into carriers they are fed past a mechanical or electronic device, which records the number of the carrier and addresses it to its first destination. Some of the more intelligent systems address the carriers with all the destinations they will have to pass through to completion. The loaded carriers are then fed onto the main powered line, which continually circulates between the rows of machines. This main, or head, line is connected to each workstation by junctions, which open automatically if the work on a carrier is addressed to that particular station. The carrier is directed to the left side of the operator and waits its turn along with the other carriers in the station. When the operator has completed work on one carrier, a push button at the side of the sewing machine is pressed and this actuates a mechanism, which transports the carrier back to the main line. As one carrier leaves the station, another is automatically fed in to take its place. When the carrier leaves the station it is recorded on the data collection system, and then addressed to its next destination.



Unit Production Basic Diagram

Unit Production System requires substantial investments, which are not always justified by conventional payback calculations. Apart from the measurable tangible benefits, UPS also have many intangible benefits such as a more orderly and controlled flow of work, and the ability via the control computer of simulating the production situation some time in advance. These intangibles are difficult to measure, but in themselves make a very positive contribution to the overall viability of the unit.
All things considered, unit production systems have major advantages over all the other manual and the mechanical systems used for the mass production of clothing. Most importantly, they provide a clothing factory with the capability to respond quickly to any changes, which might occur. In the fast moving fashion business, this is essential.
Advantages

1. Bundle handling completely eliminated.
2. The time involved in the pick-up and disposal is reduced to minimum.
3. Output is automatically recorded, eliminates the operator to register the work.
4. The computerized systems automatically balance the work between stations.
5. Up to 40 styles can be produced simultaneously on one system.

Benefits of a unit garments production system depend on how a production system is used and the effectiveness of management. Throughput time in the sewing room can be drastically reduced when compared to the progressive bundle system of garments production because works in process levels are reduced. Garments operator productivity increases. Direct labor costs are reduced because of prepositioned parts in the carriers and elimination of bundle processing. Indirect labor costs may be reduced by elimination of bundle handling and requiring fewer supervisors. Quality is improved because of accountability of all garments operators and immediate visibility of problems that are no longer concealed in bundles for extended periods of time. The central control system in garments production makes it possible to immediately track a quality problem to the operator that completed the operation. Other benefits that are realized are improved attendance and employee turnover and reduced space utilization.

Disadvantages
1. Unit production system requires high investments.
2. The payback period of the investment takes long time.
3. Proper planning is required to be effective.

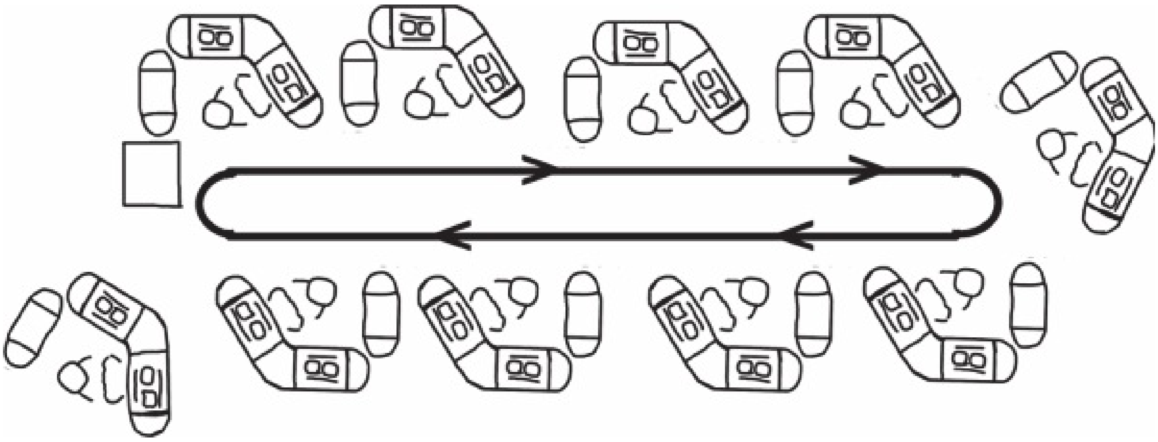
Considerations for installing a UPS include costs of buying equipment, cost of installing, specialized training for the production system, and prevention of downtime. Down time is a potential problem with any of the garments production systems, but the low work in process that is maintained makes UPS especially vulnerable

Quick Response Sewing System (Just in Time)

Shorter lead times improve quality, reduce cost and eliminate non-value-added waste within the organization while simultaneously increasing the organization's competitiveness and market share by serving customers better and faster. The time-based framework of QRM accommodates strategic variability such as offering custom-engineered products while eliminating dysfunctional variability such as rework and changing due dates. For this reason, companies making products in low or varying volumes have used QRM as an alternative or to complement other strategies such as Lean Manufacturing, Total Quality Management, Six Sigma or Kaizen.

This system was first developed in Japan to enable quick responses to be made to market changes, especially when orders for individual styles were in small lots. Each workstation is equipped with two or four machines and the operator will take the garment through the required operations, including pressing, before it is transported to the next workstation. Some of the basic machinery is duplicated in different stations and if there is a bottleneck in one section the overload is automatically transported to other stations where operator capacity is available. All the parts of one garment are loaded into a hanging clamp attached to the trolley and in theory, there should only be one garment at each workstation. Work is transported by a computer controlled, overhead trolley system and each station has an individual controller, which provides the operator with information on the style being worked on. This information comes from an information card, which accompanies

each trolley.
A less sophisticated version of QRS uses a wheeled trolley, which contains the components for one garment and is pushed along the floor from operator to operator.
Another feature of QRS is that all the operator's work in a standing position so that they can move quickly from one machine to another within their own workstation. Machine heights are adjusted accordingly and touch pads and knee-pads controls are used instead of conventional foot pedals.



Features

○ Supervision: Free to work with the operators.
○ Labour: Of necessity the operators must be highly skilled in the operation of all the different machines in one workstation.

○ Quality: In-process inspection stations are built into the line and the inspector is able to return faulty work via the system to the operator concerned.
○ Productivity: This is very high because the operator handles the garment once only for a number of operations, instead of once for each operation.
○ Throughput time: As there are so few garments on the line throughput time is extremely short, which is the objective of this system.
○ Layout: A typical unit would have eight work stations arranges around the transport system.

QRM requires four fundamental structural changes to transform a company organized around cost-based management strategies to a time-based focus:

Functional to Cellular: Functional departments must be dissolved. In their place, QRM cells become the main organizational unit. QRM cells are more flexible and holistic in their implementation compared to other cell concepts, and can be applied outside the shop floor

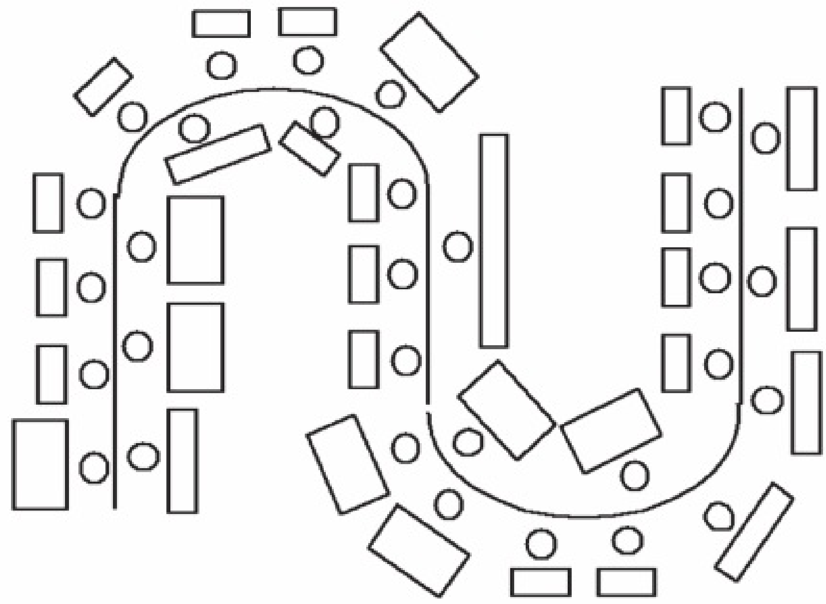
Top-down Control to Team Ownership: Top-down control of processes by managers and supervisors in departments needs to be transformed to a decision-making structure in which QRM cells manage themselves and have ownership of the entire process within the cell

Specialized Workers to a Cross-trained Workforce: Workers need to be trained to perform multiple tasks.

Efficiency/Utilization Goals to Lead Time Reduction: To support this new structure, companies must replace cost-based goals of efficiency and utilization with the overarching goal of lead time reduction
There is no doubt that this type of system is one of the best answers to the garment production revolution,
which is becoming more apparent every day. Fashion changes are becoming more frequent and as a
consequence order lots are proportionately smaller. A production system, which enables changeovers to
be made in the minimum of time is ideally suited to this new and dynamic situation.

Modular Production System

A modular garments production system is a contained, manageable work unit that includes an empowered work team, equipment, and work to be executed. Modules frequently operate as mini factories with teams responsible for group goals and self-management. The number of teams in a plant varies with the size and needs of the firm and product line in garments. Teams can have a niche function as long as there are orders for that type of garments product, but the success of this type of garments operation is in the flexibility of being able to produce a wide variety of products in small quantities in garments. Many different names are currently used to identify modular garments production systems, including modular garments manufacturing, cellular garments manufacturing units, compact work teams, flexible work groups, self-directed work teams, and Toyota Sewing System (TSS) in garments. The basic premise is similar among these production systems, although the organization and implementation may vary. The modular system was first implemented at company Toyota in 1978 as part of JIT, and was known in the 1980s in the West as the Toyota Sewing System. Monden in 1998 gave this system a U-turn layout and claimed that the main advantage of that system was that the amount produced can easily be arranged by changing the number of operators working in the system. The modular system works on the principle of pull-type production systems, in which the job order comes from the last step to previous steps. Because of this, the amount of work in process is low, even working when no inventory is possible.

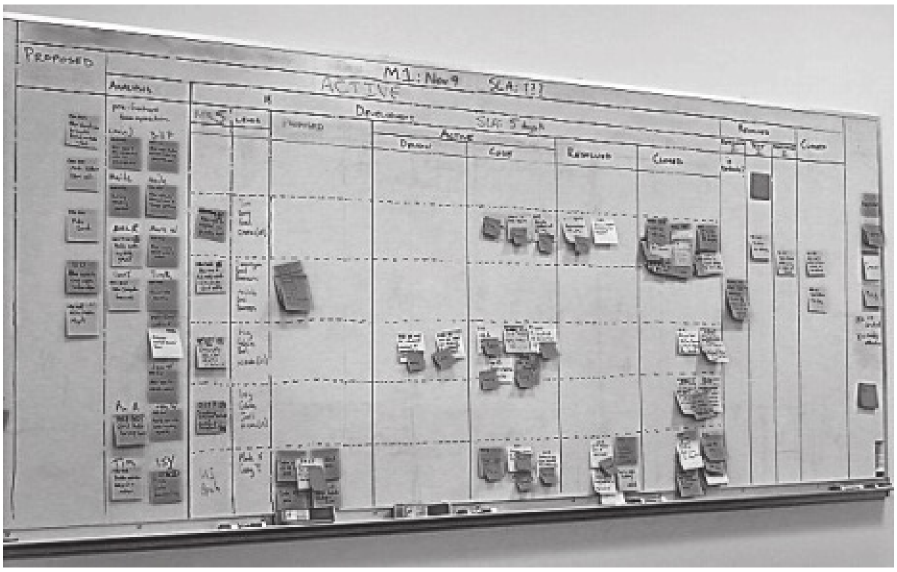


The number of employees on a team, usually 4 to 15, varies with the product mix. A general rule of thumb is to determine the average number of operations required for a style being produced and divide by three. Team members cross-trained and interchangeable among tasks within the group. Incentive compensation is based on group pay and bonuses for meeting team goals for output and quality. Individual incentive compensation is not appropriate for team-based garments production. Teams may be used to perform all the operations or a certain portion of the assembly operations depending on the organization of the module and processes required. Before a firm can establish a modular production system, it must prioritize its goals and make decisions that reflect the needs of the firm. With a team-based system operators are given the responsibility for operating their module to meet goals for throughput and quality. The team is responsible for maintaining a smooth work flow, meeting production goals, maintaining a specified quality level, and handling motivational support for the team. Team members develop an interdependency to improve the process and accomplish their goals. Interdependency is the relationship among team members that utilizes everyone's strengths for the betterment of the team.

Work flow in modular garments production

A Modular garments Production System operates as a Pull System, with demand for work coming from the next operator in line to process the garment. Wastage is normal, and workflow is continuous and does not wait ahead of each operation. This increases the potentials for flexibility of styles and quantities of products that can be produced. Teams usually operate as 'Stand-up' or 'Sit-down' units. A module may be divided into several work zones based on the sequence of garments operations and the time required for each operation. A work zone consists of a group of sequential garment operations. Operators are trained to perform the operations in their work zone and adjacent operations in adjoining work zones so they can move freely from one operation to another as the garment progresses. Work flow within a module may be with a Single-piece hand-off, Kanban (a system to control the logistical chain from a production point of view, and is an inventory control system. Kanban was developed by Taiichi Ohno, an industrial engineer at Toyota, as a system to improve and maintain a high level of production.), or Bump-back

system. If a single-piece hand-off is used, machines are arranged in a very tight configuration. As soon as an operation is completed the part is handed to the next operator for processing. Operations need to be well balanced as there is usually only one garment component between each operation. Some modules may operate with a buffer or small bundle of up to ten pieces of work between operators. If a small bundle is used, an operator will complete the operation on the entire bundle and carry the bundle to the next operation. An operator may follow a component or bundle for as many operations as they have been trained or until the adjacent operator is ready to assume work on the bundle. A Kanban uses a designated work space between operations to balance supply with demand. The designated space will hold a limited number of completed components (two or three) in queue for the next operation. If the designated space is full, there is no need to produce more until it is needed or the space empties. This limits buildup of product ahead of the next operation. When the space is full the operator can assist with other operations that may be slow. A kanban board prepared for production is shown here.



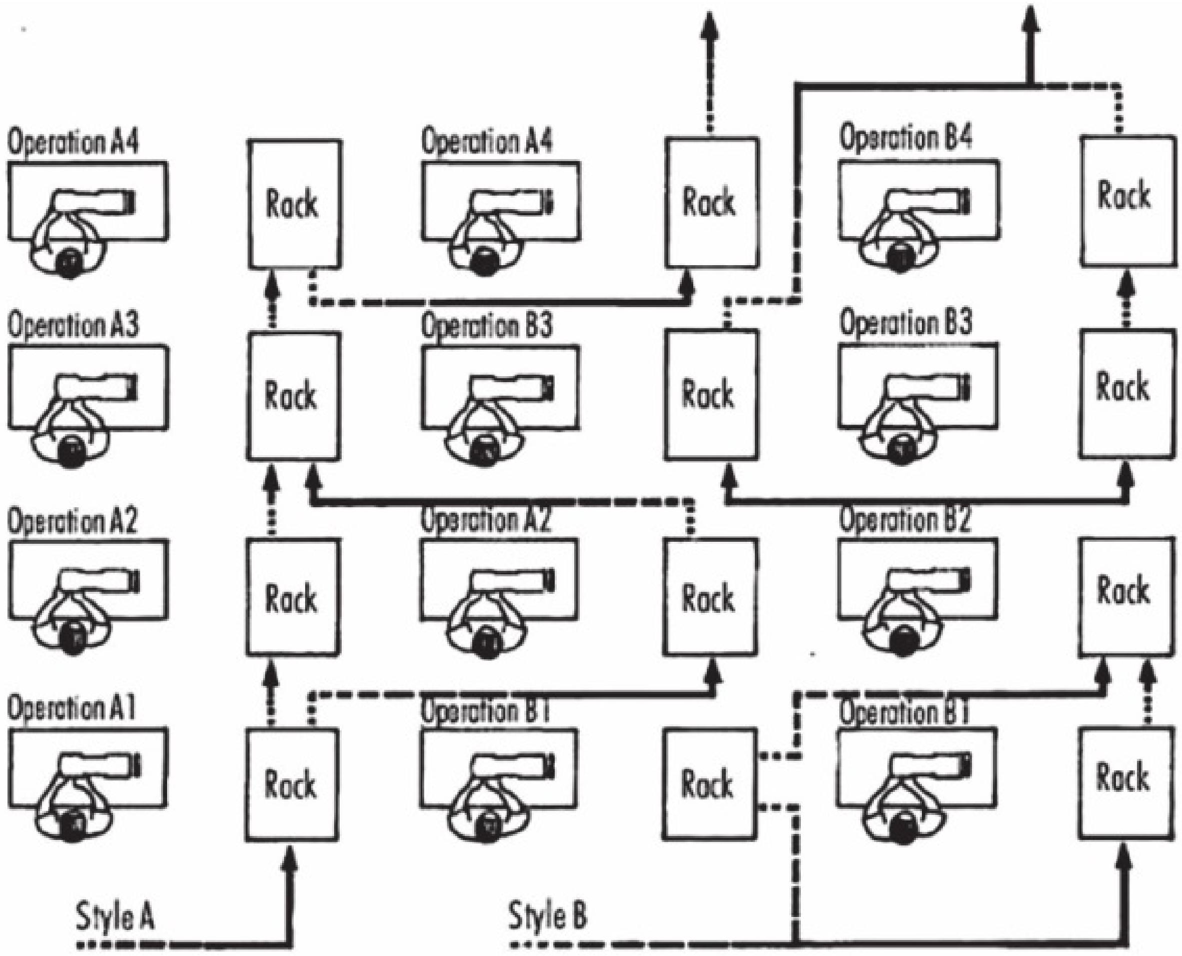
The bump-back or TSS (Toyota Sewing System) approach was developed by the Toyota Sewn Product Management System and is probably the most widely used type of team-based manufacturing. It is a stand-up module with flexible work zones and crosstrained operators. Operators may be cross-trained on up to four different successive operations. This enables operators to shift from operation to operation until the next operator is ready to begin work on the garment. The operator needing work steps to the beginning of the zone and takes over the processing at whatever point it is in the production process. The operator who has been relieved of the garment will then move back to the beginning of the work zone and take over work on another garment. This approach enables continuous work on a garment and allows each operator to perform several different operations. This arrangement frequently uses a 4-to-l ratio of machines to operators.

Advantages
High flexibility

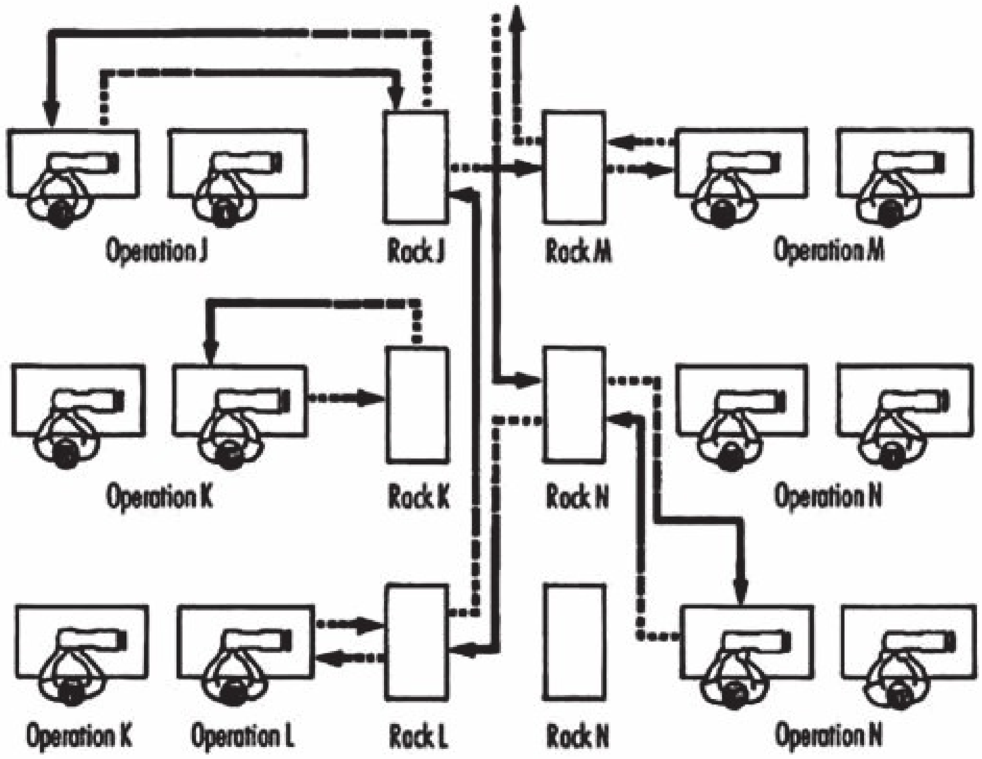
Fast throughput times
Low wastages
Reduced Absenteeism
Reduced Repetitive Motion Ailments
Increased employee ownership of the production process Empowered employees
Improved Quality
Disadvantages

A high capital investment in equipment. High investment in initial training. High cost incurred in continued training

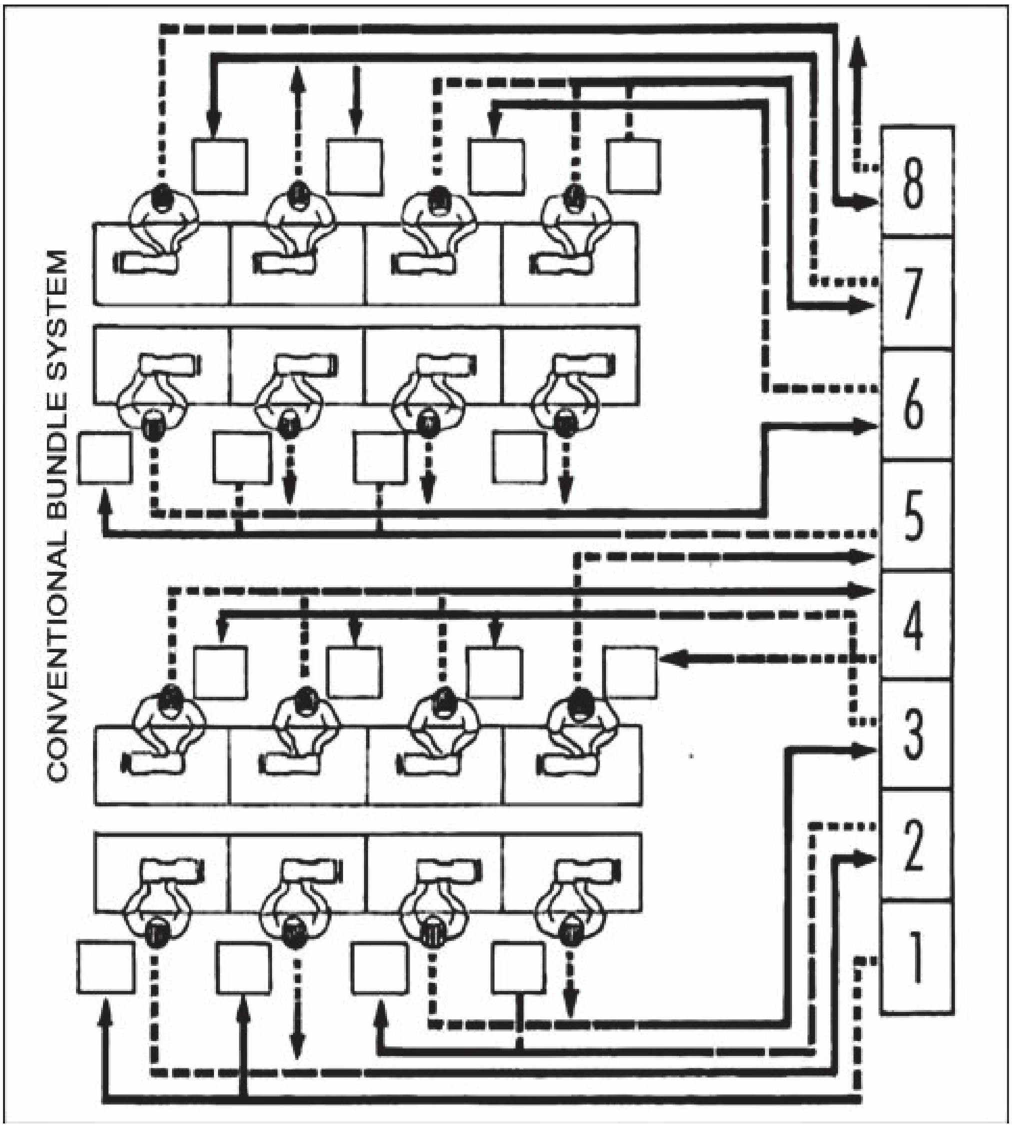
Any production system has four primary factors, which make up the system. Processing Time + Transportation Time + Temporary Storage Time + Inspection Time = Total Production Time. Processing time is sum total of working time of all operations involved in manufacture of a garment. Transportation time involves the time taken to transport semi-finished or finished garments from one department to another or from one operation/machine to another. Temporary storage time is time during which the garment/bundle is idle as it waits for next operation or for completion of certain parts. Inspection time is time taken for inspecting semi-finished garments for any defects during manufacturing or inspecting fully finished garments before packing.
The main aim of any production system is to achieve minimum possible total production time. This automatically reduces in-process inventory and its cost. The sub-assembly system reduces temporary storage time to zero by combining temporary storage time with transportation time.
Hence, while considering all these aspects the production system, layout, material flow etc. will closely related to the product, skill level of workers, frequency of style change etc. has to be included while deciding the system. Some possible common layout options are illustrated below for reference.



FLEXIBLE FLOW SYSTEM



INTERFlOW PRODUCTION SYSTEM



Combinations of Garments Production Systems

Some firms may use the progressive bundle system for producing small parts combined with modular production for garment assembly. This reduces the investment in specialized equipment and reduces the team size needed. Some industry consultants believe that a modular system combined with a unit production system provides the most flexibility, fastest throughput, and most consistent quality. This would be particularly useful for large items such as coveralls or heavy coats. The UPS would move the garment instead of the operators. Each manufacturer needs to determine what is best for its product line and production requirements.

Capacity, utilization, required, load etc.

4 Capacity Planning

Capacity planning is the process of determining the production capacity needed by an organization to meet changing demands for its products. In the context of capacity planning, design capacity is the maximum amount of work that an organization is capable of completing in a given period. Effective capacity is the maximum amount of work that an organization is capable of completing in a given period due to constraints such as quality problems, delays, material handling, etc.
A discrepancy between the capacity of an organization and the demands of its customers results in inefficiency, either in under-utilized resources or unfulfilled customers. The goal of capacity planning is to minimize this discrepancy. Demand for an organization's capacity varies based on changes in production output, such as increasing or decreasing the production quantity of an existing product, or producing new products. Better utilization of existing capacity can be accomplished through improvements in overall equipment effectiveness (OEE). Capacity can be increased through introducing new techniques, equipment and materials, increasing the number of workers or machines, increasing the number of shifts, or acquiring additional production facilities.

Capacity is the ability of a systems potential for producing goods or delivering services over a specific time interval. The capacity decisions within a company are very important because they help determine the limit of output and provide a major insight to determining operating costs. Basic decisions about capacity often have long term consequences and this chapter explains the ramifications of those choices. When considering capacity planning within a company, three key inputs should be considered. The three inputs are the kind of capacity to be determined, how much of the products will be needed, and when will the product be needed.

The most important concept of capacity planning is to find a medium between long term supply and capabilities of an organization and the predicted level of long term demand. Organizations also have to plan for actual changes in capacity, changes in consumer wants and demand, technology and even the environment. When evaluating alternatives in capacity planning, managers have to consider qualitative and quantitative aspects of the business. These aspects involve economic factors, public opinions, personal preferences of managers.
Excess capacity arises when actual production is less than what is achievable or optimal for a firm. This often means that the demand in the market for the product is below what the firm could potentially supply to the market. Excess capacity is inefficient and will cause manufacturers to incur extra costs or lose market share. Capacity can be broken down in two categories: Design Capacity and Effective Capacity: refers to the maximum designed service capacity or output rate. Effective capacity is design capacity minus personal and other allowances. Product and service factors effect capacity tremendously. When selecting a measure of capacity, it is best to choose one that doesn't need updating. When dealing with more than one product, it is best to measure capacity in terms of each product.

For example, the capacity of a firm is to either produce 100 Trouser or 75 Shirts. This is less confusing than just saying the capacity is 100 or 75. Another method of measuring

capacity is by referring to the availability of inputs. Note that one specific measure of capacity can't be used in all situations; it needs tailored to the specific situation at hand.

Determinants of Effective Capacity

Facilities: - The size and provision for expansion are key in the design of facilities. Other facility factors include locational factors (transportation costs, distance to market, labor supply, and energy sources). The layout of the work area can determine how smoothly work can be performed. Product and Service Factors: - The more uniform the output, the more opportunities there are for standardization of methods and materials. This leads to greater capacity.
Process Factors: - Quantity capability is an important determinant of capacity, but so is output quality. If the quality does not meet standards, then output rate decreases because of need of inspection and rework activities. Process improvements that increase quality and productivity can result in increased capacity. Another process factor to consider is the time it takes to change over equipment settings for different products or services.
Human Factors: the tasks that are needed in certain jobs, the array of activities involved and the training, skill, and experience required to perform a job all affect the potential and actual output. Employee motivation, absenteeism, and labor turnover all affect the output rate as well. Policy Factors: Management policy can affect capacity by allowing or not allowing capacity options such as overtime or second or third shifts.
Operational Factors: Scheduling problems may occur when an organization has differences in equipment capabilities among different pieces of equipment or differences in job requirements. Other areas of impact on effective capacity include inventory stocking decisions, late deliveries, purchasing requirements, acceptability of purchased materials and parts, and quality inspection and control procedures.
Supply Chain Factors: Questions include: What impact will the changes have on suppliers, warehousing, transportation, and distributors? If capacity will be increased, will these elements of the supply chain be able to handle the increase? If capacity is to be decreased, what impact will the loss of business have on these elements of the supply chain?
External Factors: Minimum quality and performance standards can restrict management's options for increasing and using capacity.
Inadequate planning can be a major limiting determining of effective capacity.

The most important parts of effective capacity are process and human factors. Process factors must be efficient and must operate smoothly, if not the rate of output will dramatically decrease. Human factors must be trained well and have experience, they must be motivated and have a low absenteeism and labor turnover. In resolving constraint issues, all possible alternative solutions must be evaluated. This is possible by using CVP analysis and the Break-Even Point formula

Steps in the Capacity Planning Process

1. Estimate future capacity requirements
2. Evaluate existing capacity and facilities and identify gaps
3. Identify alternatives for meeting requirements
4. Conduct financial analyses of each alternative
5. Assess key qualitative issues for each alternative
6. Select the alternative to pursue that will be best in the long term

7. Implement the selected alternative
8. Monitor results

Factory Production Capacity: - is derived from the resources available at the manufacturing plant. It is calculated simply by the amount of machines available and hours per day determined to work to be realistic, one has to determine the efficiency level of the operators and incorporate the percentage to derive actual capacity.
Example: if a factory has 100 machines and working hours are 8 hours per day and 26 days per month. The efficiency level of operators is observed to be at 80%, the production capacity available time per month would be calculated as below:

Available monthly production time capacity: 100 machines x 480 Min x 80 / 100
= 38400 Min / day. 38400 Min x 26 days
= 998400 Min /month or 16640 hours/month

Special Machine Production Capacity : - Once planning production, it has to be known that if any special operation is required within the garment which require special machine or machines. If so, the output capacity for those garments have to be based upon special machine production. The management can then decide if those machines be worked overtime or if required to meet shipment date, additional machines be purchased.
For Example, To calculate special machine capacity per month , the available machines are 10 , work hours /day are 8 hours , efficiency level is 80% and working days per month is 26 days. Special production capacity in time / month = 10 machines x 480 Min x 80 / 100

= 3840 Min / day 3840 Min x 26 days = 99840 Min / month or 1664 hours /month.
Maximum Capacity: Total hours available under normal conditions in a given period of time. *Potential Capacity:* Maximum capacity adjusted for efficiency.
Committed Capacity: Total hours previously allocated for production during a certain time period.

Available Capacity: Difference between potential capacity and committed capacity for a certain time period.
Required Capacity: Sam or SAH necessary to produce a specified volume in a certain time period *Excess Capacity:* Difference between potential capacity and required capacity.

For better understanding of these, let us work out a data. Let’s say ABC Garments Company has 20 operators who work 8 hours a day. The plant has 90% efficiency level. Working shift is 8 hours a day in which 1 hour is mainly for lunch and tea time break. So, their Potential capacity for next 10 days will be, Potential production hours /day.

Potential capacity for a day Potential capacity for 10 days = 20 machines x 7 hours /day = 140 hours/day = 140 hours p day x 90% efficiency
= 10 days x 126 hours = 1260 hours potential capacity.

A Sale brings in order for 10000 units of style “ax” that needs to be delivered in 10 days. The plant already has a committed capacity of 600 hours for the 10 days period. It was established that style “a” has a production time of 5 SAM. So their required capacity for 10000 units will be;

5 SAM /unit x 10000 units Capacity required
Currently Available capacity Available capacity

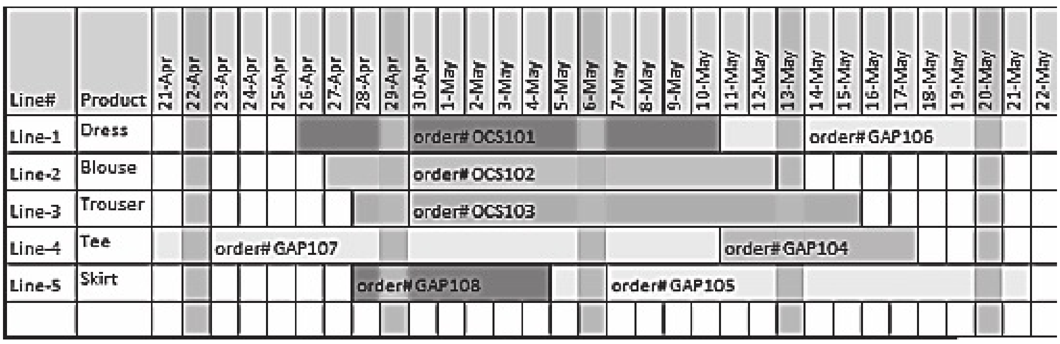
= 50,000 SAM or
= 50,000 / 60 min = 833 SAH to complete the order. = potential capacity – committed capacity
= 1260 hours – 600 hours
= 660 hours available

Let us check with some other details also,
Let’s say ABC Garments Company has 10 operators who work 8 hours a day. The plant has 90% efficiency level. A customer brings in order for 6000 units of style “a” that needs to be delivered in 10 days. The plant already has a committed capacity of 300 hours for the 10 days period. Working shift is 8 hours a day in which 1 hour is mainly for lunch and tea time break. It was established that style “a” has a production time of 5 SAM. The order of 6000 units require 30,000 SAM (500 hours).
What factors should be considered in deciding whether to accept the order or refuse?
Potential capacity of company for the 10 working days = 10 machines x 7 hours /day = 70 hours Potential production hours /day = 70 hours/day x 90% efficiency = 63 PP hours /day Potential capacity for 10 days = 10 days x 63 hours = 630 hours potential capacity. What is required capacity for the 6000 unit order?
Required capacity for the 6000 unit order = 5 SAM /unit x 6000 units = 30,000 SAM
Required capacity in SAH = 30,000/60min =500 SAH to complete the order. Capacity required = 500 hours.

What is available capacity in the plant currently? Available capacity Available capacity = potential capacity – committed capacity = 630 hours – 300 hours = 330 hours available

Is available capacity adequate to accept the order?
Ans. 330 hours of available capacity – 500 hours of required capacity = 170 hours

Capacity is not sufficient to accept order in the same period of time. To process the second order we need additional time, or the shift timings to be elevated as overtime to cover the required 170 hours or increase the machinery.



A planning sheet have to be prepared for each line for effective monitoring of the factory, to find what is available, utilized and balance capacity plotted better.
Utilization if the term used to Measures how much of the available capacity is actually being used, and this directly related to the Return on Investment of the floor. And the effectiveness of the system.

It is necessary to identify the difference between the terms *Design Capacity and Actual Capacity*. The difference between these two should be kept low to obtain maximum ROI, the Design capacity is the maximum output rate under ideal conditions and Effective

capacity is the maximum output rate under normal (realistic) conditions.

Process of Capacity Planning

While doing capacity planning, we should think about Effective capacity, which is the maximum amount of work that an organization is capable of completing in a given period due to constraints such as quality problems, delays, material handling, etc. and the main object kept in mind is to obtain maximum effective capacity possible out of the present situation.

During the various process stages, after environmental analysis we are in a position to predict the available capacity. We then try to prepare alternative capacity plans for our various possible predicted demands or future demands. For the selection of suitable capacity schedule, we will run an economic analysis to decide. *Prediction:* Capacity plans are depended on the demand forecasting for outputs. It is not possible to estimate the long-term demands and other contingencies like act of god or else. Which may not be predictable. But as a rule, mature products are subject to better prediction than the recent launches either in introductory or in growth stages of Product Life Cycle (PLC).

Multiple Outputs: - for a producer factory, there could be many products of different stages of PLC for which demand is to be forecasted. In this case, the total output might not fluctuate as a whole, but individual outputs having different growth rates affects demand fluctuation. Multiple outputs insure us against such uncertainties, especially different brands for each segment results in a better planning for total capacity. “Demand forecasting for a flexible output is easier than that of a specific output of a continuous process or industries.

Long-term demand Forecasting: - while doing long-term forecasting we may use the judgmental methods like Delphi, Executive opinions etc. for the finalization. The past history methods like moving averages, smoothing data etc. may also helpful or a casual forecasting model like regression analysis and econometric models are also used to do. Regression analysis is a forecasting model which relates the dependent variable like sales, pre-production etc. to one or more independent variable like income, construction etc. for example the demand for a wedding saree for new weddings solemnized previous year versus the trend effect of income ranges etc. regression forecasting is a long and costlier process. Econometric forecasting is further improved on regression. It consists of a system of simultaneous regression. For example the demand of soap is function of its price and advertising and the personal disposal income of the customer. Judgmental methods are used when a good data is not readily available.

Marketing research on consumer behavior, product, price distribution and research verifies extremely useful for long-term forecasting. While dealing with multiple outputs, the demand for each is estimated independently and then summed up, heterogeneous products need separate planning for each process or sub process.

Capacity Plans – Size: - To meet the growing demand, a small doe’s capacity is added in frequently. It can be added in anticipation of the growing requirement of can wait till the requirement overtakes the available capacities.

Alternative Capacity Sources: - it is not always necessary to create additional capacity for the growing requirements. We can utilize the facilities intensively, such as doing over time, doing shit working (2 or 3 shifts a day), holiday shifts etc. to get more output. Sometimes we can do sub-contract either in full or in part work load. For a company with continuous process it is not feasible to have more intensive use hence sub-contracting may

be effective. If alternative capacity sources are possible, we can reduce the cost of carrying a high capacity.
Also we have to do a Cost-Volume (CV) Relationship, analysis between fixed costs and variable costs. Economics of Sale, high capacity plans have high fixed cost and low variable cost per unit can offer an economic sale, Lost Sales etc. are to be planned and taken care while doing a capacity plan. The various alternative capacity plans are to be evaluated for consequences in future which is uncertain. The plans have a different set of constraints. Certain effects in future are not easy to quantify. Hence a quantitative and qualitative risk analysis is to be done. A capacity plan is an investment proposal that pays us or makes cash flow over a period of time in future. Hence the future investments are however discounted at a particular rate to get their present value.
Risk Analysis: the actual demand may be higher than the predicted in some times, if higher there will be under capacity and if lower there arises over capacity loses.
Factors favoring over capacity rather than under capacity

1) Building capacity is not so costlier
2) Buying outside is not feasible
3) Lead time to add capacity is long
4) Demand rate approximates to the optimistic prediction

5) Lost sales are viewed very negatively by trading circles, resulting in big incline in demand. Factors favoring addition of capacity on conservative basis

1) Alternative capacity plans are easily available
2) Buildup cost of capacity is low
3) Lead time to build new capacity is short
4) Lost sales have no disastrous results
Some may not be quantified, judgment is taken as to how these affect the position of organization.

Capacity Utilization
Machine Requirements:
For every industry, a substantial part of the financial resources are invested in the plant are machine and equipment. The return of investment is the one required by every investor, and this can be maximized by

i) Making the optimum investment in the plant and machines, and
ii) Making the optimum utilization of the installed production capacity.

Machine requirements deals with the first and line balancing is for second. Machine capacity is generally expressed in terms of machine hours. The number of machines required for the operation is expressed as below,

Where, N = Number of Machines required for the operation
ST = Standard Time per Job for operation in Hrs.
MP = Maximum Production required during the time
UC = Utilization of Machine capacity in percentage

For example, let us calculate the number of machines required for a job requires 6 minutes to do the job, the maximum quantity required is 70,000 pieces per month and the standard capacity of the plant is 200 hr/month with an average utilization of machine 90%.

ST = 6 Min = 6/60Hrs = 0.01 Hrs
= =
= 3.89 units of machine, As the machine is an indivisible then 4 machines are required for the order to process in time.

Line Balancing.

A line is defined as a group of operators under the control of one production supervisor or doing same volume of target.
Line balancing is the equal distribution of work among the workers of a particular line, on the basis of time taken of each operation. Line balancing is a vital key in the efficient running of a line. The object of the process is to “balance the work load” of each operation to make sure that the flow of work is smooth, that no bottlenecks are created and the operators are able to work at peak performance throughout the day. This process is intended to reduce waiting time to a minimum and thereby reducing idle time. Or in fact, with the use of some work in progress to eliminate waiting time completely.
More details are explained in chapter 9.

Utilization.

The available time is the maximum hours we can expect from the work center. However, it is unlikely this will be attained all the time. Downtime can occur due to machine breakdown, absenteeism, lack of material, and all those problems that cause unavoidable delays. The percentage of time that the work center is active compared to the available time is called work center utilization:

Efficiency.

It is possible for a work center to utilize 100 hours a week but not produce 100 standard hours of work. The workers might be working at a faster or slower pace than the standard working pace, causing the efficiency of the work center to be more or less than 100%.

Rated capacity.

Rated capacity is calculated by taking into account the work center utilization and efficiency:

For understanding, A work center consists of four machines and is operated eight hours per day for five days a week. Historically, the utilization has been 85% and the efficiency 110%. What is the rated capacity? Answer

Available time = 4 x 8 x 5 = 160 hours per week
Rated capacity = 160 x 0.85 x 1.10 = 149.6 standard hours
We expect to get 149.6 standard hours of work from that work center in an average week.

Demonstrated Capacity

One way to find out the capacity of a work center is to examine the previous production records and to use that information as the available capacity of the work center. Demonstrated capacity is the average capacity achieved over past years.

Capacity Required (Load)

Capacity requirements are generated by the priority planning system and involve translating priorities, given in units of product or some common unit, into hours of work required at each work center in each time period. This translation takes place at each of the

priority planning levels from production planning to master production scheduling to material requirements planning. Figure 5.2 illustrates this relationship. The level of detail, the planning horizon, and the techniques used vary with each planning level. In this text, we will study the material requirements planning/capacity requirements planning level.
Determining the capacity required is a two-step process. First, determine the time needed for each order at each work center; then, sum up the capacity required for individual orders to obtain the load.

Time Needed for Each Order

The time needed for each order is the sum of the setup time and the run time. The run time is equal to the run time per piece multiplied by the number of pieces in the order.
Example Problem.
A work center is to process 150 units of gear shaft SG 123 on work order 333. The setup time is 1.5 hours, and the run time is 0.2 hours per piece. What is the standard time needed to run the order? Answer

Total standard time = setup time + run time
= 1.5 + (150 x 0.2)
= 31.5 standard hours

In the previous problem, how much actual time will be needed to run the order if the work center has an efficiency of 120% and a utilization of 80%?
Answer

Capacity required = (actual time) (efficiency) (utilization)
Actual time = Capacity required / (efficiency x utilization)
= 31.5 / (1.2 x 0.8)
= 32.8 Hr.

Load

The load on a work center is the sum of the required times for all the planned and actual orders to be run on the work center in a specified period. The steps in calculating load are as follows:

Determine the standard hours of operation time for each planned and released order for each work center by time period.
Add all the standard hours together for each work center in each period. The result is the total required capacity (load) on that work center for each time period of the plan.

Example Problem
A work center has the following open orders and planned orders for week 20, Calculate the total standard time required (load) on this work center in week 20, Order 222 is already in progress, and there are 100 remaining to run.

Order
Quantity

Setup Time (hours)
Run Time Total Time (hours/piece) (hours)

Released Orders
222

333
Planned Orders
444
555
Answer
Released Orders 222
333
Planned Orders 444
555
Total Time
100 150 0
1.5 0.2 0.2

200 300 3
2.5 0.25 0.15

Total time = 0 + (100 X 0.2) Total time = 1.5 + (150 x 0.2) = 20.0 standard hours = 31.5 standard hours

Total time = 3 + (200 x 0.25) Total time = 2.5 + (300 x 0.15) = 152.0 standard hours = 53.0 standard hours = 47.5 standard hours

In week 20, there is a load (requirement) for 152 standard hours.
The load must now be compared to the available capacity. One way of doing this is with a work center load report.

Work Center Load Report
The work center load report shows future capacity requirements based on released and planned orders for each time period of the plan.
The load of 152 hours calculated in the previous example is for week 20. Similarly, loads for other weeks can be calculated and recorded on a load report such as is shown in Figure 5.5. Figure 5.6 shows the same data in graphical form. Note that the report shows released and planned load, total load, rated capacity and (over)/under capacity. The term overcapacity means that the work center is overloaded and the term under capacity means the work center is under loaded. This type of display gives information used to adjust available capacity or to adjust the load by changing the priority plan. In this example, weeks 1 and 2 are overloaded, the balance are under loaded, and the cumulative load is less than the available. For the planner,

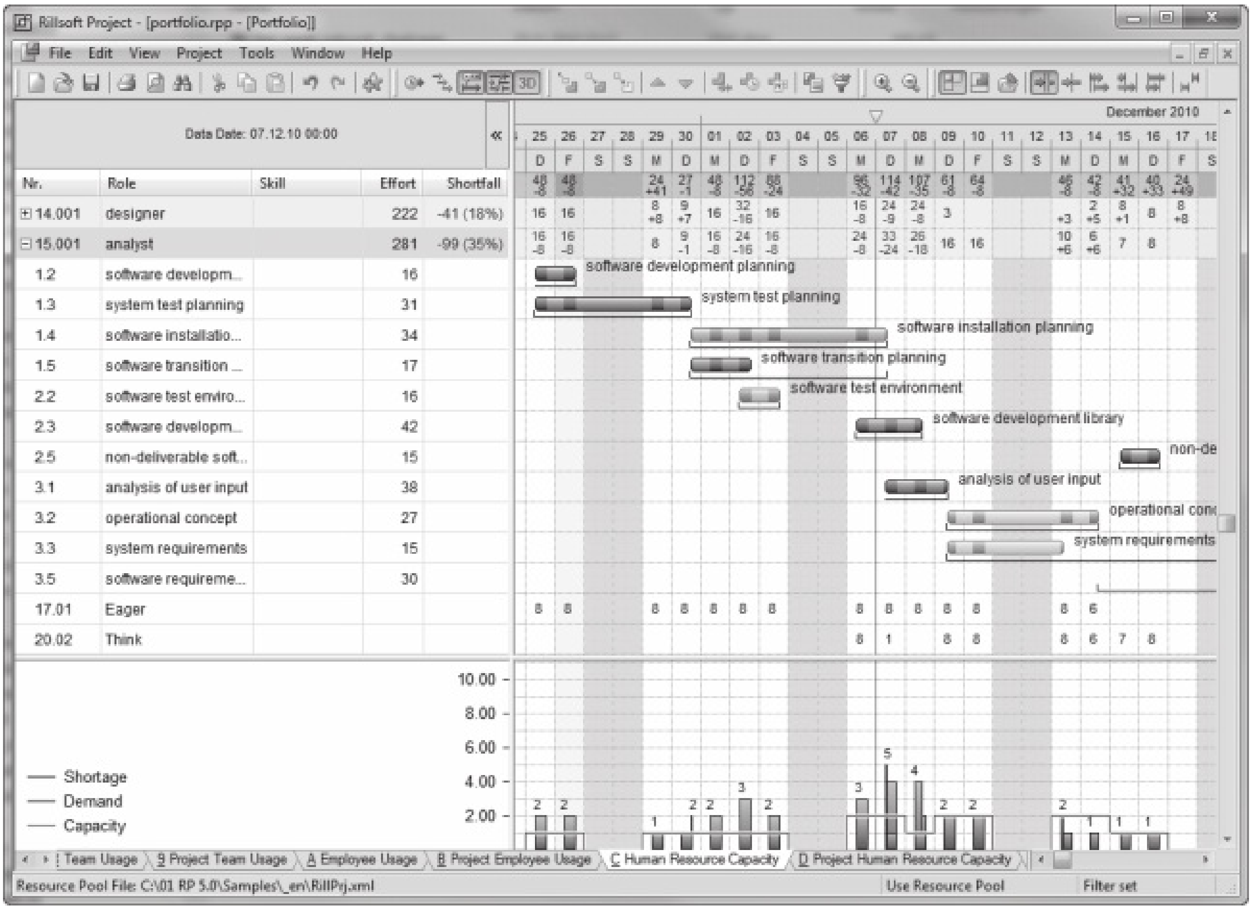
Work Center Load Report
Week 20 21 22 23 24 Total Released Load 51.5 45 30 30 25 181.5 Planned Load 100.5 120 100 90 100 510.5 Total Load 152 165 130 120 125 692 Rated Capacity 140 140 140 140 140 700 (Over)/Under capacity (12) (25) 10 20 15 8

140
120
100
80

60 Released Load Planned Load

40
20
0 20 21 22 23 24 Week

This shows there is enough total capacity over the planning horizon, and available Capacity or priority can be juggled to meet the plan.
There are software’s available for capacity planning and most of the planning software like PRO SMV, GSD etc. are coming with attached capacity planning tools.



Marker planning, processing fabric faults, cut order planning, fabric reconciliation

5 Marker Planning and Cutting

Material cost is a major component of manufacturing costs. Of primary importance in managing material cost is the establishment of control over marker utilization. Waste in markers cause serious financial losses by reducing the profitability of the line. It is common knowledge that increasing the number of garments as the number of sizes in a marker can give higher marker utilization. It is useful to break marker making into two.

1) Marker Planning, or the placement of pattern pieces to meet technical requirements and the needs of material economy
2) Marker Utilization, which may include drawing the marker plan directly to fabric or onto a paper marker or cut the fabric directly using an auto cutter.
The original diagram of a lay and marker implied a large sheet of paper on which were drawn the edges of all the pattern pieces, this is only appropriate when cutting is done by manually controlled knifes and a line must be provided for the operator to follow. In earlier days marker is drawn directly to the fabric and latter printer paper makers were in practice, by the year 2005 and now a days cutting is done by computer controlled knifes and drawing pattern shapes are unnecessary.
Where a paper marker is used, it is normally stabilized on the top ply of the lay by various means, the paper marker is cut along with the fabric plies.
For better understanding Apparel Research Foundation in USA suggested in 1979, that products could be grouped into three broad categories according to way of marker utilization.

Relatively Simple Products: These products includes towels, seat covers, and any other items with rectangular parts. In these cases, the marker planning is able to tessellate the pieces to approach 100% utilization.

Products with Large Number of Small Parts : - these products include men’s suits, shirts and some blouses. They show a systematic increase in the utilization, there are large number of small parts, and the planner finds that having more garments marked does provide more options to explore. The benefit of these small pieces does diminish after some quantity as a practical limit is reached.

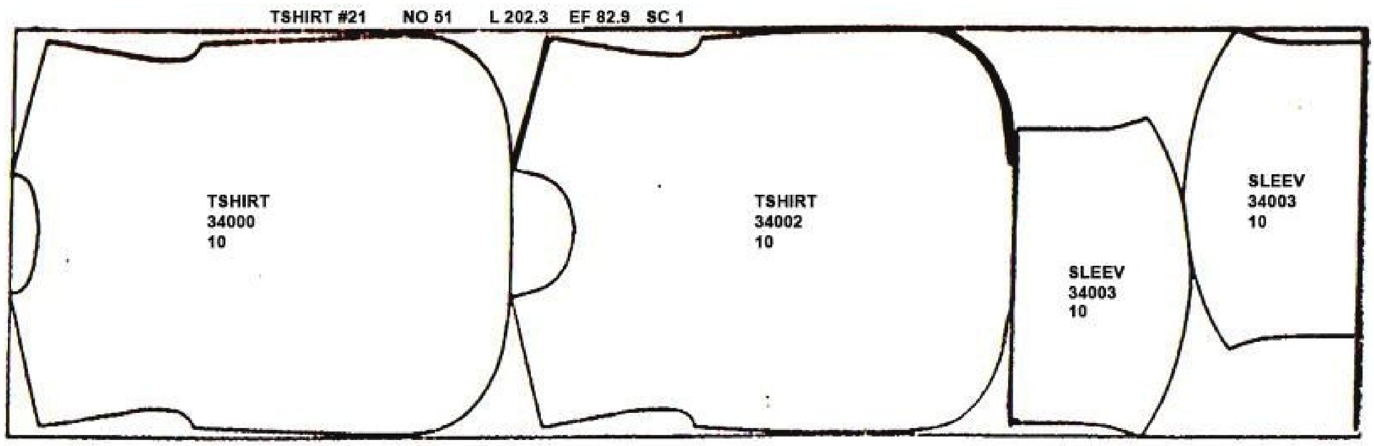
“ *The Number of sizes required to produce an ‘efficient’ marker is usually over estimated by the apparel industry” – Trautman 1979*

Products with relatively Large Panels that fit in multiples across the width : - these products include men’s and ladies slacks (chinos, trousers etc.), some dress, sweatshirts, and other ‘panel’ products. The large panels effectively controls the fabric requirements and the smaller pieces are cut from the waste generated after placing the larger pieces.

Fabric Width
The width of the fabric is of great importance in marker planning there are three main class can be identified; tubular knitted fabric, narrow open width fabric and wide open width fabric.

Tubular Knitted fabric: circular knitting machines produces tubes of fabric, which may or may not slit open while finishing. If they are cut open then they can be grouped under the other categories according to its width. Leisurewear and underwear manufacturers makes

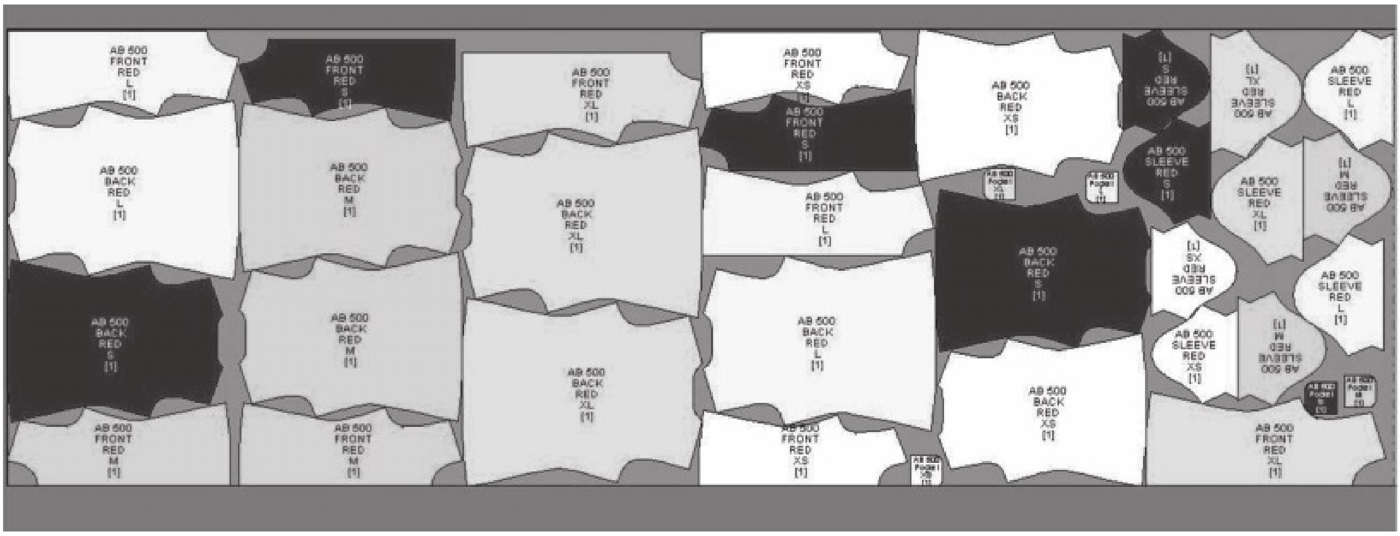
extensive use of tubular knitted fabric. The material width generally is selected to match the width of the body panel. So that the waste can be minimized. An example marker is shown here. Here the repeat is one garment hence the efficiency is low but as nearer to 75 %, but while increasing the garments the efficiency can be brought above 90 or



more.

Narrow Open width Fabric: a fabric width of approximately near to One Meter (1 Meter) are defined as narrow. Constraint to marker planner is that approximately two body pieces can be fitted across the width of the marker. In this case, it is usual to pair the sizes and exploit the fact of grading increments as consistent moving up or down range. Here usually starts with an approximate middle size range, and an efficient marker is prepared. Then the size above and below the pivot sizes are selected and another marker is prepared keeping the pieces in the same general position. In the ideal case, the additional space occupied by the larger pieces is released by the corresponding reductions in the smaller pieces. In this way, a series of two-size markers are prepared for the range.

These paired markers are popularly known as 'married lays'. Once a marker for the pivot size is prepared, the remaining markers can be drawn very quickly. The situation works well as long as the marked sizes are required in equal quantities. If this is not the case, additional markers must be made with uncertain implications for reduction in waste.



Wide Open Width Fabric : - fabric of nearly 150cm or more width provide considerably fewer constraints on marker planning. Characteristically, three body pieces can be placed across the width and many variations are possible. If there are sufficient number of small pieces, marker utilization can be achieved high rate. And if there are fewer small pieces and more large pieces utilization will be low as well. It is usual to make the ratio of the sizes marked the same as the ratio of the sizes in the Purchase Order. These other way termed as ‘Ratio Lays’.
The ratio lays have three benefits.

1) The cutwork comes off in the correct ratio of the order. (sometimes two or more markers are made if there is complex ratio in order)
2) The mixing of sizes gives potential for improved marker utilization.
3) Only very few markers are need to prepare for an order.

This type has an increased workload on operators in the sewing preparatory. Also need more storage space if there are many sizes and if shades need to be separated then the time need to complete work may increase.

Sometimes, the wide open width fabric been cut ‘on the fold’. The fabric was folded in half across the width and then layed as equivalent to narrow width. This method is usually to process a small batch of fabric by allocating a single spreader or cutter.

Grain Direction

Pattern pieces normally carry a grain line. When pattern pieces are layed down on fabric, it is common with large patterns, the grain line should be parallel to the line of the warp in the woven fabric of the wales in a knitted fabric, in bias cutting, which is often used in large pattern pieces as part of the garment design the grain lines will normally at 45^{o} to the warp. However may be the placement of the pattern on the fabric the grain line should be drawn and placed parallel to the grain of the fabric only. The angles or placement of the grain line in pattern only have different directions. The placement of the patterns on the fabric is depend on various other factors, such as Symmetry of the fabric etc.

Symmetry and asymmetry fabrics.

Many fabric can be turned round through 180^{o} and retain the same appearance and these type of fabrics are designated as ‘either way’ or symmetrical fabrics. They require no

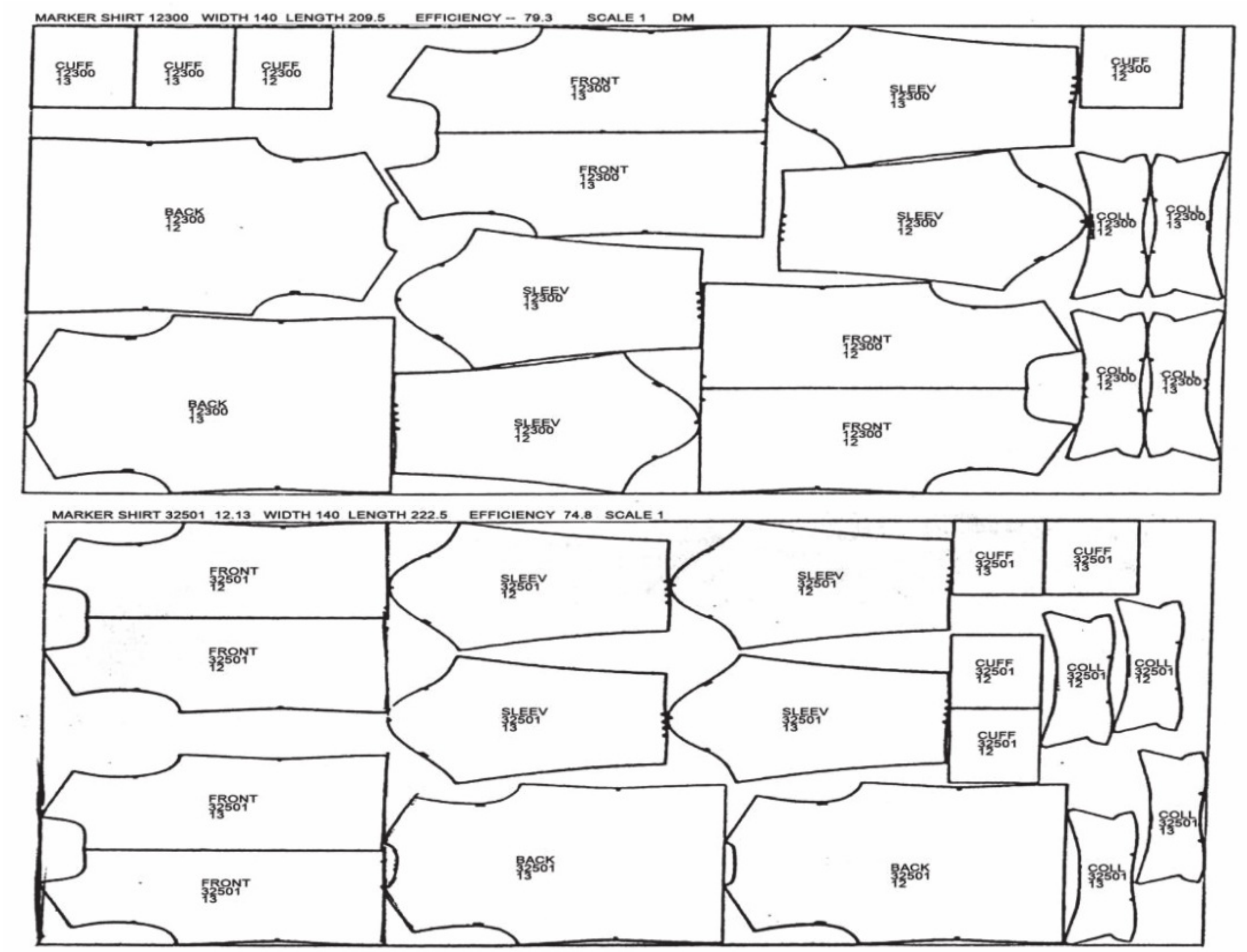
special action on the part of the marker planner. Restrictions are more in the case of ‘one way – either way’ or asymmetrical fabrics. In this case if a fabric ply is turned round it does not retain the same appearance, especially when the two opposite ways are sewn together. There are some fabrics termed as ‘one-way only’ this is also an asymmetric fabric, fabrics such as corduroy, large headed object printed fabrics etc. are examples of oneway only fabric, here the patterns can only be places according to the nap of the fabric only and we cannot always lay strict with the grains marked.

Even though while planning we follow a simple rule that the grain of one garment should always be in one direction. That means all patterns of a single garment while sewing should be of same lay and same gran flowed. Hence the marker planner should ensure that the top ends of the pattern pieces, as they will be worn in the garment, all face the same way. For example, if a vertical stripe does not show a complete mirror image repeat, the right and left sides of a garment may be designed to be mirror images of each other. In this case the marker is planned using a half set of patterns, and the required effect is created in the spreading of the fabric conventionally, which places pairs of plies face to face.

Two-Way Marker & One Way Marker

Two way marker has the patterns placed on both directions, and one way marker has all garments placed in same direction. Planner must specify the grain direction and prepare 1-way markers for asymmetry fabrics. Since none of the patterns can be flipped through 180^{o}, the number of options in the marker is reduced, and by reducing marker utilization. Refer the details in the following figure, comparing two marker plans one is prepared as two way marker and the other as one way marker for the same pattern pieces.

The two way marker plan has utilization of 79.3% and the one way marker has 74.8%. There are few basic differences between the two markers, but the additional facility of reversing certain pieces has made a significant difference in material usage. Every percentage of saving in a marker will give huge saving in material cost.
This implies that one-way marker utilization are likely to be less, but never exceeded those for two-way marker using the same pieces. However the effect of the fabric may vary some time. It is not advised to reverence the pieces all time, because the drape effect and design features of the fabric and garment may not be same. Hence before the marker planning, it is must for a planner to know what are the type of fabric, their effect requirement in the finished garment etc. then only a better marker with best utilization is producible. For example the inner yoke can be revered for a stripe or check but not possible to reverse the pieces of a cuff in most time, but possible if design allow.



The key points to note are,

○ Increased number of garments marked lead to improved marker utilization.
○ Wider width fabrics reduce the constraints on the marker planner and may improve utilization ○ Ratio markers reduce the number of markers to plan and simplify production control procedures.

Marker planning with stripped and check fabrics.

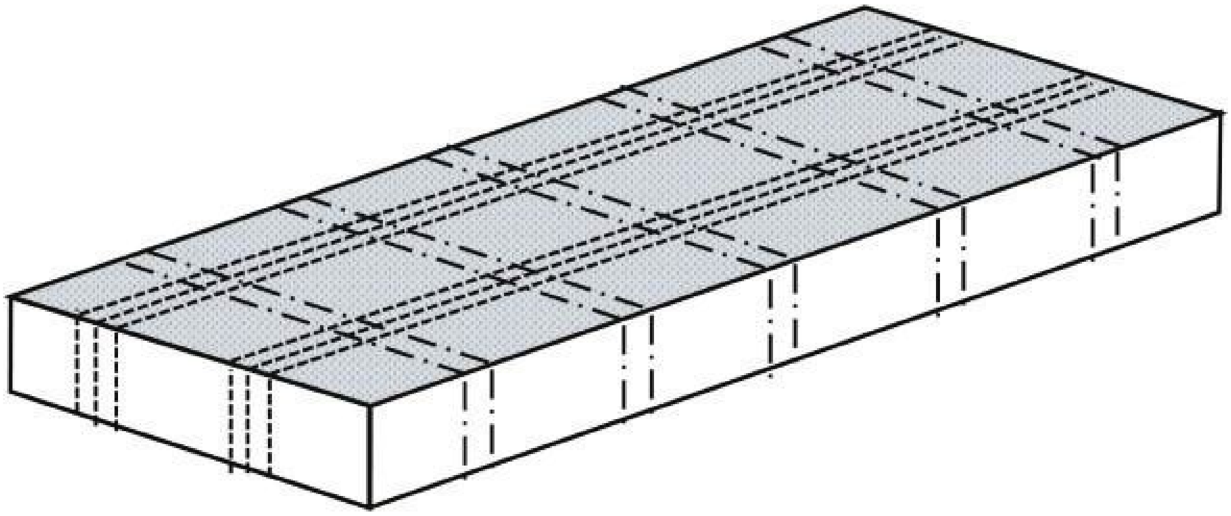
Placing pattern pieces on the checked (Plaids) or stripped fabrics imposes numerous problems on cutting room personnel's which, despite many years of endeavor, automation has failed to solve. There are three main difficulties which affect the marker making and spreading procedure;

Fabric dimensions show variations : - problems associated with bowing and skewing, width way striped and plaids are very good at showing up these distortions. They also show dimensional variations along the length of the fabric. Distance between pattern repeats can be measured easily to determine the magnitude of the problem. The difference arise wherever the fabric can be distorted during its formation and finishing.

Superimposed plies must be matched : - in order to lay up these plaid fabrics, it is essential that the play length be determined by the pattern and not by the absolute length. Consequently, to superimpose successive plies, areas of fullness and tightness must be accommodated within the lay.

Garment pieces must be positioned accurately in relation to the fabric pattern : - having layed up the fabric, the marker must be placed over the top ply. However, the marker is made to fit fabric with specification of pattern repeat dimensions, and an exact match may not occur. This means adjustments must be made manually during cutting.

Plaid garments are designed with a variety of matching positions. Some may need matching only in the neck and shoulder, others may have matching side seams; some may be required to match where ever is possible. Each additional matching position adds to the complexity of

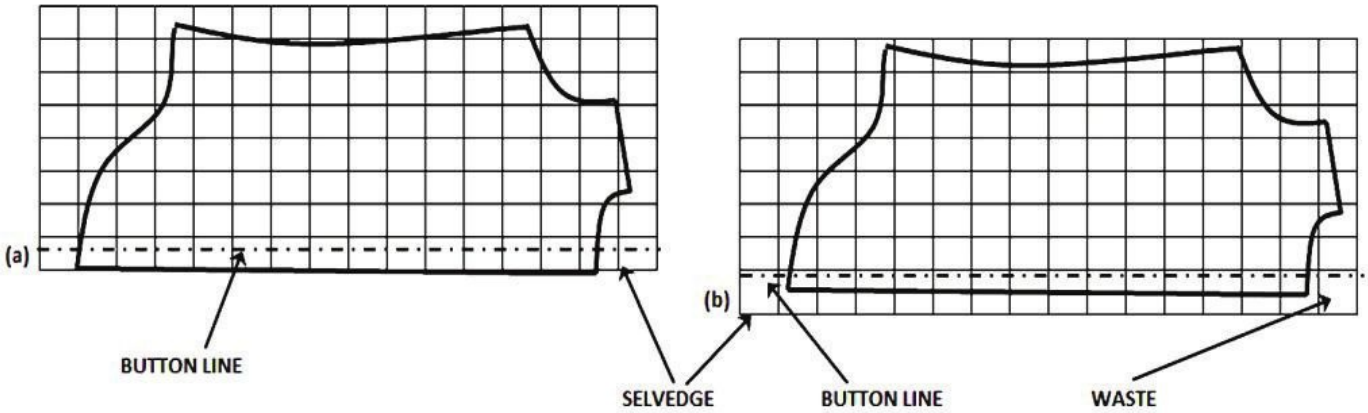


processing.

There is great potential for patterned fabric to reduce utilization it is hence an apparel engineer has to study carefully before selecting a method. The examination of designs for its manufacturability is the first aspect. Questions must be asked in detail for the possible wasteful incompatibilities. The key points to remember explained with examples are,

Selection of pattern repeat distances to minimize waste : - the figure (a) shows the number of garment piece placed on a checked fabric with 10cm repeat. The predominant stripes falls on the button line and determines where the front pieces need to be placed. Hence it is desirable to place the pieces one another so that problem of matching check lines across the front are minimized but gaps between patterns are prominent and is waste. But if we reduce the check size to 9 cm repeat as in figure (b) the gaps have gone and waste is reduced. Hence the apparel engineer should consult with the designing team for the possibility of reducing the check size to 9cm. but always it may not be possible but this is why an apparel engineer is always takes part in merchandising and sampling activities for the practicability of designs producing can be solved before is comes to floor.

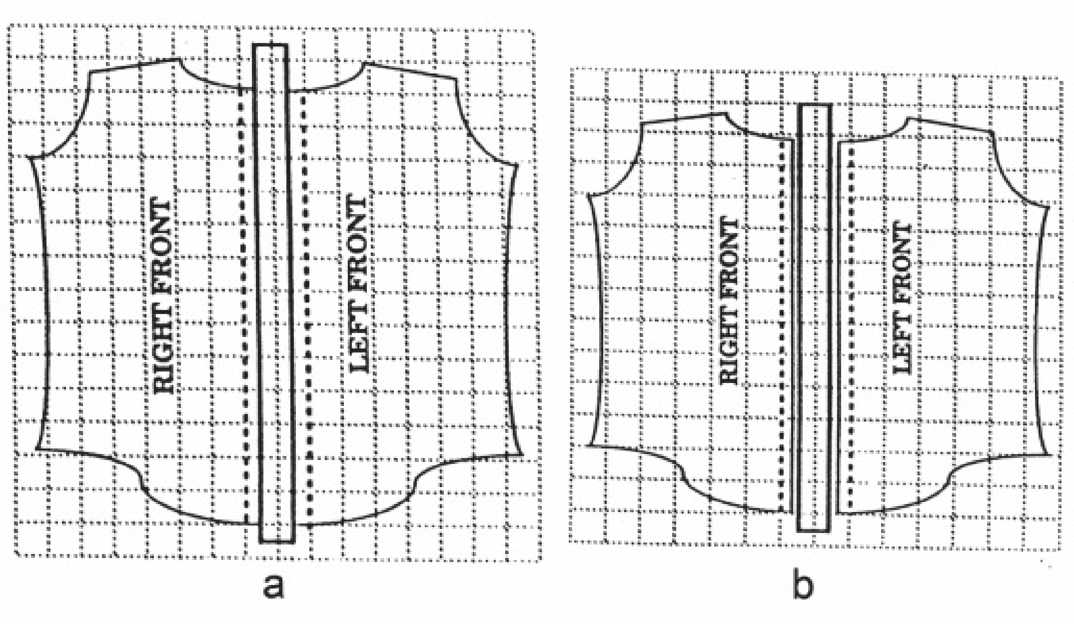
Modification of the location of the predominant stripe: - it is usual to include the selvedge of the shirting material into the front pieces. On striped and checked fabrics with a wide repeat length, it is important to position the button line in relation to the selvedge. This is to avoid waste and to get proper matching. There are



two options, one is to exclude the selvedge from cut piece and second is to include the selvedge inside placket folding. While we include, the wastage can be reduced.

Spreading technique for Stripes and checks

All trials for spreading striped and checked methods are time consuming and labour intensive. In some situations cutting individual plies may be the best suitable method. Spreading is generally possible and



makes better use. The common spreading techniques are based on locating particular stripes or checks and superimposing plies in a controlled manner. Short length lays are spread commonly. Major tools and methods used are,

Check Spikes : - important matching points are located on a spike to ensure that they are overlaid or superimposed during spreading. These inexpensive alignment aids are used to ensure that critical points are matched but they may produce localized distortions in fabric.

Pinning Table : - they are designed to overcome the drawbacks of check spike principle. The spreading table has many holes through which pins can pass. The operator can move the pin when in is necessary. Each successive ply is positioned on the table with matching points on the pins.it is necessary to ensure that the pins protrude out just above the ply. Spreading is generally by hand, but machines may also be used.

Folding: - the fabric is folded to match the stripes to compensate for any bow of skew that is present. This is generally used for processing relatively simple striped knits. From the

folded length a small lay is prepared and then cut. Circular knives and die cutter have are used with thin lays. This technique is very effective in minimizing bow effect but not convenient for styles with more components.

Blocking Out and Relaying : - the marker is planned with some relaying allowance around plies to be matched and then cut into blocks. The blocks those require matching are then relayed, often using a small pinning table, so that all the plies are correctly positioned and then cut normally. This method is used if there are relatively few pieces require matching. This can reduce spreading time and makes possible to prepare long markers. In this method the main factors to be calculated are the material cost. When the material cost is too high this method is not advisable especially when pattern repeat length become longer.

Fabric Loses outside marker.

Although most of the fabric usage is controlled by the marker, the losses outside marker are extreme from minor. There are essential losses associated with spreading, such as end ply waste, end of piece waste etc. the loses outside marker are classified mainly as below,

Direct losses
End ply losses
Ends piece losses
Edge Losses
Splicing losses and fabric faults

Indirect Losses
Remnant losses
Marker planning losses
Ticket length losses etc.

End ofplylosses : - the limpness and extensibility of fabrics and the sort of limitation of spreading equipment necessitates the requirement of some fabric at each ends of each ply. These losses are typically from 2cm at each end (or 4 cm per lay). Some stable fabrics may permit smaller allowance and some unstable fabrics may require more. It is useful to be aware of the level of these losses. With an 8m lay the ends make up 0.5% of the total usage of material while a 4m lay the end waste increases to 1.0%.

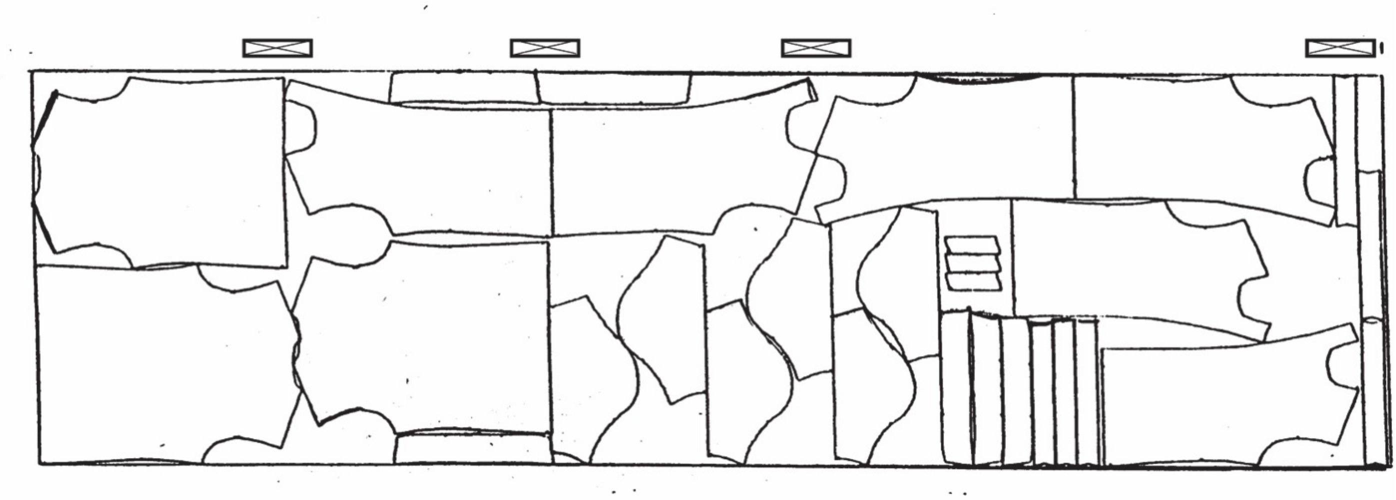
These is a tendency for end waste to become excessive on thicker fabrics, it makes laying up and cutting easier and reduces the waste. Each type of fabric should be checked for the actual end losses and a company standard should be made to control this.

E nd ofpiecelosses: -the ends of the fabric may be unsuitable because of marks or distortions created during fabric finishing processes, but the length affected should be a few centimeters. The most important loss comes because the fabric length is not an exact multiple of the ply length. Hence while spreading we have to splice to the next piece to the nearest splice point or the part by ply must be laid aside as a remnant and processed separately, but both the methods result in loss of fabric. To minimize loss we have to increase the average length of fabric while purchasing. if we have 50cm average splice length and an average fabric length is 100m then we are having end piece loss about 0.5% of the total. Although end piece losses cannot be eliminated, but it can be controlled, and clear procedures are needed for splicing and the processing of remnants. The waste reduction methods of marker is explained latter.

Ed gelosses:it is usual for the width of marker to be kept 3cm less than the edge-to-edge width of the fabric lay. The marker is said to be made to the usable width of the fabric and it is dependent on the quality of the selvedge, consistency of fabric width, and precision of edge control during spreading. If the edge-to-edge width is 100cm, the edge loss is about 3% and if the edge-to-edge distance is 150cm then the edge loss is about 2%. Hence wider fabrics have other benefits besides improved marker utilizations. For an exceptionally stable fabric, we have even reduce the edge width to 2cm. hence width variations of the fabric must be controlled alongside these allowances.

S plicingLossesand fabricfaults: during spreading it may necessary to cut out fabric faults which would make the product unsalable. If fault are cut out at lay, it is necessary to include splicing positions into the marker plan. The splicing positions are identified by being able to draw a reasonably straight line between the pieces. This means the fault which falls between the two splice lines can be cut out, the cut edge can be drawn back to the preceding splice line, and spreading continued.

If the marker has been planned without the splice positions and a faulty length of material has to be cut, then length from the ply end to the fault has to be laid aside as a remnant. Spreading proceeds starting again at the lay end. The distance between splicing positions influence the waste produced by splicing, the average waste will be nearly half the average distance between splice lines. A splicing allowance is made to ensure that only a complete panels are being cut.



The splicing allowance are made to ensure that only complete panels are cut. These are other way safety margins for cutting, which compensates for some factors like; difficulty of cutting the fabric square to the selvedge, uncertainty about a precise position, many splice lines are far from straight lines, etc.

R emnant losses:these are produced when, separate different shades of fabric pieces and lay up only complete plies. All partly ply lengths are put to one side and cut separately. Remnant length are also generated when short lengths of material are left over after completion of a lay. Short markers are to be made to obtain further pieces from these lengths. They may be single garment markers if the pieces are large and can have many garment marker is pieces are small. Also we can use the remnant length for recutting.

For example if the average marker length is 10m and the average piece length is 100m, the average remnant length is approximately 5m thus 5m out of every 100m i.e. about 5% of

total is gone as remnant length. As this is a significant waste, we can have a step lay at one end of the production marker, may help to clear the remnants with the main lay itself.

Remnant length can be reduced by utilizing two or more production markers. If two markers available one of 10m and another of 8m, it is possible to allocate individual pieces to specific markers so that the length of remnant is minimized. This a pieces of 97 m would be allocated to the 8m marker and pieces of 91 can be allocated to the 10m marker but this is only possible when both markers having significantly higher utilization.

Markerplanninglosses: - it occurs, when the costed marker plan is not used and the marker actually used has a reduced utilization. There are three main reasons

1) *Special markers for use with narrow fabrics:* - it is usual to receive smaller width fabrics than the specification usable. To avoid downgrading cut panels because they contain selvedges, a new marker must be prepared. Even if the marker utilization is maintained, the rating of fabric usage must increase with the new marker so a loss will be made against the original costed usage. If utilization reduces, the losses are even larger. It is possible to determine the material losses and the additional labor cost for planning the narrower marker, so a basis exists for financial compensation.

2) *Special markers responding to customer requirements:* trends may require some certain colours and certain sizes, and garments that are not selling may be modified in some way in an attempt to stimulate consumer interest and in shorter time, hence shorter markers are likely to have reduced utilization and will produce fabric losses against costed values.

3) Special markers due to production pressures:- the sewing room is the customer of cutting room, the sewing rooms certain customer activities like machine failure, may create a bottleneck in a sewing line, In such cases we have to transfer operations temporarily to another line, reducing throughput on the line with the short-term issue and increasing throughput in another line with additional operates, in such conditions it may be necessary to do additional cutting to match the targets.

T icketlengthlosses:- in some cases the supplier attaches a ticket to each piece indicating the length for which customer is billed. In many cases a gross length is recorded, which is the distance between the ends, and is also a net length the difference between the two figures arises because the supplier credits the purchases with an agreed length of fabric for each strung fault. If there are errors in the gross length measurement they are unlikely to be as losses to the purchaser. To reduce this a practice of sampling inspection of incoming pieces to check the reliability of their supplier’s measurement and maintain control over the situation is necessary.

Processing of fabric faults

There are three general methods of dealing with fabric faults, which may be employed readily in contemporary cutting rooms. It is assumed that all faults which would make the garment unsalable even as a second (large holes, flaws, extreme staining, sewn joints etc.) would be cut out during spreading. The faults under consideration here are faults which would make the perfect garments into seconds. The methods are

1) To leave all faults alone and detect and remove the resulting seconds garments at final examination.

2) To examine every cut piece and recut any that are faulty
3) To cut out during spreading

After calculating the economic influence of both the methods and the most economic option may only determine for the particular lay. The cost of processing faults vary according to the method of production selected,

1) *Make Through – the cost of ignoring faults:* cost is the loss which occur when otherwise perfect garments have to be downgraded to seconds because of faults in the fabric. It is assumed that each faulty panel results in one faulty garment.
Let P = selling price of perfect garment ($ per doz)

S = Selling price of seconds garments ($ per doz)
N = Number of faults per 100m
Y = Costed length (m/doz)
U = Marker utilization (%)
To find out the loss,

2) *Sort and recut:* this technique requires faulty panels to be identified and replaced. To achieve this, additional fabric is required to recut the faulty pieces, and there are labour cost for this. It is assumed that each fault affects one piece in the garment only. There are a number of different variations in practice, depending on the technology resources of cutting room.

Let F = Fabric cost ($/doz) p = No of pieces per garment R = Labour rate ($/ SMV)

These calculations are direct labour cost and here excludes departmental overheads. Recuts require more fabric than is given by the costed length about 50% is assumed there for, the costed length per dozen recut garments is 1.5Y meters, and this is based on the current practices.

Hence, 12 pieces are cut from 1.5Ymeters
1 piece is cut from
Therefore,

The labour cost for 100% examination of all cut pieces prior to counting and bundling has been estimated at 0.5 SAM per dozen for a leisure wear factory with 5 pieces per garment and standard time was 2.5 min per dozen. The average recutting time has been estimated as 2.6 SAM per piece then

Hence,

3) *Cut at Lay:* the cost is the fabric cut out of the lay, going back to the nearest splice point, and the labour. Since many of the faults are localized, the fabric loss can be estimated at approximately half the average splice length. This will not be true with larger faults and if the splice positions are not clearely defined in marker, but it provides more realistic estimate of fabric loss than averaging the data obtained from a variety of lays.
Let L = meters per fault cut out = half the average splice length (m)

T = average time to cut out a fault (STD)
From workstudy records an average of 0.33 m for T is been obtained, where it related to hand cutting practices during the spreading of tubular fabric. In some conditions it may be

less than 1 min or may be more than 1 m. but an average proper method the standard time can be set to 0.33 min for T. hence

An example for the above session, when three styles have been examined to find out the information for calculating the cost of dealing with faults.
Cost data for the production styles.

Loss while selling as seconds Cost Length
Utilization
Fabric cost
Number of pieces in garment Labour rate
Fault cut length or ½ of splice Average time to cut a fault 1% of selling price per doz 2% of fabric cost per doz Palin cap sleeve Bolero Dress Velour Top

P-S ($/doz) 7.04 10.10 26.75 Y (m/doz) 6.36 3.21 7.16 U (%) 75 85 85 F ($/m) 2.20 1.40 4.81 P 2 5 10 R ($/doz) 0.045 0.045 0.045 L (m) 0.35 0.30 0.25 T(sm) 0.33 0.33 0.33

0.30 0.44 0.93 0.28 0.09 0.69
If the cut quantity set as 100 pcs, then the losses in three sessions are calculated as below. With different possible defect rates, here we have taken from 4 to 26 defect points per 100 m.

Defect % => Loss in Make through
loss in Cut at lay
Loss in Sort and Recut

Defect % => Loss in Make through
loss in Cut at lay
Loss in Sort and Recut

Defect % => Loss in Make through
loss in Cut at lay
Loss in Sort and Recut

Plain cap sleeve
0 4 8 12 16 20 24
0 11 22 34 45 56 67
0 20 39 59 78 98 118
5 21 38 55 72 89 105
Bolero Dress
0 4 8 12 16 20 24
0 9 18 28 37 46 55
0 5 11 16 22 27 32
11 13 14 15 16 18 19
Velour Top
0 4 8 12 16 20 24
0 54 109 163 217 271 326
0 34 69 103 138 172 207
23 33 44 54 65 75 86

Once the losses are prepared then it need to be charted out and observed the right method

by matching the defect rate of the fabric to be cut.

PLAIN CAP SLEEVE - COST VARIATION

Loss in Make through loss in Cut at lay Loss in Sort and Recut 140
120
100
80
60
40
20

0 0 4 8 12 16 20 24 NUMBER OF DEFECTS PER 100 M

The cap sleeve is with two pieces, this means that the fabric usage for both recutting and splicing is considerable. Since the difference between the perfect and seconds selling price are small, the cheapest method of dealing with faults is to leave them alone and allow them to go into seconds garments.

BOLERO DRESS- COST VARIATION

Loss in Make through loss in Cut at lay Loss in Sort and Recut
60
50
40
30
20
10
0

0 4 8 1216 2024 NUMBER OF DEFECTS PER 100 M

The bolero dress fabric is cheap and for fault rates above 16 per 100m there is little to choose between cuttings out faults from the lay and sorting and recutting. But the loss rate for defects cut out at lay and splice is trend with low rate of loss, for low defect rates make through method may be selected but the cost effective is cut out at lay. But when at higher defect rate above 16 it is better to have the practice of sort and recut may be cost effective.

VELOUR TOP- COST VARIATION

Loss in Make through loss in Cut at lay Loss in Sort and Recut 350
300
250
200
150
100
50

0 0 4 8 12 16 20 24 NUMBER OF DEFECTS PER 100 M

The velour fabric for the top is expensive and the number of pieces in the garment is also more. The loss while this garment sells as seconds is high compared to sort and recut. Hence the cheapest method is sort and recut.

In practice, other considerations may influence the decision about which way to deal with the fabric faults. Since there are many parameters affecting to cost of fabric faults, it is probably better to look at several styles in production and to compare graphs. A general policy can be developed by looking various cases.

Fabric allowances are to be calculated before purchasing the fabric itself, the equations may be used to assess whether the fabric allowance of about 12cm per fault as agreed by most suppliers satisfactorily. This figure is reported by Wira(1971) and by Rae (1974)

For example allowance, if given on the fabric to cut the velour top is the equivalent of $0.66 per dozen garments when the fault rate is 16 per 100m

The basic equations which estimate the cost of dealing with fabric faults are given below, Where
P= selling price of perfect garment ($ per doz)
S= Selling price of seconds garments ($ per doz)
N= Number of faults per 100m
Y= Costed length (m/doz)
U= Marker utilization (%)
F= Fabric cost ($/doz)
p= No of pieces per garment
R= Labour rate ($/ SMV)
L= meters per fault cut out = half the average splice length (m) T= average time to cut out a fault (STD)

Make-through method is used when the fabric and garment is cheap, the number of fabric faults are relatively few, and there is a demand for seconds.
Sort and recut is used when fabric and garment is expensive, when the fabric is wide, when the garment is constructed from many pieces, and the number of fabric fault is relatively high.
Cut at lay is used when splice positions are fairly close together and are also clearly defined. This option is suitable for narrower width woven fabrics and tubular knitted fabrics.

Marker Utilization

It is widely recognized that, short markers have low utilization and it is possible to improve plans by increasing the number of garments marked. As a general principle longer lays allow greater scope for marker planning and may achieve higher marker utilizations

No of garments % of saving marked
1 0
2 2
4 4
8 5
Replanted marker length
1.50
2.94
5.76

11.40
Saving / garment Savings per 100 mtr garments (mtr) 0 0
0.03 3.00
0.06 6.00
0.075 7.50

The chart above is a comparison between the fabrics saving while increasing the number of garments in lay. Clearly shows the improvement in marker utilization can give substantial benefits in reducing cutting room cost. It is necessary for every industry should workout the above comparison according their company standards and availability of resources. The marker efficiency can be calculated using the below formula.

This formula is been highly utilized by the computers and CAD programs for calculating the marker plan efficiency. Where are in hard planning method like manual marker preparations, it is not easy to calculate the area of all patterns hence the below formula can also be used.
In this case, we have to weigh the total length of fabric before cutting, and then weigh the cut patters.

There are several constraints which may affect the increase in waste, of reduction in number of lays or other ways, like fabric properties, cloth availability etc. which will restrain us from the same cut order plan to be followed all the time, hence for every order it need to be planned. The major constraints are,

Fabric properties: fabric may vary in thickness and hardness 50 plies of a wool suiting may be thicker than a 150 plies of poplin, with direct implications for the number of plies that can be put. The differences in their resistance to cutting may be deceptive. High resistance to the movement of a cutting knife can also limit the depth of the lay. In some cases fabrics with high resistance to cutting produce considerable heat energy, which increases the temperature of the cutting blade. Some extreme cases thermoplastic material can fuse and join neighboring plies together, reducing the lay depth will be the solution to reduce such issues.

Machine and table dimensions: laying up machines provide a practical limit on lay depth because the feed rollers can be raised only a predetermined height above the table only. Straight knives are used for cutting out larger pieces and finer pieces are cut using a band knife machine, for which blocks are cut using the straight knife.

A cutting table should be long enough to carry the largest lays likely to be required. When working out the appropriate length, space needed for spreading machinery, for fabrics weighting for laying up, for blocks of work awaiting for band knife cutting etc. are need to be available in the cutting table.

Machine Space Spreading area

Cutting space Band knife

Cut Order Planning

Load and capacity are the two variables required by the planner to quantify efficient

planning schedule. Load is the quantity of work the factory is required to do, measured in standard minutes or standard hours. The load is determined by contracts that have been placed with the company and the coasted work content of the garments in run.

Load = (contract 1 size x work content) + (contract 2 size x work content) + … etc. The capacity is the amount of work the factory is capable of doing, measured in standard minutes or hours per week. The capacity is often determined from factory records of previous performance,
And

Once this is known, then the production schedule is prepared which balances the load and the capacity. Since bulk of the labour force in garment industry is in the sewing room, the sewing schedule must be the master schedule and the reference point for all other schedules. After that only production planning person can prepare the targets for sewing, cutting and fabric delivery.

Sewing schedule- is designed to satisfy the contracts placed by the customer

Cutting schedule: - gives the input necessary to achieve the sewing schedule. The cutting room exists to satisfy the needs of sewing room, so the cutting schedule must be derived from the sewing schedule, and is not based on the cutting room capacity.
Fabric delivery schedule: - provides the input necessary to achieve the stock required to achieve the cutting schedule. Should be considered the constraints and lead times, the stock level required to buffer against unsatisfactory quality or late delivery problems, and aims to minimize the cost of acquisition and storage.

Cut order plan takes the targets established by the cutting schedule and translates them to a loading plan of successive batches to the cutting room, so that cutting proceeds in the most efficient and cost effective manner.

Let us learn though a work example,

The sewing room is schedules to produce 200 garments a day. The marker is 9m long, with 6 garments marked. A 2% of laying losses are included and the maximum lay depth is 60 plies. Let us prepare a cutting schedule to keep the sewing room fed.

We can do different plans, and we should consider all options before make a final plan schedule. *Plan A* to cut one lay per day for 200 garments then,

Required garments for production floor per day = 200
Length of fabric required for 200 garments = 200 x 1.53 = 306m
Number of plies for 200 garments = = 33.33 34 Number of lays per week (5 day working) = 5
If we follow this pattern, we can notice that the lays are shallow and wasteful in cutting labour, and we have an increased labour cost in cutting. Hence, we may plan further options,
Plan B to cut all 60 plies deep in a cut, here,
Number of garments per lay = 60 x 6 = 360 garments
Fabric required for 360 garments = 360 x 1.53 = 550.8m
Number of cuts required per week = = 2.77 = 3
Total garments cut in a week = 3 x 360 = 1080

However we notice that, this will produce 1080 garments instead of 1000 garments in a week and this 80 garments will need temporary storage and latter proper reduction of excess quantity need to be made. *Plan C* to cut 1000 garments per week and approximately 3 lays.
Number of garments per lay = = 333.33
Number of plies per lay = =55.56

It is not possible to cut exactly 100 garments here, but we have to put 56 plies in a lay then we will cut 1008 garments per week, which is slight different then the number of garments. In this condition, The fabric required to put 56 lay = 56 x 6 x 1.53 = 514 m
Lays per week is = 3
Total Cut garments per week = 1008
For better more reduction in fabric waste, let us consider another option,

Cut	Plies per lay	total cut quantity	Fabric required
1	55	330	504.9
2	56	336	514.08
3	56	336	514.08
		1002	1533.06

While we plan this way, we can further reduce the fabric losses, so that we will cut nearly 1002 pieces and use 1533.06 meter of fabric instead of 1542.24 meters while we do 56 plies in each lay there by saving about 9.18 meter per week. When we use cheaper fabrics this is not seem to be a big value but when we calculate this saving for an year production then 9.18 meters per week means nearly 477 meters per year. This is a good saving. This worked example is to show you there are several ways for planning to achieve target and the apparel engineer to weigh the merits of different options and to make decision which promote efficiency of action. The optimum batch size is called the economic quantity. The function of cut order planning is to authorize the issuing and processing of economic cut quantities.

Width of Fabric

Marker Type

Number of Sizes

Marker Utilization

Contract Details

Fabric Properties

Essential Laying Losses

Quality Constraints

Economic Cut Quantity

Labour Costs

Equipment Constraints

Material Availability

Sewing Room Needs

Production Rates

Delivery Deadlines

Disruptions

Customer Requirement

Let us prepare a cut plan in detail for an order quantity of 2500 pieces in three different colours in the ratio 1:2:1 for Red, Blue and Green. The order has to be prepared for S, M, L, and XL sizes in a size ratio 3:2:1:1 the technical parameters are, we can put only 7 garments in a marker and can only put 50 plies in a lay. The sewing department has a production capacity of 315 pieces per day. The cut plan can be describes as the below, but the production schedule is little different, and there are more options described, this cut plan will just feed the required for sewing department. The second plan shown here has a different structure that will cut buffer quantity in cutting store for some day's production. For better understanding compare the below charts as per your own.

Marker No
1

Cut plan 1 # 30211 A
Marker Sizes$_{\textbf{Cut}}$ **Spreading**
S M L XL Colour Ply Units Total RED BLUE GREEN 3 2 1 1 1 Red 45 315 315 315
3 2 1 1 2 Red 45 315 630 315
3 2 1 1 3 Blue 45 315 945 315 3 2 1 1 4 Blue 45 315 1260 315 3 2 1 1 5 Blue 45 315 1575 315 3 2 1 1 6 Blue 44 308 1883 308 3 2 1 1 7 Green 45 315 2198 315 3 2 1 1 8 Green 45 315 2513 315

Total Cut Qty Required
Difference

Cut Qty 630 1253 630
1077 718 359 359 Required Qty 625 1250 625
1071 714 357 357 Difference 5 3 5 6 4 2 2
Total Cut Qty 2513

Let us consider the situations, this plan is for marker and cut plan, there cutting program has to be made with this chart, the chart shows the dates for cutting with which marker and which quantity etc. for better utilization.

More methods can be revealed in combination, for example the contract details of the following order are, S:M:L with quantities 300, 600, 400 the constraints on lay dimensions are ,

Maximum lay height = 75 plies
Maximum lay length = 5 garments marked

The theoretical minimum number of lays required to cut the contract is,
Maximum number of garments per lay = 5 x 75 = 375
Number of garments required = 300 + 600 + 400 =1300
Hence, the minimum number of lays = = 3.47

This gives a practical minimum of four lays to cut. If the contract is to be cut al lowest cost, the lay need to be as long and deep as possible. Consequently, a target can be identified as,

S S S S S Lay 1 - 60 plies 60x5=300 S
M M M M M Lay 2 - 75 plies 75x5 =375 M
M M M L L Lay 3 - 75 plies 75x 3 =225 M, 75x2 = 150 L L L L L L Lay 4 – 50 plies 50x5 = 250 L

There are other methods possible, but this method is also used to record the cut order. While considering the various available options it is necessary to calculate the labour and material cost required for each type of methods. And after carefully analyzing those data, then select the most economical method for the production.

Costing a cut order plan – Material Cost

Costing a cut order plan is most important, and this will give exact details of economic implications, etc. for better understanding let us work out with practical details, consider we have an order of 1200 garments with the following details identified.

Quantity 1200
Sizes A B C D E
Ratio 1 2 4 2 1

Single garment Marker length 2.0 2.2 2.4 2.5 2.6
End allowances - 3cm per lay
Maximum number of plies - 100
Maximum lay length - 10 m
Cost of fabric - $ 3.0 per meter let us work out the cost with this data,

Target Quantity per size = A, B, C, D, E = 120, 240, 480, 240, 120
Average fabric consumption = 2.34 mtr.
Number of garments in a marker = = 4.27 hence possibility is 4 garments only.

Minimum number of lays = = 3

Since, quantities are not in multiples of 100's three lays is an impossibility consequently the target must be about 4 lays. We can develop many methods for this cut plan options, the best one are followed to do further.

Order A B C D E A A E E Lay - 1 60 plies 120 0 0 0 120 B C C D Lay - 2 80 plies 0 80 160 80 0 B C C D Lay - 3 80 plies 0 80 160 80 0 B C C D Lay - 4 80 plies 0 80 160 80 0

TOTALS 120 240 480 240 120 1200

This plan has utilized the simple ratio between sizes so that only one marker need to be prepared for lays 2 to 4 hence, the total number of markers made are two and the quantity of cutting for marker 1 is one and marker 2 is four to get the total quantity cut.

Calculating material cost is calculated systematically as, calculate the marker length, add on the ends waste to obtain the ply lengths, multiply by number of plies to obtain the lay length and finally express this as cost.

Marker length for lay 1 = (2.0+2.0+2.6+2.6) x = 8.740 m

Marker length for lay 2 to 4 = (2.2+2.4+2.4+2.5) x = 9.025 m Ply length for lay 1 = 8.740 + 0.030 = 8.770m Ply length for lay 2 to 4 = 9.055 + 0.030 = 9.055 m
Lay length for lay 1 = 8.770 x 60 = 526.20 m
Lay length for lay 2 to 4 = 9.055 x 80 = 724.40 m
Hence, *Material cost* is
Total length of fabric = 526.20 + (724.40 x 3) = 2699.40
Total cost = 2699.40 x 3 = $ 8098.20

This calculation is assumed that the consumption of garment is included the marker efficiency, if separate efficiency is included additions are to be made with the fabric.
Costing a cut order plan – Labour Cost
Labour cost is also important as material cost, a proper planning should be made with reduced labour cost. For better understanding we can go with a work out example.

Quantity 1200
Sizes 36 38 40 42 44
Quantity 100 150 200 175 75

Single garment Marker length 2.0 2.1 2.2 2.3 2.4
We need some other details, as below, all time are in Standard Minutes

1 Garment 2 garment 3 garment 4 garment Spreading time / ply (min)
Fabric saving %
Marker Preparation time (hr.)
Fabric Cost
Cutting Time per garment marked
Maximum cutting height
0.75 0.80 0.85 0.90 0 2 3 6 0.5 0.75 0.90 1.0 = $ 4 per meter
= 15 minutes
= 100 plies

Maximum number of garments/ marker = 4
Labour cost = $ 2 per hour
Ends allowance = 4 cm per ply
For the easy learning we will start with a cutting plan make use of three garments marker.

44 44 44 25 plies – cut 1
First we have to find out the material requirement,
Marker length (3 x 2.4) x 97/100 = 6.984 m
Ply Length 6.984 + 0.040 = 7.024m
Lay length 7.024 x 25 = 175.60 m
Material cost 175.60 x 4.00 = $ 702.40

Time for marking = 0.90 x 60 = 54.00 minutes Time for spreading = 0.85 x 25 = 21.25 minutes Time for cutting = 15.0 x 3 = 45.00 minutes

Time for all requirements = 54.00 + 21.25 + 45.00 = 120.25 minutes = 2.00 Hrs Labour cost = = $ 4.01
The above method when followed for the cut order plan as follows for the current scenario,

Order 36 38 40 42 44
44 38 38 42 Lay - 1 60 plies 150 75 75
36 40 40 42 Lay - 2 80 plies 100 200 100

Material cost,
Marker length for lay 1 = (2.4+2.1+2.1+2.3) x 94/100 = 8.366 m Marker length for lay 2 = (2.0+2.2+2.2+2.3) x 94/100 = 8.178 m Ply length for lay 1 = 8.366 + 0.040 = 8.406 m
Ply length for lay 2 = 8.178 + 0.040 = 8.218 m
Lay length for lay 1 = 8.406 x 75 = 630.45 m
Lay length for lay 2 = 8.218 x 100 = 821.80 m
Material cost lay 1 = 630.45 x 4.00 = $ 2521.80
Material cost lay 2 = 821.80 x 4.00 = $ 3287.20
Total Material cost = $ 5809
Labour cost,
Time for marker making (lay 1 to 2) = 1.00 x 60
Time for spreading (lay 1) Time for spreading lay 2
Time for cutting (lay 1 -2) Total time requirement Lay 1 Total time requirement for lay 2 = 0.90 x 75 = 0.90 x 100 = 15.0 x 4 = 60.00 minutes = 67.50 minutes = 90.00 minutes = 60.00 minutes

= 127.50 minutes = 2.125 Hr. = 150.00 minutes = 2.5 Hr. Labour cost for lay 1 = 2.125 x 2 = 4.25
Labour cost for lay 2 = 2.5 x 2 = 5.00
Total labour cost = $ 9.25
Total material cost = $ 58020
Hence, total cost for cutting the contract = $ 5818.25

Cutting instruction

Cutting instruction is the main documentary output of the cut order planning process. It is known by a variety of names in industry such as, cut order, cut sheet, lay sheet etc. the document appears in a variety of forms depends on the local needs. But as a minimum requirement the cutting instruction must have the following information's as shown in the form below. In a manual management information system (MIS) the issue and progress of cutting instructions are recorded. It is to assure that the garments are cut in the correct ratio of sizes and in other way avoid loss of control this enables the manager to know what work is in progress, what are the overdue and need of processing, weekly production data etc. now a days computerized production management systems allow the same in system records for monitoring.

CUTTING INSTRUCTION

Style No
Marker Length Marker No Cutting Instruction Lay Length Date Issued

FABRIC TO BE CUT

Fabric Sizes Quality Marker Quantity Width Required Colour Layed LAY Checked by Cut

Bundled
GARMENTS TO BE CUT Total Signed
DETAILS OF PURCHASED MATERIALS Lot no
Piece No

Rack No
Length Issued (M) Knitted weight No of

Issued (Kg) Plies Remnant Faulty Fabric$_{\text{RemarksLength Length}}$
TOTALS Total Fabric Issued No. of faults Length credited for Remarks allowed faults
Returned Fabric (for reissue or for a claim against supplier)
Fabric reconciliation

The importance of fabric reconciliation is, for the lay, comparison is to be made between costed and actual usage of fabric. And the variance is reported and recorded. This document plays an important role to an Apparel engineer to calculate and compare what they have planned to do and what achieved.

Fabric reconciliation is done after the fabric is been cut. For the better understanding let us work out with a problem.

Rating of fabric usage = 1.53 m/ garment
Fabric cost = $2 per m
For the lay 1 , actual usage = 545 m
Number of garments cut = 360
Costed usage = 360 x 1.53 = 550.8 m Gain in fabric = 550.8 – 545.0 = 5.8 m Saving = 5.8 x 2 = $ 11.60

And for lay 2, actual usage = 463 m
Number of garments cut = 300
Costed usage = 300 x 1.53 =459m
Gain in fabric = 459 – 463 = - 4.0 (Less)
Loss = 4.0 x 2 = $8

The greatest benefit is obtained when, each styles are monitored separately as this way we can monitor the loss from early stage. Data from successive lays are recorded in reconciliation records. While the record shows satisfactory results, there may occasions when the record of cloth usage reveals significant losses against costed values. It is necessary then to take action to control this.

FABRIC RECONCILIATION RECORD

STYLE #32567 **Rating of Fabric** 0.55 m/gmt **Week End** 19/3/2016 **Fabric Cost** 1.50 $ per m

Lay Garments Actual Costed number Cut usage m Usage m 173 480 260.5 264.0 180 480 265.2 264.0 192 480 269.2 264.0 197 240 133.6 132.0 218 240 132.4 132.0 235 480 262.0 264.0 236 480 263.7 264.0

Fabric Variance Monetary Benefits Gain Loss Gain Loss

3.5 5.25
-1.2 -1.80
-5.2 -7.80
-1.6 -2.40
-0.4 -0.60

2.0 3.00
0.3 0.45
5.8 -8.4 8.70 -12.60
TOTAL -3.9

Methods, procedure, productivity, micro motion study, OB, skill matrix, thread consumption, lost time, Production study

6 Work Study

Work is the basic source of our livelihood. We regard work differently at different points of time. Our attitude towards work changes from time to time, and is different from culture to culture. Work design is a study and the design of a work system in an organizational context. In a production unit work exists and so do the work problems originating at individual work stations. The man – material – machine combination is the focus of any work problem. This a part of the entire organization or work system. Work design is systematic investigation of desired and present work systems to get ideal work system and methods to produce the optimum result i.e. the productivity of the system. Work systems are to improve productivity and effectiveness, it goes beyond a set of techniques, since it need continuous monitoring. The objectives could be increased productivity and higher effectiveness. Workstudy is one of the techniques of enhancing productivity. Workstudy should be applied properly with due support from employees and management to enhance productivity. The workstudy can be graphically represented as,

Work Study
Method Study Work Measurement Erganomics Incentives

Workstudy is defined as a technique that embraces method study and work measurement which are employed to ensure the best possible use of human and material resources in carrying out the specified activity. The main objective of workstudy is to improve productivity of men, machine and materials.

Method study is the systematic recording and critical examination of existing and proposed ways of doing a work as to develop and apply easier or more effective methods and to reduce cost. Work measurement is the application of techniques designed to establish the time qualified worker to carry out a specified job at a defined level of performance.

Both the above concepts, method study and work measurement, are closely related each other. The former tend to reduce the work content and the latter establishes time standards on the basis of work content as determined by the former. Hence, generally method study precedes work measurement time study is also enables comparison of alternative methods.

Basic Work Study Procedure
Workstudy consists of basic eight steps, some of which are common to both method study and work measurement. The basics steps are explained below,
To conduct method study, we should have a conductive human relations climate, and other supports and coordination. Workstudy if properly applied, tends to improve industrial relations. There may be resists from skilled senior workers however in a long run the technique benefits all. Workstudy is to be conducted by a properly qualified person who can win confidence of both the supervisors and the workers. He should be able to deal with people. The WS results are to be applied with tact. There is always an improvement possible in a process. Method study involves the breakdown of an operation into its component elements and the elements are analyzed.

No
1

2
3
4

Basic Step MS WS Select √ √ Record √ √ Examine √ √ Develop √ √

5Measure √
6 Define √
7Install √√
8 Maintain √

Analytically method study involves the basic procedure of Select-Record-examine-develop-installmaintain sequences. The merit of the basic procedure is that, whatever be the job or its size, it can be approached and dealt with on a common pattern.

SELECT the job to be studied by making sure it is worthwhile spending time to improve it. There are several factors to be taken into consideration while selecting a work to be studied.

1) Economic Considerations: - if the economic considerations of a job are small, then there is no reason to continue a long investigation. Some questions to need to be answered like – will it pay to begin a method study of this job?, and will it pay to continue study? Some primary choices like bottlenecks, movement of material over long distances, operations involving repetitive work etc.

2) Technical Considerations: - it must be clear if there is enough technical knowledge to carry out the study such as settings on a fusing machine, etc.

3) Human reactions: - as mental and emotional reactions to investigations and changes of methods play a big part in the process. Human reactions are important factors to take into consideration. All the necessary unions and personnel should be involved in the process. If at any time a particular process is causing conflict leave the process alone.

Cost is the basis for the selection of operations, sections or departments likely to benefit from the method study. The following defects in an organization indicate where method study is likely to bring worthwhile savings.

a) Poor use of materials, labour or machine capacity, resulting in high scrap and reprocessing costs. b) Bad layout or operations planning, resulting in unnecessary movement of materials c) Existence of bottlenecks
d) Inconsistencies in quality
e) High failure of work
f) Excessive overtime
g) Employees’ complaints about their work without logical reasons.

The question is whether a change is likely to achieve the following results sufficiently to make the cost of the study worthwhile;

a) Increase production and reduce cost
b) Maintain it with less labour, material or equipment
c) Improve quality without additional labour or equipment
d) Improve safety conditions

e) Improve standards of cleanliness and housekeeping
f) Reduce scrap.
When all these matters have been weighed up in the light of the economic importance of a task and its expected life, Apparel Engineer should be able to select the work to be investigated. It need to list the objectives for the study in order of priority. Both in selecting objectives on the large scale, and in choosing the economically appropriate methods, mathematical techniques like "Operations research" are also used along with method study.

RECORD every detail about the job even if it seems to have no effect on the method. Sometimes the most minor detail can lead to a method improvement failure. The ASME symbols – Therbligs – are used to record the along with other methods.

The activities selected for the investigations may be visualized in the entirely, with a view to improving them by subsequent critical analysis. a record of all the details is important to have a comparison between present and previous methods and their pro's and con's

Recording Techniques

Recording technique fall into two categories depending on the nature of the job and the purpose for which the record is required. At times both techniques are used to present a complete record. The information for the recording technique is obtained by the following methods.

Visual observation
Calculations
Photographic & videography techniques
Special knowledge and expertise.

There are basically two types of records are made,
1. Charts – for process and time records
2. Diagrams and Models – for path of movement and comparison

Type of Charts used are,
1) Outline Process chart
2) Flow process chart
3) Two handed Process chart
4) Multiple activity chart

5) Simultaneous motion cycle (SIMO)Charts

6) Travel Charts
Major type of Diagrams and Models are,
1) Flow and String Diagrams

Principal operations and inspections
Activities of men, material, or equipment
Activities of a worker's two hands.
Activities of a men and or machines on a common timescale.

Activities of a worker's hands, legs and other body movements on a common time scale.
Movements of materials between departments etc.

2) Two and Three dimensional models
3) Cycle graphs and chronocycle graphs Path of movement of men, material or equipment Layout of workplace and plant
High-speed and short cycle operations.

All these recording techniques are already explained in the chapter 1, whatever the type of chart or diagram prepared, care should be taken to ensure the information's recorded in it are easy to be understood and recognized.

There are *"Make Ready*" and *"Put Away"* operations which deals with the preparation of material plant of equipment to enable the "do" operations or "inspection" to be performed and with the placing aside of cleaning up after the "do" operation or inspection.

The *"Do Operations"* are the actual performance of work on the material or work with plant and equipment. Care to be taken so that the following data are included in the chart or diagram.

a) An adequate description of all the activities or movements involved in the method b) Whether the present or proposed method is shown in the record.
c) Specific reference to where the activities begin and end.
d) The time and distance scale used.
e) Explanation of any abbreviations or special devices used.
f) The date of construction of the chart or diagram.

Models are always useful in assisting the development of new layouts, and as visual aids to explain and discuss problems and proposals with other peoples easily. Besides models other aids are such as templates, and translucent planning materials are also used.

In the case of detailed investigation at a workplace where the operations may be very short duration, of performed at a high speed or where several jobs are being carried out simultaneously the observer may be unable to distinguish movements accurately enough for recording purpose in such situations photographic or video graphic recording methods are best suit. There are some advantages of this method.

a) A permanent record of work being studied is obtained
b) A record can be referred to at any time, in any place by any number of people c) An excellent means is obtained for demonstrating differences in methods, and which is valuable

aid in training new method.
d) Reproduction of the original method is possible at any time after the improved method has been
installed.
e) Repeated study of worker's activities can be made without disturbing the operator at frequent
intervals.
f) The examination of intermittent work can be processed when the work itself is not actually in
progress.
g) The recorded videos can be projected / inspected to any required speed and can be stopped at

any convenient point for observation.
h) They can be run backwards, which sometimes enables clumsy or backward movements to be
more easily detected.
i) Digital records gives more accuracy than pencil, paper and watch techniques j) They are more convenient, better than eye observation, and are positive record.

EXAMINE is the step comes after record. Critical examination of the facts collected and recorded in some form, as explained earlier, is need to solve problems. The best known approach to “examine” is the questioning technique. Which means, each activity is examined though systematic series of questions. There are, Primary and secondary questions.

The first stage is to question the need for performance, place, sequence, person, etc. and the second stage is to questions the answers of the first stage subject to further query to determine whether possible alternatives are there, the basic aim is to measure any chance of improvement is possible over the existing method.

What we have to take care is that, each activity, in its turn, is subjected to the questions, the key activities are questioned first and then other. All the primary questions are need to be satisfied first. The primary questions aim at reaching conclusions on five cardinal points such as, purpose, place, sequence, person means. Once these conclusions have been reached then we can go with the secondary questions. The objective of secondary questioning is to discover all the possible alternatives for each of the five principal points and then finally, to reach a decision as to which alternative should be adopted for optimum results.

All the conclusions reached after the primary stage of questions must be collected and recorded at the end of primary examination. Then narrow down the range of alternatives that will present themselves for consideration.
SECONDARY QUESTIONS

PRIMARY QUESTIONS Possible alternatives Selected alternatives What is achieved? Is it necessary? Why?
What else could be done? What should be done?
Where is it done? Why there?

When it is done? Advantages:
Disadvantages: Why then?

After:
Before:

Who does it? Advantages:
Disadvantages:

Why that person Where else could it be? Advantages:
Disadvantages
Where should it?

When should it? When else could it be? Advantages:
Disadvantages

Who else could do it? Who should?

How is it? Advantages: Disadvantages Why that way? Advantages: Disadvantages

How else could it be? How should it?

Advantages: Disadvantages Advantages: Disadvantages

The 10 major factors explored during operation analysis, together with typical questions which should be asked about each factor, are as follows:

1. Purpose of operation
a. Is the result accomplished by the operation necessary?
b. Can the purpose of the operation be accomplished better in any other way?

2. Design of part
a. Can motions be eliminated by design changes which will not affect the functioning and other desirable characteristics of the product?

b. Is the design satisfactory for automated assembly?
3. Complete survey of all operations performed on part
a. Can the operation being analyzed be eliminated by changing the procedure or the sequence of operations?
b. Can it be combined with another operation?
4. Inspection requirements
a. Are tolerance, allowance, finish, and other requirements necessary?
b. Will changing the requirements of a previous operation make this operation easier to perform? 5. Material
a. Is the material furnished in a suitable condition for use?
b. Is material utilized to best advantage during processing?
6. Material handling
a. Where should incoming and outgoing material be located with respect to the work station? b. Can a progressive assembly line be set up?
7. Workplace layout, setup, and tool equipment
a. Does the workplace layout conform to the principles of motion economy? b. Can the work be held in the machine by other means to better advantage? 8. Common possibilities for job improvement
a. Can ‘‘drop delivery’’ be used?
b. Can foot-operated mechanisms be used to free the hand for other work?
9. Working conditions
a. Has safety received due consideration?
b. Are new workers properly introduced to their surroundings, and are sufficient instructions given them?
10. Method
a. Is the repetitiveness of the job sufficient to justify more detailed motion study? b. Should full automation be considered?

As a second stage of conclusion, which is mostly depend on the toughness of the primary questioning and initial examination. It is necessary to record the advantages and disadvantages of all alternatives for better method development. The unnecessary

advantages and disadvantages should be excluded to maximum. Finally list out the list of alternatives, which have its own advantages and disadvantages evaluated against the intention of the investigation. And then the next stage starts.

The results which the critical examination technique can achieve will be influenced by the attitude of mind of the Apparel Engineer. The final result will depend upon the skill with which he has examined the recorded facts. The engineer should pay attention to the following points.

Examine the facts as they are, not as they appear to be, or ought to be.
Should not be influenced by preconceived ideas, which often colour the interpretation of facts. Challenge all aspects of the problem and accept no answer until proved correct.
Avoid any hasty judgments
Should not ignore the smaller details, they are sometimes just as important as the major ones. Put aside any “hunches” or “bright ideas” until the appropriate places in the investigation. Should not consider new methods until the undesirable features of the existing method have been exposed by systematic examining

Both primary and secondary questions are asked for each aspect before passing on to the next. By this means it is hoped,

To challenge the facts of the present method
To discover possible alternatives.
To determine the most suitable alternative.

DEVELOP a New Method commences at the final stage of the questioning, where the examiner will have determined,

What activities are vital to the objective
What is the order of their performance
What activities might be combined
Undesirable features that should be eliminated
List of alternatives for the key activities, etc.

The development of the new method is simplified by extracting and working with the key activities that are suggested by the conclusions of the critical examination. These are the activities vital to the objective. With the background factors in mind, alternatives for each activity need to be selected. When alternatives are selected we need to examine their supportive links, which also need to be established, and a proposed method can be charted. The new chart is to be,

Checked for details and further improvements
Compare with any alternative methods developed
Compare with present method to estimate savings
Become part of the basis for defining the new method.

One aspect of evaluation to be done at this state is to test the vital features by experimentation. Mistakes, if any, must be discovered and corrected before they do harm. It is necessary to do trial before installing the new method, such trials are to,

Check each feature is practicable and safe.
Ensure that quality standards are met

Discover and eliminate difficulties and
modify or incorporate any suggestions
check services required to operate smoothly
Check assessment of staffing and training requirements.

Where and how these experiments are to be carried out depends on the floor conditions. If test runs are carried out in the floor area, there are some disadvantages that can only be offset by quality of corporation existing between the personal involved. If operators can see and agree with the need for the improvement then the obstacles are minimized. But it is preferable to do a test run in the advanced training rooms at first stage with an expert tailor and then implement on floor.

INSTALLATION is the final stage and this has five stages,

1) Acceptability of change at the supervisory level
2) Acceptance of the change at the works managers level
3) Acceptability of change at the workers union level , in some situations
4) Retention of workers to operate new system
5) Continuous monitoring to see the application of new method.

Actually the stage five comes under the maintenance. There may be casual changes due many factors which need to be studied carefully after installation.

It is important to realize that improving the method is not simply having good ideas. It is necessary to make sure that your “improved’ method has been properly thought out and that it in fact gives result as you expected.

The final stage of the basic procedure is perhaps the most difficult of all. It is at this point that active support is required from management operators alike. It is here that personal qualities of apparel engineer and his ability to explain clearly and simply, what they are trying to do, and their gift for getting along with other people and winning their trust becomes of the greatest importance.

Preparations for Installation

The installation of a new method is not simple as it may appear to be. Detailed preparations must be made before the actual installation happens.
One person only should have the responsibility during the installation. Whilst the engineer will be

responsible for the training and re-training of the workers. He must make certain that from the beginning itself, everyone understand that he cannot give executive decisions, and that the instruction concerning the introduction and application of the new method must come from the department manager or supervisor to the worker in the first instance.

If the installation is to take place in stages, then the stages must be selected to be convenient for both personnel and process.

Copies of any time-table to cover the installation should be brought into line with the dates selected for each stage. If the installation is likely to be a prolongs procedure, it may be necessary in preparing this timetable to consider (a) existing work in progress levels and (b) maintenance of a good flow of work through the department

All layouts should be checked in detail to ensure that the necessary machines, guides, and other equipment are available. And that the services are laid on. Everything special required should be ordered and delivered to in-house in accordance with the timetable.

Prepare any new clerical records which are required
Select and train the operatives as required. Careful selection and thorough training is essential where

team work is involved. Try to avoid any difficulties which may arise between those selected for the new method. And those remain on the old method.
Provide the necessary training away from the production line, preferably in an independent training department, if it is possible.
Notify everyone concerned of the plans and timetable for the installation.
Only when all the detailed preparations have been made should the apparel engineer begin to install the new method. The engineer should take into consideration of the following factors,
The changeover of the machines, the workplace and the requirement should be done outside working hours. This is to keep the disturbances will be minimum

The first few days of operating the new method are critical. Extra supervision will be necessary during the period of time to enable the workers to learn the method and follow the method only. Sometimes by some expertise tailors may not accept the new method unless until they got felt effort saving.

Any minor modifications to the new method which must be made should be completed as quickly as possible.
If there are any problems with any part of the new method, the reasons should be established and the problem solved.
A small reserve of labour is useful, either to replace unsuitable personnel, or to increase temporarily the labour allotted to parts of the method. This is to avoid temporary bottlenecks due the new method

A close watch should be kept of the effect of the new method on the supply of work Tact, encouragement and retraining are required through the period of installation. Plenty credit to

the operators should be given at all time for progress made and enthusiasm should be shown at every opportunity by the engineer, particularly if there is very little progress being made by the operators at the time.

Finally, when the new method is running smoothly, and produce effective output with increased efficiency and reduced cost, the installation can be considered complete temporarily. There are five essential steps in the teaching of a new method.
1) The mind of the operator must be focused upon what is to be learned

2) The method must be demonstrated and explained well
3) The operator must be allowed to practice
4) Constant correction of faults
5) Operator must continue the same method
One of the difficulties of teaching a new method is an operator will usually feel safer doing the job by the old method and will show and unwillingness to change until

convinced that the new method is better from every point of view.
Tendency of operators retain to old habits. It is difficult to teach “old dog new tricks” some people will not accept method changes and it is therefore advisable to train new people in the new method and give the other ones different jobs.
Films or videos are particularly valuable when re-training, in breaking old habits it may be found that the operator is quite unaware of what he or she is doing. A video in slow motion will enable them to see the exact movements, and once they know, they can start to learn the new method.
Apparently the operators will be more interested in the new method if they feel they have played some part in its development. The apparel engineer should discuss the original method with the operators that will be investigated and encourage them to make suggestions for its development. The suggestions may or may not be of much value, but if they are listened to and possibly used in some form, the interest of the operator in the improvement is stimulated.
In learning a new series of movements, the operator gathers sped and reduces the time required to perform them very quickly at first, but the rate of improvement soon begins to slow up, and it required long practice to achieve really high and constant speed. It should be valued that concentration level required by the operator will increase fatigue. This situation rapidly alters, however, and once the operator has begun to grasp the new method and pick up speed, rest periods can be much shorter.

Once we know the correct time for doing a job, and we have established a good way of doing it, we can use this information for all sort of things like,

Costing ,
Pre-production planning,
Line balancing and worker allocations and Target setting
Development of incentive systems and schemes
Investment appraisal
Operator monitoring
Operator training etc.

Productivity
Productivity is the ratio of output to input and is normally represented in the following formula

Output refers the good or services produced, Input refers to all resources used in producing the output this includes, Land and buildings, materials, machines and people. The use of which is made of all these resources combined, determines the productivity of the enterprise.
It is necessary to ensure that the best use of all resources to get the better productivity. This can be achieved by coordinating the efforts to everyone in the organization to achieve the best results and to use the resources as effectively as possible.

Higher productivity can contribute to higher standard of living and will also provide,
Larger supplies of consumer goods and capital goods at lower cost and lower price with high quality Higher rate of real earnings
Improvement in working and living conditions including shorter hours of work
A strengthening of economic foundations on which the wellbeing of individuals is based

To achieve improvement or increase in productivity a country should have balanced programs for economic development. They need to take steps to maintain employment. They have to create opportunities for employment for those who are unemployed of under employed or those who become unemployed as a result of productivity improvements. Even though the general requirements are related to country planning but the main responsibility for raising productivity still rests with the management of companies, because they have the ability and resources at their disposal, to implement and create favorite conditions for this. This obviously requires cooperation from the workers and trade unions can encourage workers when they are satisfied that the productivity improvement program benefits the workers as well as the company and hence the country. It is important to distinguish between Production and Productivity. Although production may be increased it is not necessary that productivity will have increased. Let us consider the example below, The factory 1 producing 500 dress per day with 50 operators and factory 2 producing 675 dress per day with 75 operators. When we see the production factory 2 has higher production per day but when we consider the productivity ratio the factory one has 10:1 and factory 2 has 9:1 means one operator is producing 10 garments per day in factory 1 while 9 garments in factory 2. Hence, factory 1 is more productive than factory 2.
The effective use of maximum productivity of Land Buildings is an important source of cost reduction, especially when an enterprise is expanding and needs increased working space. This is achieved wither by higher production from existing land and buildings or by obtaining the same production from a smaller area of land and building.
To obtain higher productivity from machine of people, it is necessary to think in terms of TIME, since it is the output of good production from a machine or from a worker. Productivity of a worker or machine is expressed as the "output per man-hour or machine hour" where a man hour is the labour of one person for one hour and a machine hour is the running of a machine for one hour. High productivity of material is achieved by saving in materials direct or indirect are achieved in the following way,

- At the design stage or time of preparation of work specification
- By ensuring that the design is such that the garment can be manufactured with the least possible use of fabric and trims, especially when they are scarce (rare) or expensive
- By ensuring that plant and equipment specified for purchase is the most economical possible, in terms of production. For example we have to do a lap felled seam and we have only a single needle available the material and labour use are high where if we can get a double needle with lap fell folder we can sew the same seam with one worker and at a stretch reducing material use in thread and labour use and increased production rate.

High productivity is achieved where the excess work content and ineffective time for a job are small, or have been eliminated. The basic work content is a high percentage of the total time for the job. Productivity improvement may be achieved in one of the following ways;

Increase output without increasing input
Maintain output but decrease the input
Increase the output at the same time decreasing the input
Increasing input with corresponding higher increase in output
Decreasing output with a corresponding higher decrease in input.

Factors tending to reduce productivity

1) Excess work content added by defects in design or specification of product

- The bad design of the garment prevents the use of the most economic method of sewing.
- The lack of standardization prevents the use of high speed production process
- Incorrect quality standards cause unnecessary work
- The design of the garment may mean that an excessive amount of fabric has to be wasted in cutting, due to the shape of the patter parts.
- Large size of the rages and colours reduce the number of sizes which can be marked in, thereby increasing the cloth usage per size.

2) Excess Work content added by inefficient methods of manufacturing operation

- The use of wrong machines can cause reduced output
- If the method is not being adhered to, then productivity will be reduced
- Bad workplace layout causes wasted movement
- An operator's bad working method causes wasted time and effort.

3) Ineffective time due to shortcomings of management or supervisors

- Excess product variety adds to idle time, due to short runs.
- The lack of standardization adds idle time due to changeovers
- Design changes add ineffective time due to stoppages for re-training
- Bad planning of the work and orders reduces efficiency
- Lack of fabric due to bad planning causes waiting time
- Badly maintained machines causes idle time
- Machines in bad condition causes bad quality
- Bad working conditions prevent the operator from working steady, feeling comfortable.
- Accidents cause lost time
- Poor service operators cause delays, waiting for fabric etc.

4) Ineffective time within the control of operator

- Absence, lateness and laziness reduce productivity
- Carelessness workmanship causes bad quality
- Accidents due to carelessness cause absenteeism

The value of workstudy

Investigations and improvements of work at the workplace is not a new task in fact it was handled by good managers ever since the industry starts. However due to short supply of skilled managers and increasing demands placed on them it is virtually impossible to devote sufficient time and effort to investigating and providing longer term solutions. The main value of workstudy is that by carrying out its systematic procedures it provides managers with result that are better and longer term than in the present. Due to its systematic nature more time is needed to carry out a study of work as a result, it become necessary to separate this task from that of a manager. Unless all that facts are know it is impossible to ensure that any alteration to current methods will be effective. Thus it requires constant observation and study and should be the responsibility of a person who is not involved in the direct management duties. Workstudy is thus a service to management and supervision and will ensure the benefits of,

- It is a means of raising the productive efficiency of a factory or organization with little or

no capital investment
- It is systematic and ensures that no factor is overlooked
- It is the most accurate means of setting standards upon which production planning and control can take place
- The resultant savings start at once and continue for as long as the operations continue in the improved form
- It is a tool which can be applied everywhere
- It is one of the most penetrating tools of investigation available to management. To achieve the full benefit of workstudy, it should be applied in all areas of an organization and done continuously. The full effect of workstudy will only be felt in an organization when all employees become accustomed to an attitude that does not tolerate in any form, whether material, time effort or human ability. The refusal to accept without questioning that things should be done in a certain way because it is the way it has always been done.

Micro motion Studies

Two handed process charts, simo charts, cycle graphs and chronocycle graphs are used for the micro motion study of operations at the workplace. The most detailed aspects of method improvement are concerned in this studies. Micro motion analysis is expensive to conduct, and should be undertaken, if it appears economically justifiable, only after large scale improvement has been fully investigated as a result of using the other recording techniques.

In certain type of operations, particularly those with very short cycles which are repeated thousands of times (such as the packing of shirts into boxes or boxes in to cartons) it is valuable to go in much greater detailed studies to determine where the movements and efforts can be saved and to develop the best possible pattern of movement thus enabling the operator to perform the operation repeatedly with minimum effort and fatigue.

The technique used usually video recording are collectively called as micro motion study. There are software used for analysis now a days. The micro motion techniques is based on the idea of dividing human activities into divisions of movement or groups of movements according to the purpose for which they are made. We sometimes divide to the minimum level till the movement of a finger and the omissions may be in form of movements of a specific finger for which may be developing a new type of gloves to use while performing the operation to avoid movement of the finger etc.

There are many methods used to do the recording of the operation, sometimes a direct camera can be used for recording operation, but while the operator is aware that he is being recorded then there may be movement differences, it is better to make aware the operator about the study and make him work without any changes is better . In some situations indirect recoding methods like over headed camera etc. may be used for the purpose.
Micro motion study is one of the most accurate technique of work analysis. It makes use of motion pictures of the different activities or movements so with the help of camera. Very small time up to 0.0005 minute can be measured and recorded by this system. The motion time data from the movie taken is transferred to the simo chart. The simo chart data can be further analyzed for the purpose of work place layout or method improvement. This technique was developed by Fran Gilbreth who considered that an operation consists

of minute elements which may be repetitive or non-repetitive. He termed these elements as Therblig. The micromotion study can be used,

- To study the nature and path of movements for obtaining the elements of an operation.
- To study the activities of the machine and the operator
- To impart training to the workers or operators regarding motion economy so that unnecessary

movements by the workers may be avoided.
- To study the relationship between the activities of operator and the machine.
- To keep permanent record of the most efficient way of performing a task for future reference.
- To obtain motion time data for developing synthetic time standards for various elements
- For carrying out research in the field of method and time study.

Operation Break down (OB)

Breakdown is a listing of the content of a job by elements. A garment consists of some parts and some group of operations. Breakdown means to writing down all parts and all process/operation after one another lying with the complete garment according to process sequence. It is a must to write down the estimated SMV and type of machine beside each and every process.

Operation Breakdown Procedure:

1. Floor section leader, team leader technician and work study officer must sit together to make breakdown.
2. Technician breaks the garments into parts an gathered the parts one after another by operation/process
3. Then work study officer and floor section leader fox up the SMV of those operation
4. By proceeding this technique when all process completed need to summarize all process SMV and the total will be called as respective garments SMV

Benefit of Operation Breakdown:

Can see the all operations of the garments at a time.
Can anticipate the difficulties of doing critical operation
Can make layout in a easy, simple and less time consuming way.
Easy to select right operator for right process.
Can know the quantity and types of machine to make the garment required. Can be conscious about quality for fill up the buyer standard.
Breakdown can know about additional guide, folder and attachment.

Calculation of Operation Breakdown:
Analysis of Operation Breakdown:

To calculate capacity study, first we have to take at least five readings of each worker of all process.
Then we have to calculate the average value of these five readings
After then, the SMV calculation
Then target calculation (60/SMV)

SHIRT SEWIN - FULL SLEEVE FORMAL
Sl. No.

Operation List
SAM
M/c

1 Pinning to profile 0.234
2 Run stitch collar (profile) 0.219 SNLS
3 Trim collar 0.285 SNLS
4 Clip and turn collar 0.223
5 Crease collar 0.381
6 Top stitch collar 0.42 SNLS
7 Run stitch (R/s) collar band 0.291 SNLS
8 Crease collar band 0.317
9 Insert collar in neck band 0.799 SNLS
10 Turn and crease collar 0.452
11 Hem cuff 0.501 SNLS
12 R/s cuff 0.565 SNLS
13 Turn cuff 0.527
14 Crease cuff bottom 0.566
15 Attach pl acket to sl eeve 0.795 SNLS
16 Lock and make diamond 1.026 SNLS
17 Sew pleats (4 no.) 0.389 SNLS
18 Hem right front 0.494 SNLS
19 Attach front pl acket 0.603 SNLS
20 Crease pocket 0.542
21 Hem pocket mouth 0.28 SNLS
22 Attach pocket to front 0.861 SNLS
23 Attach brand label and tack loop 0.589 SNLS
24 Attach yoke to back 0.475 SNLS
25 Top stitch back yoke 0.365 SNLS
26 Join shoulder 0.64 SNLS
27 Top stitch shoulder 0.656 SNLS
28 Attach collar 0.535 SNLS
29 Close collar with size label 1.01 SNLS
30 Sl eeve attach 0.862 SNLS
31 Top stitch armhole 0.678 SNLS
32 Top stitch side seam 1.036 FOA
33 Attach & close cuff 0.696 SNLS
34 Top stitch cuff 0.524 SNLS
35 Hem bottom 0.947 SNLS **Total SAM 19.783**

hemmer

Machine Nos SNLS 26
FOA 1
Button Hole 1
ButtonSew 1

Fusing Machine 1
Steam Press 1
31

att/ oth

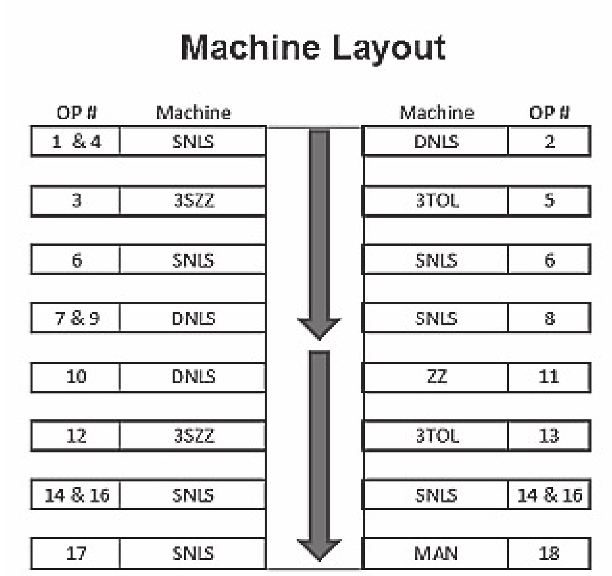
Manual

EC
Turner
Hand/iron

Hand/iron
Hand/iron
Hand/iron Hand/iron
Hand/iron binder

Operation Breakdown: Bra

OP # SEWING PROCESS SAM MACHINE
1 Join Cups 0.57 SNLS
2 Attach Tape to Cups 0.73 DNLS
3 attach Elastic to side cups 0.44 3SZZ
4 Set support Panels 0.39 SNLS
5 Serge support panels 0.62 3TOL
6 Join support panels, cup and front 1.52 SNLS
7 Attach coverstitch tape to front 0.61 DNLS
8 Join backs to cups 0.55 SNLS
9 Attach coverstitch tape to sides 0.47 DNLS 10 Attach lace and tape to cups 0.76 DNLS 11 Attach elastic to band 0.9 ZZ 12 Attach upper elastic & straps 0.91 3SZZ 13 Cover support panels edges 0.54 3TOL 14 Attach hooks and eyes to straps 1.39 SNLS 15 Set eye to back 0.36 ZZ 16 Set hook to back 0.5 SNLS 17 Attach trimming to front 0.25 SNLS 18 Trim thread and inspect 1 MAN Total SAM **12.51**



Skill Matrix for Sewing Operator

Skill Matrix is a chart or a database where operator's past performances on various operations are recorded in a systematic way for the future reference. In a skill matrix operator performance is recorded in efficiency percentage. Skill matrix is also called as skill inventory of the operators. A basic skill matrix is shown in Figure7a. Skill matrix is updated on a regular interval. Or after completion of each style operator's current performance (efficiency %) updated on the database (for manually developed skill matrix)

The benefits of an operator skill matrix are enlisted below.

It keeps record of all operations an operator had done in the past and efficiency level in each operation.
Engineers / line supervisors need minimum time to find and select most efficient operators for an operation from the pull of operators.
For line balancing, operators can be selected according to work content. For example – where an operation is required 50% less time than pitch time, engineers can select an operator whose efficiency level is 50% on that operation.
When operation clubbing is required (for less work content works), skill matrix gives the information what all operation to be given to an operator.
When someone is absent, supervisor can easily find suitable person from the skill matrix table and replace.

A skill matrix can be made in spread sheet. Or real time shop floor data tracking system can be used for skill matrix development. In the skill matrix, a user can do sorting of operator performance in various operation and other way in a operation how many operator are there who had earlier worked on and their efficiency level.

Preparation of operator Skill Inventory (Skill Matrix):
A standard work minute library is developed by measuring the amount of time taken by a good worker to do various tasks, measured by the stopwatch as given in the following Table.

Once the skill matrix has been developed, for the setting of production line with respect to new style the pattern maker decides the production type, production steps in the sequence and the amount of

Table 1: Study of operation performance of three expert operators

Operator	Sequence		
	Collar Attach	Sleeve Attach	Pocket Attach
A	100%	70%	120%
B	80%	90%	100%
C	110%	80%	80%

work for each production step. Then he uses the standard work minute library to determine the number of standard work minute needed for each tasks.

Allocation of Operator's

Appropriate allocation of the skill operators for particular operations is the keystone for any line balancing in the garment industry. Allocation also depends on type of balance required. One approach of allocation is to find the closest match between operators required and operators available. This type of allocation results in intrinsic balance of line. Another approach is the effective utilization of operator's skill so far he can do the best, this approach results in dynamic balance of line.

From the Tables 2 and 3 for a setting the operators are selected as B-A-D because the operational efficiencies of these operators are as per the required for the particular jobs which will have the effective use of all operators' skills.

Table 2: Operators performance required with respective operation

Operator	Operation's	SAM	Machine	Target (Pieces)	Operators Performance Required (%)
A	Collar Attach	1.5	SNLS	40	100
B	Sleeve Attach	1.2	SNLS	48	80.0
C	Pocket Attach	1.0	SNLS	60	66.0

Table 3: From operator's skill inventory the operator performances available are

Operators	A	B	C	D
Collar Attach	70%	105%	-	140%
Sleeve Attach	80%	-	100%	-
Pocket Attach	120%	70%	100%	70%

By considering this details, and calculating the required output in comparison with the time and efficiency levels, we can distribute labour force between operations. This step is done usually after doing the line balancing.

Thread Consumption

Several factors determine the extent of thread consumption in any sewn product, such as stitch type, seam type, material thickness, number of layers, construction and SPI (stitches per inch).

However, these factors are not constant with the different style preferences. Hence, thread consumption is never standard for sewn product categories such as shirts, trousers and footwear.

There are two methods generally used to calculate the amount of thread in a seam and hence the thread consumption in the sewn product:

By measuring the actual amount of thread consumed

By calculation using thread consumption ratios

1. Measuring Actual Thread Consumed

A specified length of a given seam is measured and then the thread is pulled out of this length. We can use the amount pulled out of this specified length to calculate the ratio of thread consumed in the entire seam. By dividing the amount of thread by the seam length, we get the ratio of thread consumed. If we multiply this factor times the total length of seam, we can determine the total thread consumed for that seam.

Example:
Length of seam = 100 cm (1 metre)
Stitch class 401 = 2-Thread Chain stitch
Length of seam for which thread is removed = 15 cm
Needle thread removed = 19.5 cm
Needle thread factor = 19.5/15 = 1.3
Looper thread removed = 62.0 cm
Looper thread factor = 62.0/15 = 4.1
Total Needle thread = 100 cm x 1.3 = 130 cm
Total Looper thread = 100 cm x 4.1 = 410 cm
Total thread consumed = 130 + 410 = 540 cm
Add 15% wastage = 540 cm x 1.15 = 621 cm

Generally, 10% to 15% wastage of thread is added to the consumption derived. This wastage occurs due to shop-floor conditions like machine running, thread breakage, repairs, etc. The above example shows the total thread consumed for one type of stitch class in a garment. By following a similar procedure, you can calculate the thread consumed for different stitching operations in a garment.

2. Thread Consumption Ratios

The easier method is to use the generally applicable Thread Consumption Ratios for the various stitch types that are listed in the table below. By relating these ratios to the length of seams using each stitch type, total thread consumption can be calculated.

Stitch Description Class

301 Lockstitch
101 Chainstitch
401 Two Thread Chain Stitch
304 Zigzag Lockstitch
503 Two Thread Overedge Stitch
504 Three Thread Overedge Stitch
512 Four Thread Mock Safety Stitch
516 Five Thread Safety Stitch
406 Three Thread Covering Stitch
602 Four Thread Covering Stitch
605 Five Thread Covering Stitch

Total Thread Usage (cm per cm of seam) / Thread Ratio
2.5

4
5.5
7
12
14
18
20
18

25
28

No. of Needle Looper / Under (incl. Needles Thread % Cover) Threads %

1 50 50
1 100 0
1 25 75
1 50 50
1 55 45
1 20 80
2 25 75
2 20 80
2 30 70
2 20 80
3 30 70

The above ratios are arrived at with a stitch density of 7 stitches per cm (18 stitches per inch). These ratios are the prescribed minimum in regular conditions and marginally vary with the factors affecting thread consumption.
A certain percentage of wastage is to be added to the above ratios as per shop floor conditions. It may vary from 10% to 15%.
Example
Thread consumption for an average-sized knitted t-shirt
Stitch
Type
Seam
Thread
Total Thread
Consumption NT LT Length (m) Ratio (m)

301 Lockstitch 4 2.5 10 5 5
504 Three Thread Overedge Stitch 3 14 42 8.5 33.6
401 Two Thread Chain Stitch 0.75 5.5 4 1 3
503 Two Thread Overedge Stitch 0.95 12 11.4 6.3 5.1
101 One Thread Chain Stitch 0.1 4 0.4 0.4 0
Total thread consumed 67.8 21.1 46.7 Wastage (15%) 10 3 7 Total after considering wastage 77.8 24.1 53.7

These days, thread consumption and costing can be calculated without the need to pick the thread from seams. There are easy programs available to use with,

American & Efird Thread Consumption Calculator Light Wt. Fabrics
Fill in the information highlighted in 'yellow' Company Name:
ABC MFG. COMPANY

Thread Description (ex. Tex Ok to change (ie, Topstitching) Size / Brand / Clr) Thread #1 T -24 Perma Core
Copy & Paste from column "M" to Column "O"
= T -24 Perma Core

Garment Description:
CASUAL SHIRT - SHORT SLEEVE SIZE: Large

= = = = =

Cost Per Garment = 0.0049 US $
Rows Seam Needle Needle

Oper
Name of Operation ISO of Length Thread Thread Stitch Stitch SPI CM Metres Tex / Type / Color
Bobbin Bobbin Thread Thread Metres Tex / Type / Color
1 RUNSTITCH COLLAR & BAND

301 Lockstitch 301 1 11 84 1.30 T -24 Perma Core
2 TOPSTITCH COLLAR & BAND
301 Lockstitch 1 11 84 1.30 T -24 Perma Core
3 BUTTONSEW COLLAR BAND
BS 4 hole 1 1 1 0.14 T -24 Perma Core 4 BUTTONHOLE COLLAR BAND
BH 5/8" 1 1 1 0.18 T -24 Perma Core 1.25 T -24 Perma Core
1.25 T -24 Perma Core
0.05 T -24 Perma Core 0.08 T -24 Perma Core
5 HEM SLEEVE
301 Lockstitch 1 10 102 1.53 T -24 Perma Core 6 SEW LABEL TO YOKE
301 Lockstitch 1 10 20 0.31 T -24 Perma Core
7 SEW YOKES TO BACK
301 Lockstitch 1 10 52 0.78 T -24 Perma Core 8 TOPSTITCH BACK SEAM
301 Lockstitch 1 10 53 0.80 T -24 Perma Core
9 HEM RIGHT FRONT
301 Lockstitch 1 10 76 1.14 T -24 Perma Core 10 BUTTONSEW RIGHT FRONT
BS 4 hole 6 1 1 0.81 T -24 Perma Core
11 HEM FRONT POCKET
301 Lockstitch 1 14 20 0.34 T -24 Perma Core 12 SET FRONT POCKET
301 Lockstitch 1 14 46 0.77 T -24 Perma Core
13 HEM LEFT FRONT
301 Lockstitch 2 10 76 2.29 T -24 Perma Core 14 BUTTONHOLE LEFT FRONT
BH 5/8" 6 1 1 1.05 T -24 Perma Core
15 JOIN SHOULDERS & TOPSTITCH
301 Lockstitch 1 10 97 1.45 T -24 Perma Core 16 SET COLLAR TO SHIRT
301 Lockstitch 1 10 91 1.37 T -24 Perma Core 17 SET SLEEVES
516 /Both Safetystitc 1 10 122 8.06 T -24 Perma Core
18 CLOSE SLEEVE & SIDE
516 /Both Safetystitc 1 10 147 9.74 T -24 Perma Core 19 HEM BOTTOM
301 Lockstitch 1 10 142 2.14 T -24 Perma Core Stitch #?

SUBTOTALS 35.50
1.47 T -24 Perma Core
0.29 T -24 Perma Core

0.75 T -24 Perma Core 0.77 T -24 Perma Core
1.10 T -24 Perma Core 0.27 T -24 Perma Core
0.33 T -24 Perma Core 0.74 T -24 Perma Core
2.20 T -24 Perma Core 0.45 T -24 Perma Core
1.39 T -24 Perma Core
1.32 T -24 Perma Core
2.05 T -24 Perma Core 15.76
89.10

Percent Waste 10% 8.91
98.01

ANECALC
Avg. Seam Thickness
1.2 mm
Photo


Looper Looper / Cover **Total Thread** Thread **Metres / Metres** Tex / Type / Color **Oper.**

2.55 2.55
0.18 0.25
2.99 0.60
1.53 1.57
2.24 1.08
0.68 1.52
4.49 1.50
2.84 2.69
17.14 T -24 Perma Core 25.20

20.71 T -24 Perma Core 30.45
4.19
37.84 TOTALS 89.10

Total Metres/Garment Consumed Metres/Garment - Waste
Total Metres/Garment w Waste
ANE

CALC **THREAD COST ANALYSIS** Program Sz (units) Copy & Paste Thread SKU's **TOTAL** Put-Up From Above **METRES** (5000M)

Price **Thread Price Per Metre Thread Price Per Garment**

10,000 **# of Cones needed 1 T -24 Perma Core 98.01 5000 $ 0.25 $ 0.00005 $ 0.00490 196.0**

2
3
4
5
6
Currency

98.01 Total Metres/Garment w Waste $ 0.0049 US $

Per Garment *Pcesare forcomparative pupose ony.ConactyourA&ERepesentativeforyouexactpices.*

Thread consumption for a shirt, worked through excel utilities.

Lost Time

Lost time is the time an operator loses which is out of his control. This time will affect the efficiency of an operator unless it is taken into consideration. Otherwise known as Non-Productive Time (NPT) Major lost time categories are,

Waiting for work,
Machine Trouble,
Doing other people's repairs
Doing samples
Power failure
Meetings.
Line setting

Since the above points cannot be controlled by the operator, the time spent is subtracted from the attended minutes of the operator.
For example, if no lost time occurred the operators efficiency is calculated as follows:

= 64.8%

If, however, the operator had waited for work for Done samples for Machine trouble for

Total The calculation would now be worked as follows:

350 .
540 – 100 X 100 30 minutes 40 minutes 30 minutes

100 minutes
= 79.5%

LOST TIME REPORT

NAME CLOCK NO WEEK ENDING

A) MACHINE B/DOWN	B) NO SUPPLY	C) NO CUT WORK	D) INSTR/SUPERVISOR
E) REPAIRS	F) SAMPLES	G) CUTTING ROOM FAULTS	
H) TRIMMING SUPPLY	I) OTHER		

	ON	OFF	CODE TOTAL	ON	OFF	CODE TOTAL	ON	OFF	CODE TOTAL	ON	OFF	CODE TOTAL
MONDAY												
TUESDAY												
WEDNESDAY												
THURSDAY												
FRIDAY												
SATURDAY												

1. Christine has an attended time of 525 minutes, lost time of 37 minutes and produced 300 mins.

What is her efficiency?

2. Janet has attended time of 525 mins, lost time of 27 mins for machine trouble, and 62 mins on samples. The minutes on her ticket for the day amounted to 400. The bonus scheme in this factory pays 0.018 cents per minute on standard for every percentage increase above 70%. What is Janet’s bonus?

3. The normal day has a total attended time of 525 minutes, operator 163 left 45 minutes early to go to the doctor. Before she left she did: 25 bundles of join shoulders

16 bundles of set sleeves 3 bundles of side seams 8 mins per bundle 10 mins per bundle 15 mins per bundle

Her machine was broken from 08:30 until 08:45 and she worked on samples from 12:00 until 12:30. What is her efficiency?

1.) 300

525 – 37 = 61,4%

2.) 525 – 89 = 436
Mins produced = 400
Efficiency = 91.7% (91,7 – 70) x 436 x 0.018 = R1.70

3.) Attended time = 525 – 45 = 480 Lost time : MT 15

Samples 30 = 45 Time on standard = 435 Minutes produced :

25 x 8 = 200
16 x 10 = 160
3 x 15 = 45
200+160+45 = 405

Efficiency = 405
435 x 100 = 93%

Production Study

A Production Study is a continuous study of a relatively lengthy duration, often extending over a period of one or more hours, taken with the object of checking an existing or proposed standard time, or for obtaining other information affecting the rate of output.

From time to time, the supervisor will find a problem with an operator whom she /he knows should be able to reach the required standard or output, but does not do so. Often in such cases, neither the supervisor, nor the operator him / herself, will be able to suggest any particular reason for the low performance. If a preliminary check by conventional Time Study does not show any reason for the difference, it is essential that a Production Study be made to establish why the operator is unable to perform the task in the required Standard Time.

The inability of the operator to accomplish the task in the required time may be due to several factors;

a. Changes in the fabric
b. Changes in the method, layout or working conditions
c. Inadequate training
d. Errors in the original Time Study
e. Operator laziness

Although every effort should be made to prevent errors in setting the original Time Standard, it is essential that management be willing, at all times, to rectify errors or to demonstrate the correctness of the time standard. Operators must have confidence in the standards and in the people who set them.

Whilst the production study is used to investigate complaints from operators regarding rates or production standards, it is also used to determine other facts. These include the following:
1) To ensure that Time Standards do in fact cover all of the activities involved,
2) To observe the incidence of waiting time and other details, to which the operator may be subject,

3) To obtain new data on which to compile interference and contingency allowances,
4) To record the performance of a particular department for future reference,
5) To establish whether the output of an operator is showing a downward trend,
6) To establish what times during the day fatigue affects the operator’s performance,
7) To inspire confidence, operators should believe in the fairness of the Standard Times set. The values may form the basis of an agreement between management and worker, both parties must be able to place their trust in the agreement.
If this trust is lost by either party, then Work Study will not succeed. It is also vital that the Work Study staff should gain confidence in the accuracy of the times which they are

setting.
The procedure involves timing, recording each cycle and noting each disturbance as follows: a) In the example, the operator began by making six fronts, one after the other, with cycle times of 32, 30, 28, 32, 35 and 29 centiminutes. The observer noted these figures in the ‘Cycle Time’ section. b) During the seventh front, the operator had a thread break, the observer operated his/her watch and noted the time of 22 for the first portion then 29 for re-threading the machine, as shown under “thread breaks”, then 10 for finishing off front number seven.
c) During front number 10 the operator had to renew the bobbin. The cycle time is therefore split into two portions again with the time for the bobbin change 36, being entered into the appropriate column.
d) The operator then continued through to the end of the bundle, when the observer recorded a time of 74 for bundle handling, cutting of the coupon, etc.
e) In this example, the observer then left three blank lines to allow space to calculate the operator’s performance for that bundle, then continued to record details for the next bundle. f) In bundle two the observer noted that 50 centiminutes were lost because the supervisor came to talk to the worker. In this instance the disturbance came between one cycle and the next, so there is no need to split cycle time readings. There was, a thread break on the seventh cycle which is dealt with as before and bundle handling of 68.
g) In bundle three there were two separate thread breaks, and he/she was also given back one front to repair and bundle handling.
h) The observer completed the study at this point, and returned to the office to calculate the following: a. The totals of his/her readings under each category - cycle time, thread breaks, bundle handling, etc.
b. The total observed time shown on the study as a whole.
c. The operator observed performance against the standard time (including bundle handling), calculated as:

i) Finally, he/she will calculate the percentages for each type of disturbance to assist in diagnosing the operator problem.

j) Calculating the bundle handling and colour change (BH & CC) per single will assist in diagnosing whether the operator took too long on any particular activity. In order to calculate this the total time for both activities must be added together and the new total divided by the total number of units produced. A comparison is then made between the figure and the allowed time for these activities.

k) He/she will also give a projection of the operator’s expected or potential performance over a whole day. This will not be the same as the performance calculated under 3 above, since the standard time includes a provision for personal and fatigue times (usually 11%).

11% if the study is less than 1 hour duration,
or 8% if the study is between one and two hours,
or 5% if the study is longer than 2 hours and does not include tea breaks.

The observer then should have all of the information necessary to determine which the most serious problem is affecting the operator, for example:
i. If the workers true performance is low say 50 - 60%, the observer must help the workers

method, or motivation.
ii. If the bundle handling time is much higher than the allowance provided in the Standard Time,
due concentration must be given here. Similarly, with thread breaks, personal and fatigue times,
colour changes or any other factor built into the standard time.
iii. Alternatively, the study may reveal some other problems not provided for, such as a high
proportion of repairs or interruptions by other operators, etc. The effect of these will then be
clear, and the Engineer will now focus his/her attention on solving the problems at hand.

Most importantly, Production Study provides an excellent way of proving to the operator, that the standard time is correct. This gives the operator the confidence and knowledge that they can achieve the standard time which has been set.

Production Study is a valuable “every day” technique which gives quick and clear insight into what is happening on the factory floor.

Production Study Sheet

Operation	Join Fronts			Operator	Sharifa
Basic	0.275	Std	0.34	Machine	Plain
T.S	08:00	T.F	08:28	E.T	28 mins
Date	15/5/98				

Cycles										Thread Breaks		Change Bobbin		Change Colour		Pers		Bundle Handling		Other	
0.32	0.30	0.28	0.32	0.35	0.29	0.32	0.29	0.30	0.30	0.24			0.36					0.74			
0.30	0.29	0.28	0.31	0.31	0.30	0.27	0.30	0.31	0.29												
0.28	0.28	0.30	0.31	0.29																	
	7.49	/ 25	= 0.299																		
0.30	0.30	0.29	0.29	0.31	0.30	0.28	0.29	0.32	0.30	0.22								0.68		0.50	Sup
0.31	0.30	0.28	0.27	0.30	0.28	0.32	0.31	0.30	0.29												
0.29	0.30	0.30	0.29	0.29																	
	7.41	/25	= 0.296																		
0.32	0.32	0.31	0.30	0.29	0.29	0.30	0.30	0.29	0.32	0.22	0.30							0.81		0.75	Rep
0.29	0.28	0.31	0.29	0.31	30.00	0.32	0.31	0.30	0.30												
0.31	0.32	0.29	0.29	0.31	0.30																
	7.80	/ 26	= 0.302																		

				Thread Breaks	Change Bobbin	Change Colour	Pers	Bundle Handling	Other
Total	27.590	Total	22.77	0.980	0.36			2.230	1.25
Observed	98.54%	Cycle	82.53%	3.55%	1.30%			8.08%	4.53%

Total Units Prod	76	Perf Against Basic	75.75%
Avg Cycle Time	0.299	Perf Against Std	93.66 %
Avg Obs Time	0.363	Proj. Daily Perf	84.38 %
Bundle Handlling & CC	0.034		

Elements, Rating, Allowances, Sampling, Cycle checks, PMTS,

7 Work Measurement

Work measurement is concerned with the determination of the amount of time required to perform a unit of work. It enables apparel engineers to compare alternative methods, and also to do initial staffing. Work measurement data are the basis for planning and scheduling also it is important for wage and salary administration and for devising incentive schemes.
It has been defined by the British standard institutions as “The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance”

Objectives
Using as a target the times established for jobs at the defined level of performance, work measurement will be found to have the following uses,

To assist in method study by comparison of times for alternative methods, and for allocating labour to jobs in proportion to the work involved so that the labour on a job is properly balanced. To enable realistic schedules of work to be prepared by relating reasonably accurate assessments of human work to plant capacity.
As the basis of realistic and fair incentive schemes
To assist in the organization of labour by enabling a daily comparison to be made between actual times and target times.
As a basis for labour budgeting and budgetary control systems
To enable estimates to be prepared of future labour requirements and costs.
Method study

Method study is the principal technique for reducing the work involved primarily by eliminating unnecessary movements on the part of material or operatives and by suggesting good methods for poor ones.

Method study can reveal short comings of design, material, and method of manufacturing and such affect mainly technical people

Work Measurement

Work measurement is concerned with investigating and reducing and subsequently eliminating ineffective time. Note only can it reveal the existence of ineffective time, but it can be used to set standard times for carrying out the work, so that, if any ineffective time does evolve latter, it will immediately be found out by the increased standard time.
Work measurement is more likely to show up the management itself and the behavior of workers.

Work Measurement Techniques
There are two type of work, according to work measurement.

1) Repetitive work: - where the main operation or group of operations recurs continuously during the time spent at the job. This applies equally to work cycles of extremely short duration and to those of several minutes or even hours duration.

2) Non repetitive work: - it includes some type of maintenance on construction work, where the work cycle itself is hardly ever repeated identically.

The principal techniques of work measurement are;
1) Time study
2) Synthesis from standard data
3) Predetermined motion time system (PMTS)
4) Analytical estimating
5) Comparative estimating
6) Estimating
7) Activity of work sampling
8) Related activity sampling
9) MOST (Maynard Operation Sequence Technique)
The practice of work measurement can be represented as,
a) The job is broken down into its elements
b) For elements of human work, the records of basic of norm times are consulted for this time for each element.
c) For those elements for which there is no basic time already available, the basic time is determined by the appropriate work measurement techniques
d) The values so determined for any of the elements which could possibly recur in another job are added to the records of basic time.
e) The proportion of rest required is assessed and added to the basic time, to arrive at the time for doing the work at the standard rate of working and for recovering from the effort or the work content. f) The addition of relaxation allowance may be made element by element or the basic times for the elements may be summed and the relaxation allowances added job wise, again to give the work content.
g) The necessary technical data are collected for any machine involved in the job.
h) The values for human work, the technical data and any other appropriate allowances are combined to arrive at the standard time for the job.

Source - Time study Source

- PMTS

Work Measurement Data

Basic Time

Analytical

estimating

Relaxation Allowances

Work Content The records of basic times for elements are termed as synthetic data and the compilation of as much synthetic data is an important objective of any work measurement study program.

Time Study

Work measurement technique for recording the times and rates of working for the elements within specific conditions of a specified job, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance. The basic steps in doing time study procedure are,

SURVEY JOB CONTENT
(Correct method, operating conditions, quality, etc.)
PLAN
(all constituents can be measured economically and accurately)
DEFINE ELEMENTS
(Covering the whole job, selected for convenience of observation, measurement, analysis and synthesis)
MEASURE
Recording the rate and time for each element repeated in sufficient volume to provide reliable data covering all expected conditions)
EXTEND
(to obtain the basic time for each element by calculations)
COLLATE DATA
(To establish a representative basic time for each element in the task)
DETERMINE RELAXATION ALLOWANCE (For each element in the task)
ALLOW
(For other relevant factors, and summate to establish)
STANDARD TIME (for the final job)

Selecting the job to be studied

Generally there is a lot of pressure on the apparel engineer to study number of jobs in a well-organized factory also there may be hundreds of time standards that had to be carried out. It becomes necessary to understand what are the reasons for which time study may be done first. There are some reason to take into key consideration,
1) The job in question is a new one which means they are not previously carried out. 2) Change in the method of existing time standards
3) Complaints received from workers or unions regarding the time standard of the work or its targets

not achievable.
4) A particular operation appears to be a "bottleneck" operation, which holds up a number of
subsequent activities.
5) Change in management policy about how time standards are to be used. For example if we go wages
according to time standards then we should be have more accurate time standards.

Steps in making a Time Study

a) Obtain and record all information of job, operator, and surrounding conditions likely to affect the carrying out of the work.
b) Record the complete description of the method and breaking down the operation into elements.
c) Measuring with timing device preferably a decimal chronometer and record the time taken by the operator to perform each element of operation.
d) At the same time assessing the effective speed rating of the operator relative to predetermined normal speed. This normally depends with the expertise of the apparel engineer.
e) Converting the observed time to "normal times" or "Basic time"
f) Determine the allowances to be made over and above the basic time for operations
g) Determine the allowed time or standard time for the operation.

There are some other information must to be recorded along with the sheet, such as, Study number or sheet number on job sheet

Name of engineer took the study and date
Name of product, drawing or specification or techpack number, part number etc.
Department or location where the operation is taking place and its description Sketch of workplace layout, plant or machines and tools utilized.
Operators clock number and rating
Starting time and finishing time of study and its duration etc.

Before recording the method, care should be taken that systematic method study has been carried out, if not, it should be done at this time. It is meaningless to talk about time study in absence of proper method. Corresponding to each method there will be only one Standard Time. Method study allows us to define various possible alternatives of challenging a given task and choosing the best among the alternatives. And the best is taken up for establishing the Time standards.

Braking the job into Elements

Elements are distinct part of a specified activity of task composed of one or more fundamental motions or machine activities, selected for convenience of observation, measurement and analysis. Elements should be easily identified with definite beginning and endings, so that once established they can be repeatedly recognized.
The point at which one element ends and another begins is called as a "*Break Point*" these break points can be either seen or heard. Generally elements should be no less than 0.05 minutes and no longer than about 0.60 minutes.
Work Cycle is a complete sequence of elements necessary to perform a specified activity or task so as to yield one unit of production. It may also include elements which do not occur in every cycle for example bundling is an activity repeats only after the expiry of an open bundle.
The reasons for breaking down the job into its elements are,
1) To ensure that the productive work (needle moving or sewing is a productive work but aligning pieces

are not productive) is separated from unproductive activity.
2) To permit the rate of performance to be assessed more accurately than over a complete cycle. Because
the operator may not work at the same pace and may be found to perform some operations faster
than others.
3) To enable the elements involving light fatigue to be isolated and to make the allocation of the rest
allowance more accurate.
4) Time standards to be checked so that the later omission or incretion of elements quickly detected. 5) To enable detailed job specifications to be produced.
6) To enable standard time values for frequently recurring elements such as the operation of machine
controls of loading and unloading etc. from fixture to be established.

Various types of elements

1) *Repetitive Elements:* - are those which occur in every cycle of the given activity of task, e.g. Picking from bundle and dispatch to bin of sewn parts

2) *Constant Elements:* - are those which may occur in every cycle or not, but they are identical in specification and time from cycle to cycle, e.g. switch on machine, put trimmers on side etc.
3) *Variable Elements:* - are those, in which the time of performance varies in relation with characteristics of product equipment on process. Such as dimension, or weight of the object, e.g. size variation of shirt S size and XL size as next bundle.
4) *Occasional Elements:* are those elements which do not occur in every cycle of the task, but may take place either at regular intervals of randomly, e.g. replacing the pern (bobbin) in a weaving machine is regular interval, breaking of threads is random.
5) *Foreign Element:* - these are observed during the study but do not form the necessary part of the given activity of the cycle, e.g. operator stopping the machine and talk to his friend.
6) *Governing Element:* - When two elements are going on simultaneously in a given cycle, the element that takes longer time is called governing element.
7) *Manual Element:* is the element performed by the worker manually
8) *Machine Element:* is an element automatically performed by a machine e.g. sewing a bartack.

Break the job Elements

1) Elements should be easily identified and should have distinct beginning and end. These break points must be recognized a different sound, so that the observer knows precisely when it starts and when it ends. e.g. clinching sound by stopping of the machine, pressing a tool on table, movement of a specific machine part etc. these break pints need to be described on the breaking down of the job.

2) Elements should not be too small nor too large (more than 0.05 and less than 0.60 minutes as maximum in some cases, but in general less than 0.33 min is preferred). If the elements are too large the performance rate may vary during the duration of the element there by causing loss in the rating accuracy or it may difficult to rate if the time is too small

3) Elements should be unified as possible. This means that a certain group of basic motions such as reach for, grasp, or move may be combined together because they achieve a given purpose.
4) Elements of important nature should not be combined together
5) Measure each element in terms of time.

The BST definition of an element is a different part to a job selected for convenience of observation, measurement, and analysis.
For the purpose of timing, the whole job is broken down into element among 0.05 to 0.5 of a minute duration. The reason why a cycle of work has to be broken down into elements arises from the need to be able to identify the causes of time variation that will appear in actual practice. Timing the overall cycle does not provide the opportunity for isolating these causes and measuring their individual effect. The element breakdown enables the Apparel Engineer to,

- Account for variation in time – the variation of speed at which the operator works can be easily seen.

- to ensure that productive work is separated from unproductive work
- to increase accuracy in rating the operation
- to identify different levels of fatigue allowance requirement
- to produce more detailed work specification easier to cross check
- future use of compiling standard data

Certain motions or activities need to be grouped into an element to make ease of measurement. It is to take note that, if a sound cannot be used as a break point, then a visual one has to take its place. Whatever is selected, it must capable of precise recognition otherwise one element overlaps into another. Each element should be given a number or letter to identify it so that the requirement for writing is minimized during study.

Measuring with stopwatch

Since the great majority of operations in the clothing industry are less than a minute, the most suitable type of stopwatch unit is the “decimal minute”. A decimal stop watch can record time in different formats

- seconds and minutes
- in decimal minutes
- in TMU
- Split Laps.

A decimal minute is the most favorite of all kinds of stop watches. Now a days in digital stop watches all the facilities are incorporated in one. In a decimal minute one minute is divided into 100 parts and each division represents 0.01(one cent minute) and a decaminute recorder is often used where one minute is divided into 1000 parts. This is used where shorter elements are to be measure and to increase accuracy. There are two ways for taking reading from a stop watch i.e. snap back (fly back) timing and cumulative (continuous) timing.

Snap Back Timing is a method in which the hands of the stop watch are returned to zero at the end of each element and are allowed to restart immediately, the time of the element being obtained directly.

Cumulative Timing is a method in which the hands of the stop watch are allowed to continue to move without returning them to zero at the end of each element, the time for each element being obtained subsequently by subtraction.

Most predetermined motion time systems (MTM and MOST) use Time Measurement Unit (TMU) as its unit instead of seconds or minutes. One TMU is defined to be 0.00001 hours or 0.036 seconds. These smaller units allow for more accurate calculation without the use of decimals. In the most in-depth PMTS systems, motions observed will be on the level of individual TMUs, like toss (3TMU in mini MOST) and simple pick up (2 TMU is MTM-1).

TMU in American System
1 TMU = 0.036 seconds
1 Hour = 100,000 TMUs
1 second = 27.78 TMU
1 Minute = 1666.67 TMU TMU in British System 1 TMU = 0.030 seconds 1 Hour = 120,000 TMU 1 Second = 33.33 TMU 1 Minute = 2000 TMU As general the ASTM

system of TMU is commonly used but the stop watch may have both universally. The British system is more accurate near to a HD video recording rate of 2000 frames per minute so that each frame can be count as a TMU while counting from the frames of a video.

Performance rating

Performance rating is the step in the work measurement in which the analyst observes the worker's performance and records a value representing that performance relative to the analyst's concept of standard performance. *Performance Rating can be defined as the procedure in which the time study engineer compares the performance of operator(s) under observation to the Normal Performance and determines a factor called Rating Factor*. During the time study, time study engineer carefully observes the performance of the operator. This performance seldom conforms to the exact definition of normal or standard. Therefore, it becomes necessary to apply some 'adjustment' to the mean observed time to arrive at the time that the normal operator would have taken to do that job when working at an average pace. This 'adjustment' is called Performance Rating. Determination of performance rating is an important step in the work measurement procedure. It is based entirely on the experience, training, and judgment of the work-study engineer. It is the step most subjective and therefore is subject to criticism. *"Rating is a subjective comparison of any condition or activity to a benchmark, based upon our experience."* While the mechanics of time study record the time a task did take, applying a rating will determine the time a task should take.
Operators don't work all the time at the same speed, neither do they work from morning to night, day in and day out with the same intensity. There are many contributory causes for these variations, but no matter what they are, the apparel engineer must be able to deal with the effect. (i.e. change from the established method or change in the speed of working). *Rating is the mental comparison by the engineer of an operator under observation with his own idea of "normal performance"*
Normal Performance is the working rate of average worker working under capable supervision, but without the stimulus of an incentive wage payment plan. This pace can be easily maintained day after day, without undue physical or mental fatigue, and is characterized by the fairly steady exertion of reasonable effort. In spite of the difficulties involved, much progress has been made and it is surprising how close the Workstudy engineers have to the same standard time when timing the same job under the same conditions. For example; a normal performance of a man's walking is 4.8 km per hour but most of us easily compare and tell is seen some one "walking slowly" or someone "walking fast" this comparison arises from the comparison with the normal speed of walking is understood in our mind as 4.8 and compares with that happens in our mind.
In actual, the effective speed of the working is to be rated. This is not the speed of movement, because an unskilled operator may more extremely fast and yet take longer to perform an operation than a skilled operator who appears to be working quite slowly. The unskilled operator puts in a lot of unnecessary movements which the experienced operator has long since eliminated. Judgment of effective speed can only be acquired through experience and knowledge of the operations being observed. "Efforts are not rated" the result of variations in effort can be seen in the effective speed.

Factors affecting Rating

It may be that because of adverse conditions either outside or within himself controls, a worker takes longer to perform an element on one occasion than another, even though his speed or working effort are greater. Some factors outside operators control includes,

- Variations in quality of the fabric used
- Changes in the operating efficiency of machines within their useful life.
- Minor changes in methods or conditions or operations.
- Variation in the mental attention necessary for the performance of certain elements of work.
- Changes in climatic and other surrounding conditions such as lighting, temperature, humidity, noise levels etc.

These can generally be accounted for by taking a sufficient number of studies to ensure that a representative sample if times is obtained.

There are some factors affecting operator performance those are within the control of the worker, some of them are,
- Variation in the quality of product within the specification.
- Variations due to operator activity
- Variations due to their attitude of mind, especially his/ her attitude to the organization for which he works. This includes interest and top management deals.

The optimum pace at which worker will work depends on some factors such that,
- The physical effort demanded by the work. Generally a demand for increased physical effort will lead to a slower speed.
- The care required on the part of operator, a need for increased care in carrying out an element of work will also reduce the speed.

Because various factors will influence the worker’s motion patterns and effective speed in different ways, the WS observer must be familiar with the motion pattern followed by an average worker competent and familiar to his work, and with how the pattern may change to meet a varied range of conditions. Rating is very much easier if a good method study has been made first, in which the activities works for special skill or effort have been reduced to the minimum. The more the method has been simplified, the less the element of skill to be assessed, and the more rating becomes a matter simply of judging speed. By careful training of staff and by cross checking of assessments, consistency of rating between observers can be assured to a high degree.

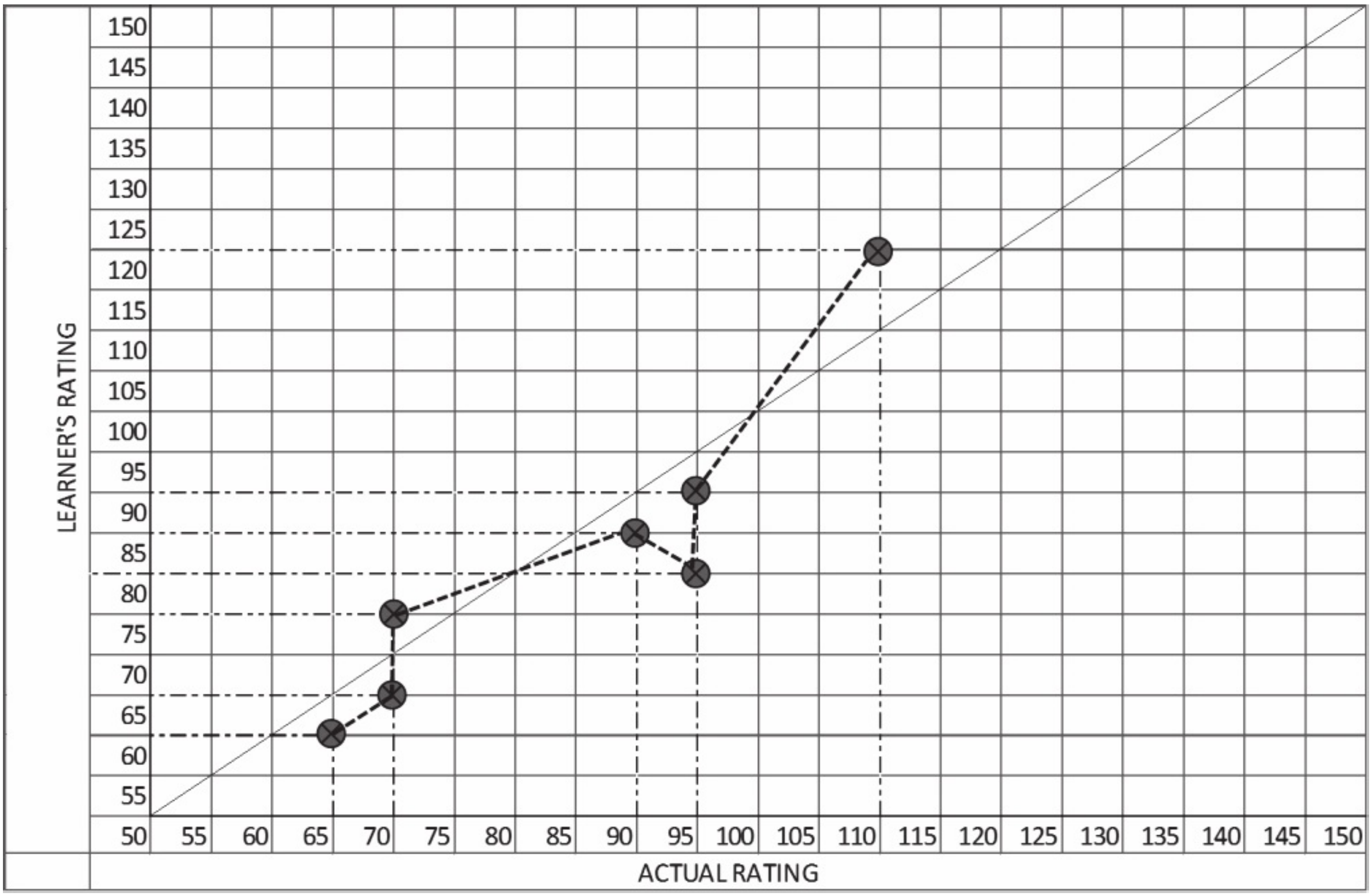
How the rating factor is to be used

If the WS engineer decides that the operation observed is being performed less efficiently than his idea of standard then he will use a factor of less than 100 relatively, say 75 or 80 of whatever he considers represents a proper assessment. On the other hand if it seems being done more effectively then he may give rating of 105 or 115 etc. it is usual practice to round of rating to the nearest multiple of 5 on the scale. With proper training and continual practice a competent WS engineer can assess the effort of an operator on a 5 point basis from about 60 to 125 rating scale. Outside these values, accuracy of rating diminishes but most operators rating fall within the range.

While training, we have to prepare a rating chart to identify the consistency, and accuracy of rating. Once the WS engineer is getting a nearly steady rating line then only his ratings are more accurate. If we had perfect workstudy engineers and perfect operations and

perfect conditions, the formula follows would hold good for each element.

In actual practice the observed time x rating is very rarely constant for the same element because of the variations in the method of performing the element, and or variations in the work content of the element and or inaccuracies in the noting a recording the observed time.
Each element is rated separately whilst the element is in progress and noted before the time is taken, otherwise there is a very great risk that previous times and ratings for the same element will influence the assessment. For this reason the rating column of the Time study sheet placed to the left of the watch reading column. It is perhaps, a further advantage of the continuous method of timing that the element time does not immediately appear as a separate figure, which might influence the rating or tempt the WS engineer to rate by the watch attitude.
Sound initial training and regular refresher checks provide the means of keeping rating errors down, always it need to prepare a rating graph of yours after doing the rating.



The more rating gets accurate the graph will be running more 45’ to the axis. This can be achieved only by practice.

Scale of Rating
Before any comparison between performance observed and the normal performance can be used to modify the observed time. It must be translated to numerical terms. There are different scales of rating, the most commonly used being those which rates the standard performance as 100.

100/133 Scale
(Percentage scale)

60 /80 Scale (Bedaux Scale)
75 / 100 Scale
0/100 scale BSI Scale

This is the most widely used scale in the USA, where the normal performance is rated at 100% and the incentive pace is 133% for this reason this is known as percentage scale.

This was the most widely used scale in Britain and developed in France, where the normal performance is rated at 60 and the incentive pace is 80 points

This is an alternative scale used when the normal performance is rated at 75 and incentive pace at 100

This is the scale suggested by British Standards institute where the standard performance is the incentive pace. There is no normal performance as the BSI states that it does not follow that when worker are paid on time work they will work at a normal performance (i.e. 60,75, or 100 depends upon the scale used)

Loose Rating: - an inaccurate rating which is too high to the actual. 130

Tight Rating: - an inaccurate rating which is too low to the actual 120
Flat Rating: - a set of ratings in which the observer has under 110
estimated the variations in the workers rate of performance. 80 133 100
Steep Rating: - a set of ratings where the observer has 90
overestimated the variations in the workers rate of working. 80

60 100

Inconsistent rating: - a combination of all the previous four type 70
of errors, usually attributable to the lack of experience if the 60
observers nor understanding the rating concept. 50

Synthetic Rating 0 - 100 scale This method of rating has two main advantages over other methods. These are

○ it does not rely on the judgment of time study person and
○ it gives consistent results.

The time study is made as usual. Some manually controlled elements of the work cycle are selected. Using
a PMT system (Pre-determined motion time system), the times for these selected elements are determined.
The times of these elements as determined are compared with the actual observed times and the
performance factor is estimated for each of the selected elements.

Performance or Rating Factor, R = P / A
Where P = Predetermined motion time of the element, and
A = Average actual observed time of the element.
The overall rating factor is the mean of rating factors determined for the selected elements. This is applied uniformly to all the manually controlled elements of the work cycle.

Allowances
Before it is possible to complete and issue that standard time for a job, it is necessary to add the basic time with certain allowances. The readings of any time study are taken over a relatively short period of time. The normal time arrived at, therefore, does not include unavoidable delay and other legitimate lost time, for example, in waiting for materials, tools or equipment; periodic inspection of parts; interruptions due to legitimate personal needs, etc. It is necessary and important that the time study person applies some adjustment, or allowances, to compensate for such losses so that fair time standard is established for the given job.
Allowances are generally applied to total cycle time as some percentage of it, but sometimes these are given separately for machine time as some percentage and for manual effort time some other percentage. However, no allowances are given for interruptions which may be due to factors which are within the operator's control or which are avoidable.
Most companies allow the following allowances to their employees.

Constant allowances (for personal needs and basic fatigue)
Delay Allowance (for unavoidable delays)
Fatigue Allowance (for job dependent fatigue)
Personal Allowance
Special Allowance

De layAllowance:This time allowance is given to operator for the numerous unavoidable delays and interruptions that he experiences every day during the course of his work. These interruptions include interruptions from the supervisor, inspector, planners, expediters, fellow workers, production personnel and others. This allowance also covers interruptions due to material irregularities, difficulty in maintaining specifications and tolerances, and interference delays where the operator has to attend to more than one machine.

Fatigue Allowance:This allowance can be divided into two parts: (i) basic fatigue allowance and (ii) variable fatigue allowance.

The basic fatigue allowance is given to the operator to compensate for the energy expended for carrying out the work and to alleviate monotony. For an operator who is doing light work while seated, under good working conditions and under normal demands on the sensory or motor system, a 4% of normal time is considered adequate. This can be treated as a *constant allowance*.

The magnitude of variable fatigue allowance given to the operator depends upon the severity of conditions, which cause extra (more than normal) fatigue to him. As we know, fatigue is not homogeneous. It ranges from strictly physical to purely psychological and includes combinations of the two. On some people it has a marked effect while on others, it has apparently little or no effect. Whatever may be the kind of fatigue-physical or mental, the result is same-it reduces the work output of operator. The major factors that cause more than just the basic fatigue includes severe working conditions, especially with respect to noise, illumination, heat and humidity; the nature of work, especially with respect to posture, muscular exertion and tediousness, and like that.

It is true that in modern industry, heavy manual work, and thus muscular fatigue is reducing day by day but mechanization is promoting other fatigue components like monotony and mental stress. Because fatigue in totality cannot be eliminated, proper allowance has to be given for adverse working conditions and repetitiveness of the work.

Pe rsonal Allowance:- This is allowed to compensate for the time spent by worker in meeting the physical needs, for instance a periodic break in the production routine. The amount of personal time required by operator varies with the individual more than with the kind of work, though it is seen that workers need more personal time when the work is heavy and done under unfavorable conditions.

The amount of this allowance can be determined by making all-day time study or work sampling. Mostly, a 5 % allowance for personal time (nearly 24 minutes in 8 hours) is considered appropriate. This other way also known as contingency allowances.
SpecialAllowances:These allowances are given under certain special circumstances. Some of these allowances and the conditions under which they are given are:

Policy Allowance: Some companies, as a policy, give an allowance to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstance. This may be allowed to new employees, handicap employees, workers on night shift, etc. The value of the allowance is typically decided by management.

Small Lot Allowance: This allowance is given when the actual production period is too short to allow the worker to come out of the initial learning period. When an operator completes several small-lot jobs on different setups during the day, an allowance as high as 15 percent may be given to allow the operator to make normal earnings.

Training Allowance: This allowance is provided when work is done by trainee to allow him to make reasonable earnings. It may be a sliding allowance, which progressively decreases to zero over certain length of time. If the effect of learning on the job is known, the rate of decrease of the training allowance can be set accordingly.

Rework Allowance : - This allowance is provided on certain operation when it is known that some percent of parts made are spoiled due to factors beyond the operator’s control. The time in which these spoiled parts may be reworked is converted into allowance.
Periodic Activity Allowance: - these allowances are made for work carried out periodically during the sewing of a bundle of work, an example is bundling which can if required, be expressed as a percentage and added as an allowance.
Machine interface allowance: - when an operator is required to attend more than one machine, any of which may stop for some reason or other, at any time, there is a possibility that both the machines need attention at the same time. This delay is added as an allowance.
Different organizations have decided upon the amount of allowances to be given to different operators by taking help from the specialists / consultants in the field and through negotiations between the management and the trade unions. ILO has given its recommendations about the magnitude of various allowances,

ILO Recommended Allowances
Category of Allowance %

A. Constant allowances:

1 Personal allowance 5
2 Basic fatigue allowance 4
B. Variable allowances:
1 Standing allowance 2
2 Abnormal position allowance:
a. Slightly awkward 0
b. Awkward (bending) 2
c. Very awkward (lying, stretching) 7
3 Use of force, or muscular energy (lifting, pulling, or pushing): Weight lifted, pounds:
5 0
10 1
15 2
Pounds 20 3 25 4 30 5 35 7 40 9 45 11 50 13 60 17 70 22 4 Bad light:
a. Slightly below recommended 0 b. Well below 2 c. Quite inadequate 5 5 Atmospheric conditions (heat and humidity)- variable 0-100 6 Close attention:
a. Fairly fine work 0 b. Fine or exacting 2 c. Very fine or very exacting 5 7 Noise level:
a. Continuous 0 b. Intermittent - loud 2 c. Intermittent - very loud 5 d. High-pitched - loud 5 8 Mental strain:
a. Fairly complex process 1 b. Complex or wide span of attention 4 c. Very complex 8 9 Monotony:
a. Low 0 b. Medium 1 c. High 4 10 Tediousness:
a. Rather tedious 0 b. Tedious 2 c. Very tedious 5

While we specify to apparel industry, we have more clearly specified the allowances as,
1. Personnel and fatigue allowance (mostly about 11% for sitting and 13% for standing)
2. Contingency allowance (mostly about 3% to 5 %)
3. Machine allowances (depends of the type of machine)
4. Special allowances (as need by ILO depends of situation)

Personal Allowance: - Personal allowance is one kind of relaxation allowance which is most common allowance in garments. This allowance is provided for the need to leave the work place such as going to wash room, fetching a drink, etc. The common figure is about 5% to 7% of basic time. **Fatigue Allowance:** Fatigue allowance is not common allowance in garments. It is a mental and physical tiredness developed by an employee due to continuous work. This allowance is given depending on the energy expended in doing the job and to alleviate monitory. Normally it is counted as 4% on basic time. In sewing trade we set 11% for sitting works and 13% for standing operations.

Contingency Allowance: - Contingency allowance depends on the worker, physical strength for doing the job. It is a small amount of allowance which is given to meet the legitimate delay of work. It is counted less than 5% of basic time.

Machine Delay Allowance: Some time garments, machines are off due to mechanical or technical problems. These are applied to the total basic time for those elements which are concerned with the operation of machinery.

Here are some common figures of garments sewing floor.
Single needle lock stitch machine = 5 %
Single Needle UBT machine = 5 %
Twin needle lock stitch machine = 14 %
Three thread over lock machine = 7 %

Four thread over lock machine = 9 %
Five thread over lock machine = 11 %
Single Needle chain stitch machine = 5 %
Button Sew Chain stitch Machine = 5 %
Button Hole Lock Stitch machine = 5 %
Bartack machine = 6 %
Safety stitch machine = 8 %
This can be calculated using the ILO recommendation chart and other ways as followed, giving a higher allowance means you are reducing the efficiency and actual productivity of the factory. Analysis of a Typical Machinist's Day

Total Attended Time 535 min
Total Working Time 475 Min 60 Min Total On Standard Time 426 Min 49 min Total Basic Time 349 Min 36 min 41 Min

Sewing Time 140 Min Handling Time 209 Min
Tea & Luch Breaks OFF Standard

Machine & personal Allowance
Handling Time 60%

The above picture simply explains how much an operator is working actually after all allowances made.

Standard Time

Standard time express the total time a job will take at standard performance, i.e. work content added with contingency allowances for delay, unoccupied time, and allowances etc. the unit used to state this time are Standard Allowed Minutes (SAM) or Standard Minutes Value (SMV) remember both are same. Not different.
The formulas to remember are,

We will do the calculation in the last phase of this chapter for better understanding.

Activity Sampling.

In certain situations it is not feasible to use normal work measurement techniques to select and understand what is actually happening in the shop floor and how the proportion of time devoted to each type of work. The manufacturing of clothing becomes more operators involved and sophisticated it becomes more difficult to collect this type of information, and yet at the same time, it is more necessary to get a record of it, so as to be able to set the proper priorities.
This technique is similar to sampling inspection method, where a comparatively small sample of product inspected reveals within certain limits of accuracy the proportion of defective articles in the whole lot. The particular technique most often used in this type of study is called activity sampling. In most situations useful and reliable information can be obtained through the technique of activity sampling. In only a fraction of the time which would be required with conventional time study, and without any special qualifications or expertise.
"Activity sampling is defines as a method of finding the percentage occurrence of certain activity by statistical sampling and random observation."
Activity sampling has been used to study factory work for more than forty years, we must know exactly how the operator spends his time. This information can be gathers by

making frequent short observations while the operator is working. If an operator actually spends 20% of their time waiting for work, then an observer who makes 100 random glances at him, should see him working on 80 of those occasions and waiting on the other 20.
Conversely, if an observer makes enough separate observations to establish a representative sample, and finds one particular activity happening on 20% of the occasions, it is reasonable to assume that the activity accounts for 205 of the operators time.
The point about this technique is that the observer can now study five or ten operators together, simply by looking from one to another in turn in frequent intervals of time. The required information can therefore be obtained more economically than any other time study methods.
Method of doing an activity sampling
The observer must first decide that activities he/she is interested in for taking the study. This can be done in a sewing room, cutting room, finishing section or any other departments. For each section it need to prepare a list of distinguished activities happening or to be observed from the department's operators. Then select group of operators on whom to conduct the study. It is easy to do from five to ten operators at a time. While selecting the production line of operators it is best to select if there are any problems of lesser productivity identified lines first for the study.
The study sheet should be filled with each operators name, clock number, operation doing, and machine type at the heads.
As soon as the observer is familiar with the appearance of the activities so that he can identify this in an instant, the study can start. With the stop watch running continuously the observer should look at each operator in turn and record the activity he sees in that instant. The observations can be made at fixed time intervals on the operators. It is very convenient to make observations at intervals of 10 centiminutes because it is then easy to remember to look at operator 1 as the needle passes 10, operator 2 as the needle passes 20 and so on,
Each observation is recorded by making a small mark in the appropriate space and these are best accumulated in "five bar gate" system of marking for the ease in counting latter. The study should be continued until there are at least 500 readings in total the more readings the more reliable the information obtained. With 10 operators and experienced person will complete a study in 50 minutes, without stopping his watch and without dropping or misplacing any individual reading. When preparing to sample we need to reach the statistical tolerance of +/-95% confidence level for our desired accuracy. If we are using the sample to generate a time standard then we should aim for an accuracy of +/-5%, and if the sample is being used for calculation of contingencies or analysis of lost time we should aim for +/-10% accuracy.
Analysis of the study.
The study should be totaled across and the percentages calculated for each activity. Individual study results may vary somewhat from one to another, largely because production conditions themselves vary from hour to hour and day to day. Under widely varying conditions it is necessary to extend the study by days of weeks in order to obtain a more representative picture of what actually occurs.
This is best achieved by maintaining a cumulative record of the total number of readings

against each activity, taking place studies at a different times in the day over a period of weeks. The respective percentages can then be calculated every five of ten studies and the results entered onto a graph. The graph will show clearly when the figure have steadied out at their overall lever and when sufficient results have been obtained.

40
35
30
25
20
15
10
5

0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500
OBSERVATIONS

Well before this, the studies will already have prompted action on the more outstanding problems. In the most cases management will not have realized just how much time is being lost on the factory floor in waiting, fetching work, changing colour etc. and this data can be used to control the excess levels.

In the above sample sheet, the production functions are targeted to get 85% of time but the actual is getting only 75.48 % which means about 10% of less target reached, while analyzing more, the other disturbances are allowed to a maximum of 10% but it goes beyond and 5% is target for others but it exceeds 10 %. Which means the issues within the control of operator is more and hence reducing the efficiency.
Which means for a working day of 480 minutes 48 minutes (10%) are excessively wasted by the operator itself, in that case we may further do analysis about that particular occurrence and why the operator is absent from machine if it is by means to fetch the bundle from the racks or such, then to reduce that the bundles may be moved near to tailor.

ACTIVITY SAMPLING SHE

	Sarun	Rajan	Wilfred	Rincy		
Date						
March 2, 2016						
Observer						
FUNCTION	**1**	**2**	**3**	**4**	**5**	
Sewing	IIII/ II	IIII/ IIII/ IIII/	IIII/ IIII/ II	IIII/ IIII/	IIII/ IIII/ III	
Handling	IIII/ IIII	IIII/ IIII	IIII/ IIII/	IIII/ II	IIII/ II	
Bundle/admin	IIII/ II	II		IIII/ IIII/	I	
WORK sub total	**23**	**26**	**22**	**25**	**21**	
Waiting for work		I				
Fetching work			I	I		
Talking/queries						
Thread breaks	II				I	
Bobbin Changes	I	III	I	I		

Change colour						
Machine trouble			II			
Unpicking	I		II		III	
Other repairs	I		I			
DISTURBANCES	**5**	**4**	**7**	**2**	**4**	
Personal at machine	II					
Absent from machine	I	I	III	III	IIII/ I	
OTHER sub total	**3**	**1**	**3**	**3**	**6**	
GRAND TOTAL	**31**	**31**	**32**	**30**	**31**	

For 95% confidence limit

ET

6	OBSERVED	ACHIEVEMENT	TARGET
	57	36.77	30%
	42	27.10	
	18	11.61	
	117	**75.48**	**85%**
	1	0.65	
	2	1.29	
		0.00	
	3	1.94	
	6	3.87	
		0.00	
	2	1.29	
	6	3.87	
	2	1.29	
	22	**14.19**	**10%**
	2	1.29	
	14	9.03	
	16	**10.32**	
	155		

In order to obtain the predetermined accuracy of the value of idle time (p) the sample size or number of reading and observations should be,

Where, N = the number of observations required.
p = the percentage occurrence of the activity to be analyzed.
L = the desired level of accuracy.

We don't actually know the percentage occurrence of our activities until we have performed the study, but if we work on the worst case scenario, where our percentage occurrence of any one activity is 50%, for a sample requiring an accuracy of +/-5%:

n = 4 x 50(100 - 50)/5 x 5.
n = 10000/25
Number or observations required = 400.

Using the same formula for an accuracy of +/-10% this figure is 100.

Advantages
An activity sampling study can be made of several machines and or operators by a single observer

It requires fewer man hours and costs less than time study
Observation may take place over days or weeks, thus decreasing the effects of day to day or week to week variations.
It provides management with an accurate reflection of factors that affect production The observer does not need to be specially trained engineer
Activity sampling can be interrupted at any time, without affecting the results.
It usually requires less time to calculate the results of an activity sampling than other production studies.
It may be made with a pre assigned degree of reliability, that means, the results are more meaningful Work sampling studies are less fatiguing and less tedious to make on the part of observer Sampling studies are preferred to continuous time studies by the operators being studied. Some people do not like to be observed continuously for long period of time.
A stop watch is not needed for work sampling studies. If an electronic data collector is used, results are shown on a computer easily.

Disadvantages

It is not economical for studying a single operator or machine or for studying operator or machines located over wide area.
Time study permits a finer breakdown of activities and delays than is possible with activity sampling. The use of performance rating enables time study to determine a more accurate time for the job. The operator may change their work pattern upon sight of the observer. If this occurs, the result of such a sampling study may be of little value. It is very rare that a detailed specification of method used is made when conducting activity sampling investigation
There is tendency on part of some observers to minimize proper sample size or randomness of observation.

Cycle Checks

A cycle time is a brief time study with the purpose of setting a target quickly, or checking whether an operator is capable of achieving a standard time.
The cycle time is the time taken by the operator to perform one cycle of operation or the time (minutes) required for a certain number of steps in a process to be completed, from start to finish, as defined by the team for performing the specific task. To conduct the cycle check follow the steps.

Select operations to be studied and detail the scope to be studied.
Map the process (find the elements of the cycle and identify a cycle start and finish points
Take several time measurements of each cycle of operation and record the time for each complete operation. Also do rating of the work cycle.
Study the process between measuring points to determine if there is wasted time. If so such readings are omitted.
Circle down the smallest cycle times which repeat (this should be taken with care that, there may be nearer possible values can be taken). Try to get at least five cycle them values same. Calculate the average cycle time from five values.
Abnormal time may be occurred due to bobbin change, thread break, power cut or quality issues. Ignore those from the calculation.
Compared cycle time to the basic time of the operation set. Or calculate Basic time and standard times can be calculated.

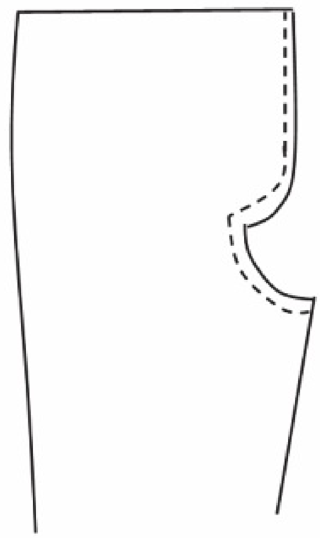
While we takes the cycle time, we can have two methods to record the reading.
1. We can break element and record each elements time and the sum up to get cycle time.
2. We can record the full cycle time.

Short Cycle Time Study

Date	March 1, 2016	Analyst	AJK	Factory	PEPY
Operator	A001	CL. No.		Study	#103
Machine	SNLS	Work Aid		Style	K&D 3423
Garment	Trouser	Cloth	Twill	Size	M/32

Operation : JOINING FRONT

Readings	Cycle Time	Rating
1	0.254	
2	0.238	
3	0.239	
4	0.228	
5	0.228	
6		
7		
8		
9		
10		
Total	1.187	
Average	0.237	
100%	0.237	



Allowances		
Machine	5%	0.012
Contigency	3%	0.007
Personal	11%	0.026
Bubdle Handling/ gmt	0.001	0.001

Cycle Time	0.283	min
Capacity	212	Pcs Per Hr
Target	250	
Efficiency	85%	

Comments

Generally while doing the cycle time study, we do rating as 100%. But the same can be done with actual ratings for personals having less productivity or if found unexpected bottleneck on an operator. The actual rating will give the changes from SAM allowed for the operation. And why the target is not being achieved if reduced rating factor is present for the operator then it need to conduct a workstudy for solutions.

Standard Time
As explained earlier, standard time expressed in total time for a job to get done including all allowances. To get the standard time of the operation,

Get necessary details of the job
Make number of observations and break down to elements
Time at least 15 cycles of operation
Do rating of all events
Circle out unusual events
Concert to basic time using formula
Add the basic times for each elements
Give necessary allowances to the basic time
Establish Standard time.

Circling Out
Unusual element time should be ignored at the calculation stage of the study, but must be recorded when making the study. Some of the unusual happening are,

Needle Break
Thread Break
Bobbin Change
Thread Change etc.

These this are covered by allowances and are there for not to be included in the calculation of basic time.

Approach to Worker
The workstudy engineer should always speak to the supervisor of the line before approaching the operator about the study. This is to ensure that everything is good before doing the study. The work study officer should always be polite, well-mannered and friendly to the operator. He

should listen to the operator because there may be something about the work need to be discussed. Sometimes it may be important for method development
Willingness of the operator to be studied is important
Stand in full view of operator, but outside his normal vision and path of movement Once the study is completed, total time recorded should be compared to the total time taken for study. If there is a difference of more than 2% the study is not sufficiently accurate, if so it must be redone.
It is most important that the workstudy officer makes the operator relaxed before and during the study.

The time study forms are recommended has provision for 15 cycles which can be broken down into 7 elements, with columns for the rating and the observed time. At the end of columns there is provision for calculating the basic time for various elements and the standard time for the complete operation.

Standard Allowed Minutes / Standard Minutes Volume

This is the standard time derived through various methods for a specific operation to be done. SAM or SMV are common for the work for the same industry conditions all time,

but may be different in different locations and situation, hence it is necessary to calculate SAM for the industry rather than adopting some ones reading. Most advanced systems of computer aided planning software have facility to calculate SAM before the actual production is going to happen and then it is possible to compare and adjust with the actual surroundings.

TIME STUDY SHEET DATE 3/3/2016 Sl No 01 Operator Manoj Clock No 354 Machine SNLS RPM 3200

Attachments

OR OT OR OT OR OT OR OT OR OT OR OT CYCLE TIME
1 90 0.150 75 0.705 70 0.712 75 0.340 75 0.334
2 75 0.229 80 0.645 75 0.802 80 0.359 80 0.396
3 80 0.123 60 1.040 65 1.313 80 0.435 85 0.424
4 85 0.179 75 0.562 75 0.669 75 0.515 70 0.436
5 70 0.260 80 0.600 80 0.724 75 0.432 75 0.347
6 75 0.358 80 0.442 80 0.742 80 0.378 70 0.321
7 80 0.246 90 0.529 75 0.861 80 0.323 80 0.446
8 85 0.315 90 0.464 80 0.872 80 0.277 95 0.259
9
10
11
12
13
14
15
Total Time 1.860 4.987 6.695 3.059 2.963 19.564 Total Rating 640 630 600 625 630
Avg Time 0.233 0.623 0.837 0.382 0.370
Avg Rating 80 78.75 75 78.125 78.75
Frequency
Basic El. Time 0.186 0.491 0.628 0.299 0.292 1.895

Total Basic Time 1.895 min

Allowances % Machine 5.0% Contigency 3.0% Personal & Fatigue 11.0% Bundling 0.05 Other

Values
0.095 Standard Time 2.305
0.057
0.208 Target 26 Per Hr.
0.050
0.000
Style Cloth Stich/ cm Garment Size Operation Nill
3243
Cotton woven poplin 6
Shirt
30
Collar Preperation

SKETCH

Time Start 13.30
Time Finish 13.51
TEBS
TEAS
Elapsed Time 21

Accuracy 93 %

There are other formats also used to take time study. The formats has to be developed according to the requirement of the industry.

Common Mistakes
There are some common errors made by the apparel engineer while taking study, they are mostly Observer forgets to do the actual rating, it is necessary to each and every element and for each occurrences.
Some engineers may put a constant of 80% or 90% as a standard rating, this is also not allowable because it need actual rating instead of actual reading if we put some imaginary figure we are actually giving chances for loss to factory and good operators some time.
Never checks the accuracy. It is required to check the accuracy because while we takes time study it need to take continuous cycles of operation do not take random cycle checks and do time calculations
The cumulated Standard Time for doing the operation cycle can be termed further as SAM or SMV.

Predetermined Motion Time System
A time standard for a job or an operation may be established by time study, by work sampling, or by the use of Pre-determined times. Predetermined time standards (PTS) are advanced techniques which aim at defining the time needed for the performance of various operations by derivation from pre-set standards of time for various motion and not by direct observation and measurement. They are not normally considered suitable for the trainee to use until he has gained a real understanding of and considerable experience in work study practice.
“A predetermined Time Standard is a work measurement technique where by times estimated for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.”
The first PMTS (since designated as “first-level” systems) were designed to provide times for detailed manual work and thus consisted of fundamental movements (reach, grasp, move, etc.) and associated times.
Large amounts of research, data collection, analysis, synthesis, and validation are required to produce PMTS data and the number of such systems is very low. “Higher level” systems have since been devised, most commonly by combining these fundamental movements into common, simple manual tasks. Such higher level systems are designed for faster standard setting of longer cycle activity.
Many PMTS are proprietary systems and users must either attend a designated and approved training course and/or pay a royalty for use of the data.

One of the major PMTS systems is MTM (Methods-Times Measurement) which is actually a ‘family’ of systems operating at different levels and applicable to different types of work. MTM1 - the ‘highest-level’ or most detailed member of the family - was developed in the 1940s by analyzing large numbers of repetitive cycles of manual work on film. MTM gives values for such basic hand/arm motions as: Reach, Move, Turn, Grasp, Position, Disengage, and Release, together with a small set of full body motions. The time taken to Reach to an object is then given by a table based on the kind of Reach (e.g. whether the object is in a fixed location - such as a tool in a tool holder - or is a single object located on a bench, or jumbled together with other objects, etc.) and the distance to be Reached. Similar tables give times for each of the other basic movements categorized and measured similarly. MTM is suitable for measuring short cycle, highly-repetitive

work. Other members of the MTM family use lower level motions (so that in MTM2, for example, the MTM1 motions of Reach and Grasp are combined into a composite motion, GET). MTM2 is thus quicker to apply, but more suited to longer-cycle work where the fine level of discrimination of MTM1 is unnecessary in terms of meeting accuracy requirements.

Predetermined motion time systems can be categorized as motion based, action based and activity based systems. Motion Based Action Based Activity Based

MTM GSD
BMT MTM0MEK MODAPTS USD

MSD
MTM-1, MTM-3 Some of the major PMTS systems are,
Maynard Operation Sequence Technique (MOST)

Basic MOST Mini MOST Max MOST

Maynard Operation Sequence Technique (MOST) is a predetermined motion time system that is used primarily in industrial settings to set the standard time in which a worker should perform a task. To calculate this, a task is broken down into individual motion elements, and each is assigned a numerical time value in units known as time measurement units, or TMUs, where 100,000 TMUs is equivalent to 1 hour. All the motion element times are then added together and any allowances are added, and the result is the standard time. It is much easier to use form of the older and now less common Methods Time Measurement technique, better known as MTM.
The most commonly used form of MOST is BasicMOST, which was released in Sweden in 1972 and in the United States in 1974. Two other variations were released in 1980, called MiniMOST and MaxiMOST. The difference between the three is their level of focus the motions recorded in BasicMOST are on the level of tens of TMUs, while MiniMOST uses individual TMUs and MaxiMOST uses hundreds of TMUs. This allows for a variety of applications.

MiniMOST is commonly used for short (less than about a minute), repetitive cycles, and MaxiMOST for longer (more than several minutes), non-repetitive operations. BasicMost is in the position between them, and can be used accurately for operations ranging from less than a minute to about ten minutes.

MODAPTS

Yet another popular PMTS used today in the automotive, sewing and healthcare industries is the MODAPTS technique. This technique was introduced in 1966 by G. C. “Chris” Heyde who originally learned the MTM-1 and MTM-2 methods in the 1950s and sought a simpler technique to use and apply. Unlike the MTM and MOST standards, MODAPTS uses a MOD as its basic unit of measurement (1 MOD = 0.129 seconds). However, like Basic-MOST, MODAPTS uses a coding technique that consists of a letter and an integer number (all but 1 code), where the integer numbers each represent MODS that can be easily added to determine a coded task’s time.

MODSEW

MODSEW is a software application of MODAPTS for the sewn products and apparel

industries. It uses very intuitive codes to represent the various motion patterns prevalent in the industry and allows the user to configure their own codes for those unique to their operation. The software is used to determine the standard time to complete an operation and has provisions to collect and maintain groups of operations in a style (product). MODSEW is owned, maintained, sold and supported by Byte Software Services, LLC of Mauldin South Carolina.

General Sewing Data (GSD)
General Sewing Data is a PMTS for the sewn products and apparel industries and is based on MTM Core Data both proprietary data systems of GSD (Corporate) Ltd of Preston, UK. The Time standards for General Sewing Data are used in GSD Enterprise and GSD QUEST. GSD company was taken over by thread giant Coats in 2015. Its primary function is to rationalize manufacturing methods and to produce an accurate evaluation of the time required to perform a specific task or operation. The system consists of two parts, the inherent GSD Database itself, which forms the heart and integrity of the system, and the GSD for Windows software, which is the vehicle that "drives" the data. Through its application, you are able to create a unique library of information to meet your own needs and reflect your unique environment. GSD is used to create the information required for product costing, pre-production planning, scheduling, delivery and profitability and because the system is predictive in its nature, each of these functions may be undertaken prior to making a commitment.

SewEasy
Seweasy is a more recent system used by Fortune 500 companies and SME sector alike in Ready Made Garment (RMG) manufacturing. Seweasy is more aligned with the lean concepts attributed to Toyota. This system focuses on providing Standard Minute Values (SAM, SMV) quickly for labour costing in sewing. Such garment sewing data is useful for "sewing load balancing" in line with Value Stream Mapping (VSM) and "added value" measurement, referred as "needle down time" among professionals. SewEasy Pvt. Ltd has trained many juniors and seniors alike, to quickly establish standards using this easy PMTS system. Recent research by Manchester University, UK on Garment Labor Costs and Living Wages Calculations brought Seweasy garment sewing data and Methods-time measurement (MTM) to the notice of apparel industry's sourcing professionals, including Walmart, who adopted same

Methods Time Management (MTM)
Methods-Time Measurement (MTM) is a predetermined motion time system that is used primarily in industrial settings to analyze the methods used to perform any manual operation or task and, as a product of that analysis, set the standard time in which a worker should complete that task.

Films were taken using constant speed cameras, running at 16 frames per second, of the work performed by qualified workers on the shop floor, each sequence was rated during filming by three qualified Industrial Engineers. The rating, or Levelling, system used was the Westinghouse or LMS system – so called after its originators Lowry, Maynard and Stegemerten. This system considers four factors independently:

Skill – Proficiency in following the given method
Effort – The will to work
Conditions – The general work surroundings

Consistency – of performance

Each factor is assigned an alpha rating, e.g. “B-“, “C+”, “A”, etc. which has a numeric value which is applied later. This reduces the possibility of “clock rating” and ensures that all factors are considered in the composite rating. Layout, distances, sizes of parts and tools and tolerances were accurately measured and recorded on the shop floor to complement the later analyses. The films were then projected frameby-frame and analyzed and classified in to a predetermined format of Basic Motions. A motion was taken to begin on the frame in which the hand first started performing the motion and was taken to end on the frame in which the motion was completed. This allowed a time for each recorded motion to be calculated in seconds, by means of a frame count, and then “levelled” to a common performance. Plots of the levelled times for the various motions were drawn. Analysis determined the best definitions of limits of motions and their major, time-determining variables, and resulted in, more or less, the structure which the manual motions of MTM-1 have today. Later work, using Time Study, gave the table of Body Motions.
Basic Body motions are,

Reach Grasp Move Release
Step Leg movement Bend & Arise Crank
Apply Pressure Eye movement

While MTM 1 has reach and grasp, in MTM 2 it combined both as GET, another combination in MTM2 is 2 Move and Release is clubbed to PUT. The unit in which movements are measured for MTM is TMU (time measurement unit): 1 TMU = 36 milliseconds; 1 hour = 100,000 TMU, 1 TMU = 0.036 second depending on length one TMU=0.03

PRO SMV

Pro SMV is another PMTS for the sewn product industry, offered by Methods Apparel Consultancy India Private ltd. as an individual module of their software series pack called Pro-Suite. Pro Suite is aimed at providing various IT solutions for various departments of Sewn product industry. It has made a very strong consumer base in India and neighboring countries. SMV consists of 36 codes in 7 categories. A list of the normal MTM2 data codes and other supplementary elements are included to be used for analysis of non-sewing or additional work.

The major factors to take in consideration while using PTS are,

The application of PMTS requires that the operation being measured be divided into basic motions.
At the time a PTS is first adopted by a company the level of performance as represented by the time standards produced by the system should be determined and adjustments made, if necessary, in order to match the company performance level.
Most predetermined time systems do not include allowances so these are added as they would be in a time study.

Advantages of PTS System are,

With PTS one time is indicated for given motion, irrespective of where such motion is

performed. In stop watch study it is not so much a motion as a sequence of motions making up an operation is timed.
Timing by direct observation and rating can sometimes lead to inconsistency. A PTS system avoids both rating and direct observation and hence can lead to more consistency in setting standard times. Since the times for the various operations can be derived from standard time tables, it is possible to define the standard time for a given operation even before production begins and often while the process is still at the design stage. This allows the workstudy man to change the layout and design of the workplace and of necessary jigs and fixtures in such a way that the optimum production time is achieved.
It is also possible before starting the operation to draw up an estimate the cost of production, and this could be valuable for budgeting.
They are not too difficult to apply and can be less time consuming than other methods when time standards are determined.
They are particularly useful for very short repetitive time cycles.

Disadvantages of PTS system are,

PTS systems took a long time to become part of general workstudy practice. The main reason for this delay is probably the considerable number of systems that have been produced, together with fact that many of them would obtained only by employing consultants. At present there are more than 250 such software but all of them need special training.
Any PTS system is rather complicated. It is not easy to learn and the WS engineer needs a good deal of practice before he can apply it in floor.
The task of learning enough about the various systems to be able to judge their claims and their relative merits is an almost impossible one.
PTS systems do not, eliminate the need for the stopwatch, or method study or work sampling methods.
Machine time, process time and waiting time are not measurable with PTS systems and occasional or incidental elements are often more economically measured using other techniques. It is difficult to obtain 1005 coverage in a plant using only a PTS system and for certain operations such as batch production or non-repetitive jobs the use of such a system can be an expensive proposal.
It is invalid to add up times for individual small motions in the way required by PTS system because the time taken to perform a particular motion is influenced by the motions preceding and following.

Hence the main uses of PTS system are divided into two classes,
Work Methods

Improving existing Methods
Evaluating proposed methods in advance of actual production
Evaluating suggested design of tools,
attachments, folder requirements etc.
Aiding in the design of the product
Training members of the staff to become motion minded
Aiding in training operators
Work Measurement

Establishing Time standards
Compilation of standard data and formulas for specific classes of work
Checking standards established by time study

Auditing time standards Balancing production line
Supporting better costing

Work Factor System

In PTS systems, there are symbols employed for the body members and work factors,

Body Member Finger
Hand
Arm
Fore Arm Swivel
Trunk
Foot
Leg
Hand Turn
Symbol Work Factor Symbol F Weight or Resistance W H Direction control (Steer) S A Care (Precaution) P FS Change Direction U T Depictive Stop D FT
L
HT

As per the work factor system has four major variable which affect the time to perform manual motions, they are

1. Body member used
2. Distance moved
3. Manual control required
4. Weight or resistance

Once we does the work, we can observe there are different elements supporting to do the act, they are known as Standard Elements of work, they are,

1. Transport (reach & move) TRP
2. Grasp GR
3. Pre-Position PP
4. Assembly ASY
5. Use (Manual, process, or machine time) US
6. Disassemble DSY
7. Mental Process MP
8. Release RL

The codes shown in combination, we can represent most of the works done by an operator while performing the work.
While considering the above all, MTM -1 is the most stable accurate system, provides most detailed methods description, but it requires the longest time for analysis. MTM 2 was developed by constructing motion combinations from the basic motions. It has smaller number of distance ranges and fewer cases of control than MTM 1 but the analysis can be made more quickly than MTM 1. The MTM 2 system consist of nine categories of manual motions.

Motion Get
Put
Apply Pressure
Regrasp
Eye Action
Crank
Step
Foot Motion
Bend & Arise
Symbol

G
P
A

R Get & Put are the only two variable categories andE only 37 time standards appear on MTM 2data card C

S
F
B

The speed of analysis with MTM 2is twice as fast with MTM 1.
MSD’s, Principles, Motion Economy, Working Area

8 Industrial Ergonomics

Injuries and muscle pain affecting the wrists, shoulders, neck and back are common problems for workers in the clothing industry. Humans play a critical role in most modern manufacturing systems and there is now a growing understanding that better consideration of human issues can greatly improve efficiency and safety. To cope with the complex dynamics of internal and external systems, manufacturing organisations often need to make changes that involve and/or affect its personnel. For this reason businesses are increasingly seeking ergonomics/human factors research and guidance to improve their understanding of how best to incorporate human behavior and performance into system design and operations.
Ergonomics can be defined simply as the study of work. More specifically, ergonomics is the science of designing the job to fit the worker, rather than physically forcing the worker's body to fit the job.
Ergonomics is a science that focuses on designing a job for the worker. An ergonomically-designed job would ensure that a taller worker had enough space to safely perform his or her job, and also that a shorter worker could reach all of his or her tools and products without reaching beyond a comfortable and safe range. The opposite to this, and what typically happens in the workplace, is that a worker is forced to work within the confines of the job or workstation that is already in place. This may require employees to work in awkward postures, perform the same motion over and over again or lift heavy loads – all of which could cause work related musculoskeletal disorders (WMSD).

Industries increasingly require higher production rates and advances in technology to remain competitive and stay in business. As a result, jobs today can involve:

Frequent lifting, carrying, and pushing or pulling loads without help from other workers or devices;
Increasing specialization that requires the worker to perform only one function or movement for a long period of time or day after day;
Working more than 8 hours a day;
Working at a quicker pace of work, such as faster assembly line speeds;
Having tighter grips when using tools etc.

These factors especially if coupled with poor machine design, tool, and workplace design or the use of improper tools create physical stress on workers' bodies, which can lead to injury.

A dramatic increase in MSDs began in the 1970s when these disorders increasingly appeared on companies' injury and illness logs. If work tasks and equipment do not include ergonomic principles in their design, workers may have exposure to undue physical stress, strain, and overexertion, including vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting.

Recognizing ergonomic risk factors in the workplace is an essential first step in correcting hazards and improving worker protection. Ergonomists, industrial engineers, occupational safety and health professionals, and other trained individuals believe that reducing physical stress in the workplace could eliminate up to half of the serious injuries each

year. Employers can learn to anticipate what might go wrong and alter tools and the work environment to make tasks safer for their workers.

What are MSDs?

MSDs, or musculoskeletal disorders, are injuries and disorders of the soft tissues (muscles, tendons, ligaments, joints, and cartilage) and nervous system. They can affect nearly all tissues, including the nerves and tendon sheaths, and most frequently involve the arms and back.

Occupational safety and health professionals have called these disorders a variety of names, including cumulative trauma disorders, repeated trauma, repetitive stress injuries, and occupational overexertion syndrome.

These painful and often disabling injuries generally develop gradually over weeks, months, and years. MSDs usually result from exposure to multiple risk factors that can cause or exacerbate the disorders, not from a single event or trauma such as a fall, collision, or entanglement.

MSDs can cause a number of conditions, including pain, numbness, tingling, stiff joints, difficulty moving, muscle loss, and sometimes paralysis. Frequently, workers must lose time from work to recover; some never regain full health. These disorders include carpal tunnel syndrome, tendinitis, sciatica, herniated discs, and low back pain. MSDs do not include injuries resulting from slips, trips, falls, or similar accidents.

Parts of the Body Affected by MSDs

• Arms • Back
• Hands • Wrists
• Fingers • Legs
• Neck • Shoulders

The clothing industry is generally seen as a safe place to work. Compared to other industries, there are relatively few serious accidents in clothing plants. The hazards we face are different. The major health risks in this industry do not arise from immediate, potentially fatal hazards. Instead, the risks that clothing workers face come from more subtle hazards whose effect accumulates over time.

Fundamental ergonomic principals

Ergonomics aims at preventing injuries by controlling the risk factors such as force, repetition, posture and vibration that can cause injuries to develop. Some fundamental ergonomic principals that should be followed in our workplaces are:

1. Use proper tools

Tools should be appropriate for the specific tasks being performed. Tools should allow operator to keep their hands and wrists straight the position they would be in if they were hanging relaxed at their side. Bend the tool not the wrist!

The tool should fit comfortably into hand. If the grip size is too large or too small it will be uncomfortable and will increase the risk of injury. Tools should not have sharp edges, create contact stresses in hand, or vibrate.

2. Keep repetitive motions to a minimum

Our workstations or tasks can often be redesigned to reduce the number of repetitive motions that must be performed. Using a power-driven screwdriver or tools with a ratchet

device can reduce the number of twisting motions with the arm. Some tasks can be automated or redesigned to eliminate repetitive movements and musculoskeletal injuries.

3. Avoid awkward postures

Job should not require operator to work with their hands above shoulder height on a regular basis. Arms should be kept low and close to body. Bending and twisting of wrists, back and neck should also be avoided.

4. Use safe lifting procedures

Avoid lifting objects that are too heavy. Use more than one person or a mechanical device to reduce the load. Workstation should not require operator to lift objects above their head or twist back while lifting. Instruct the operator to keep the load close to body and ensure that operator have a good grip. Heavy and frequently lifted objects should be stored between knee and shoulder height not on the ground or above head.

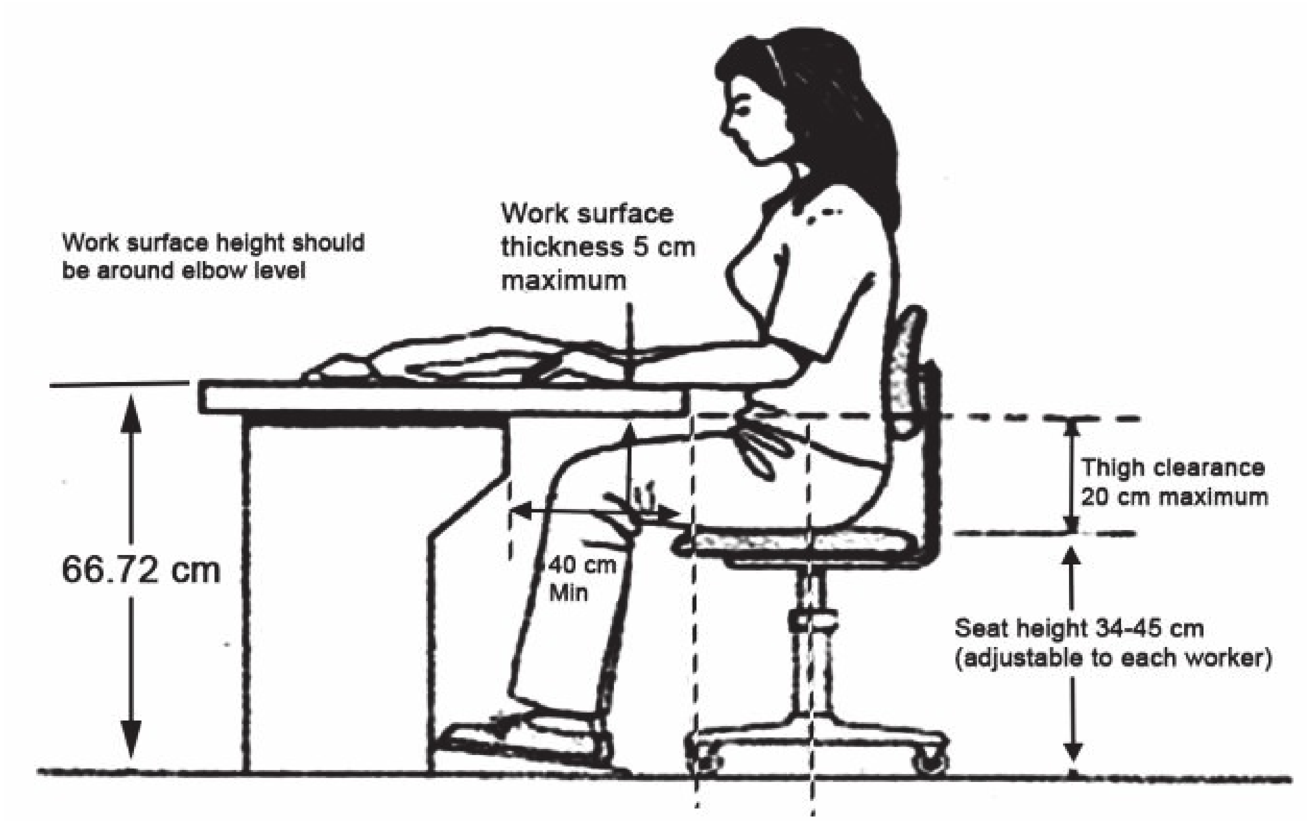
5. Get proper rest

Operators need to rest their body and mind in order to prevent injuries. Give muscles a rest during coffee breaks, lunches and weekends by doing something different from what normally does in job. For example, if you stand all day while performing your job you should sit down to rest your legs and feet during your breaks. If you sit down when working you should stand up and walk around during your breaks to give your back a rest and to increase circulation in your legs.

Common Ergonomic Problems and Solutions in the Clothing Industry

Awkward body postures are a major ergonomic concern in the garment industry. Awkward postures take the body away from a comfortable position, which reduces efficiency and increases the use of energy. Another major concern are static postures. Static means to hold in place, so these are postures where the body is held in one position for a long period of time. An example is when you work with your arms above shoulder height for long periods of time. These types of postures require constant muscle use for the time the body is held in the position. This reduces rest and recovery time, which leads to muscle tiredness. The following are recommendations which will help to reduce the risk of injury due to the above concerns.

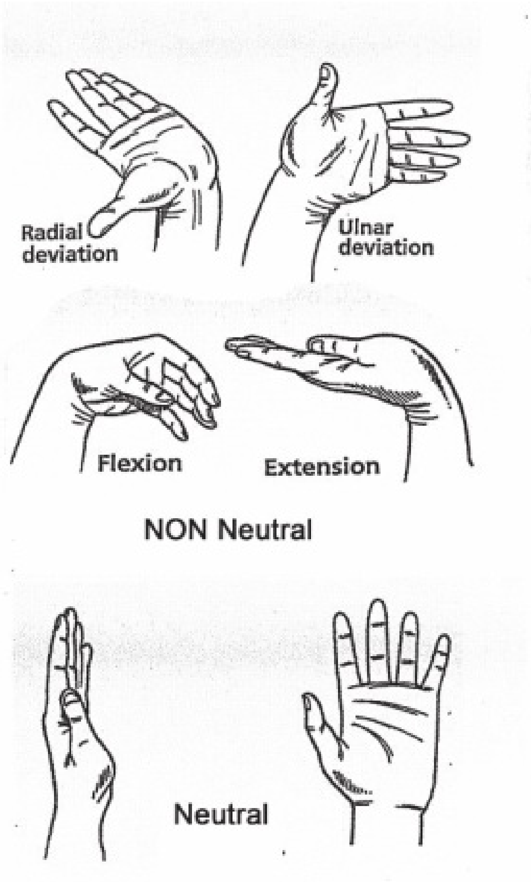
For seated and standing work, the height of the workstation should allow workers to function with elbows at 90 degrees. If the workstation is too low, the worker is forced to bend at the waist to reach the work being done. This puts stress on the lower back. If the station is too high, the worker is forced to lift their shoulders or move their elbows away from the body to reach their work. This puts increased stress on the shoulders which may lead to injury.

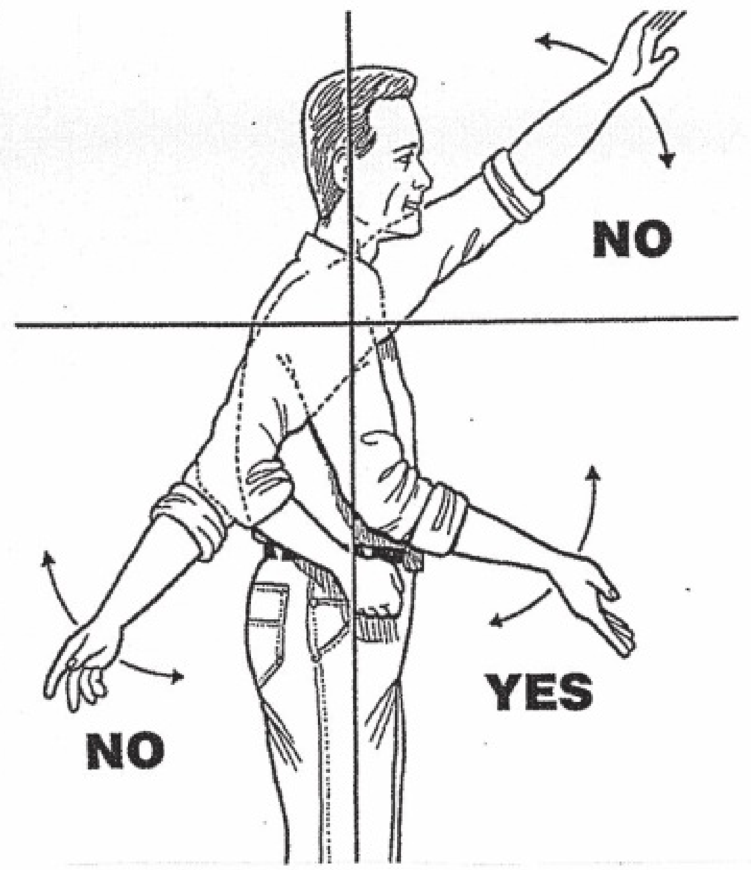


During seated work, if a good back support is not present or used, static postures occur which results in constant use of the back muscles. It is important to adjust the workstation in order to allow the worker to use the backrest. It is also important to adjust the worker's chair to allow duties to be performed with their bodies in comfortable positions. The workstation and chair should be positioned so that the worker's knees, hips, and elbows are at 90 degrees, which will reduce stress on the body. There should also be enough room to allow the worker to change their sitting position throughout the day. Static postures can also occur during standing work. If the worker stands in one position for long periods of time, muscles of the back and legs will be constantly activated. This can lead to increased fatigue, and decreased blood circulation to the legs. During the day, workers should try to walk around to allow their blood to flow. As well, workers should try and sit for short periods of time while working to give their leg and back muscles a rest.

Awkward wrist postures are one of the major causes of cumulative trauma disorders (CTD) such as *Carpal Tunnel Syndrome* (CTS), tendinitis, and muscle strains. Awkward wrist postures are those which take the wrist away from the neutral position. Neutral position is when the hand is in line with the forearm. The workstation should be adjusted and the worker educated on awkward wrist postures, their harmful effects, and the signs and symptoms of CTD's.

Workers should not constantly work with their arms above shoulder level. Work above the shoulders increases the use of the shoulder muscles. With this constant use, the muscles do not have time to rest and thus tire more rapidly. The majority of work should be done between knuckle height and shoulder level.





Workers should try not to twist their upper body when placing objects besides them. By keeping their feet in place and only moving their upper body, workers are putting large stresses on their backs, which may lead to injuries. Workers should move their feet, instead of twisting at the waist, in order to face the area where the object is going to be placed. If the worker is sitting, they should try to swivel in their chair, instead of twisting their upper body.

Principles of motion Economy

The principles of motion economy form a basis code or a body of rules, which, if applied by one trained in the motion study technique and problem solving process, will make it possible to increase the output of manual labour with a minimum fatigue.

Principles related to Human Body.

1. Two hands should begin as well as complete their motions at the same time.
2. Two hands should not be idle at the same time except during rest periods
3. Motions of the arm should be made in opposite and symmetrical direction and should be made simultaneously.

It is better to arrange similar work on the left and right hand sides of the workplace, thus enabling the left and right hands to more together. In sewing the two bundles of parts for attaching can be placed on both the sides hence enable to pick the pieces using two hands simultaneously.

4. Hand and body motions should be confined to the lowest classification with which it is possible to perform the work satisfactorily

General classification of hand motions are,

a) Finger motions
b) Motions involving finger and wrist
c) Motions involving finger, wrist and fore arm
d) Motions involving finger, wrist, forearm and upper arm
e) Motions involving finger, wrist, forearm, upper arm, and shoulder.

Finger motions are more fatiguing, less accurate, a blower than motions of forearm. Forearm is the most used for light works and that in highly repetitive works.

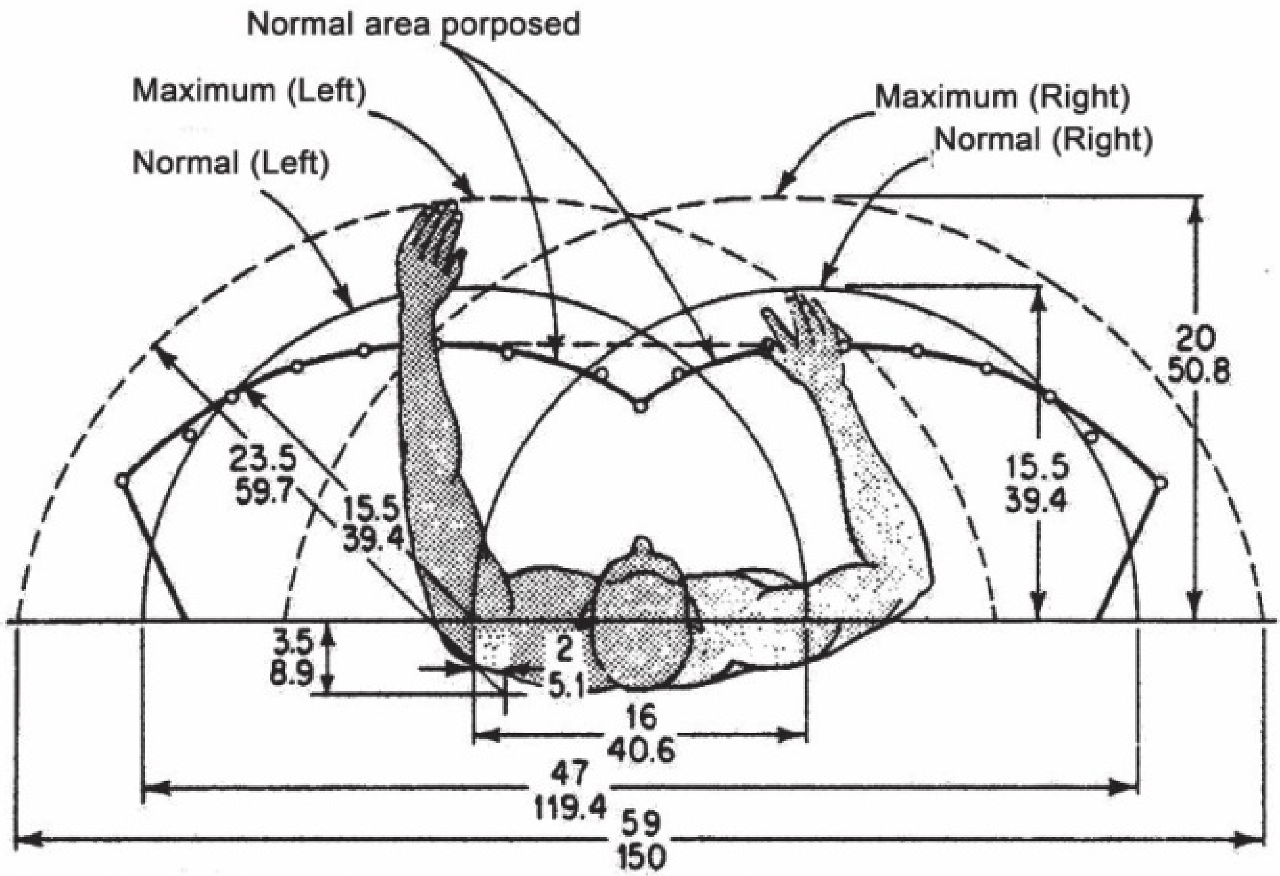
5. Momentum should be employed to assist the worker wherever possible, and it should be reduced to minimum if it must be overcome by muscular effort. (Momentum = Mass x velocity). For example, if a forcible stroke is required, the motions of the worker should be so arranged that the stroke delivered when it reaches its greatest momentum.

6. Smooth continuous curved motions of the hands are preferable to straight line motions involving sudden and sharp changes in direction.
7. Ballistic movements are faster, easier and more accurate than restricted (fixation) or controlled movements. Example for fixation movement is writing and for ballistic is swinging hammer while nailing.
8. Work should be arranged to permit an easy and natural rhythm wherever possible.
9. Eye fixations should be as few and as close together as possible.

Principles of motion economy related to work place
1. There should be a definite and fixed place for all tools and materials.
The operator should always be able to find the tools and material in the same location. Similarly finished
parts and assembled parts should be disposed in fixed places.
2. Tools, material, and controls should be located close to the point of use.
The main aim of motion ergonomics in industry is to reduce the human movements and efforts thereby
reducing fatigue.

Working Area

Considering the horizontal place, there is a very definite and limited area which the worker can use with a normal effort. The normal working area for the right hand is determined by an arc drawn with a sweep of the right hand across the table. The fore arm only is extended and the upper arm hangs at the side of the body in a natural position. The arcs of left and right hands will cross each other at a point in front of the worker. The overlapping areas constitutes a zone in which two hands work may be done most conveniently.



There is a maximum work area for the hands too, it is determined by the sweep arc of the hand with the arm pivoted at the right shoulder. The overlapping area consists a zone beyond which two handed work cannot be performed without causing considerable disturbance and accompanied by fatigue.

Arrangement of machines.

The following statements might be considered while arranging the machines and tools, In the continuous type of manufacturing, machines, process equipment, raw material, etc. should be arranged so as to require the least movement on the part of the operator.

Gravity feed bins and containers should be used to deliver material close to the point of use. (a bin

with sopping bottom permits the material to be fed to the front by gravity also relieves the operator of having to turn into the container to grasp parts.

Drop deliveries should be used whenever possible

Material and tools should be arranged to permit the best sequence of motions.

Provisions should be made for adequate conditions for seeing. Good illumination is the first requirement for satisfactory visual perception. (

o Light of proper intensity for the task.

o Light of proper colour and without glare

o Light o coming from the right (not right side) direction so that no key work positions

are hidden.

The height of the working place and the chair should preferably be arranged so that alternate sitting and standing at work are easily possible.

A chair of the type and height to permit good posture should be provided for every worker.
Foot rest – an adjustable foot rest should be provided wherever it is possible. It may be attached to the chair, floor or work table may be used.
Arm rest – arm rest are most effective on work that requires little movement of the forearms, with the hands working at approximately the same position. The arm rest must not interfere with the normal working of the arms and hands.

Principles of Motion Economy related to the design of tools and equipment

The hands should be relieved of all work that can be done more advantageously by the tools i.e. foot operated devices, scissors etc.
Two or more tools must be combined whenever it is possible. It is quicker to turn a small two ended tool end than it is to lay one tool down and pick another.
Tools and materials should be prepositioned whenever possible. For prepositioning a holder in the form of socket, compartment, bracket, or hanger should be provided.
Where each finger performs some specific movement, such as in typewriting, the load should be distributed in accordance with the inherent capacities of the fingers.
Levers, hand wheels and other controls should be located in such position that the operator can manipulate them with the least change in body position and with the greatest speed and ease.

Location of materials

The workstudy officer should consider a number of points before deciding where the parts should be placed, they include

Garment parts should be located in the normal working area, if possible, because it is easier to handle and see things within this area.
Any holders or shelves should be arranged so that the contents are used in the correct sequence and consider to place them in the extended work area to the maximum possible.

Many sewing machine in our factories are attached to a standard table supplied by manufacturer, but there are several things which can be done to make work easier. Such as,

Extensions to the table (at front, sides, rear or in front and side etc.) these are extremely useful when having to handle large or unusual shaped garment parts.
Shelves (for small parts, for large parts, for labels etc.) these can be used for stacking garment parts and they are in easy reach for pickup. This means the operator doesn't have to search for parts.

Cut outs (at the side of the table, at rear, near needle etc.) can be used either to ease the disposal of the garment after sewing, such as a cut out at the rear table, or to position the parts of the needle easier, such as a cut out in front of the needle.

Holders and Clamps for extremely small garment parts or labels and clamps for the main garment parts are useful as they eliminate the operator having to locate parts, since they are all held in one position.

Overhead conveyors or rails . These type of systems can be used for large or medium sized garment, especially where there is a need to control the workflow. The clamps may slide along the rail or may be fitted with wheels, and the rail itself can be from machine

height upwards, according to the length of the garment. The garments can be singles or in small bundles and they may either stay in the clamp while sewing or be removed for each operation.

Line, Capacity, WIP, Scheduling, Lead Time, Load Levelling, Bottleneck, Reporting sequencing

9 Production Planning

Production is the nucleus or the center of the entire organisations business operations. Production planning comprise the planning, routing, dispatching, and follow up functions in the manufacturing process so that the movement of material, performance of machines and operations of the labour, are directed as to quantity, quality, time, and place.

Production planning is the essential prerequisites to production control. It involves management decisions on the resources that the firm will require for its manufacturing operations and the selection of those resources to produce the desired goods at appropriate time and at the least possible cost.

"Production planning is the technique of foreseeing or picturing ahead, every step in a long series of separate operations, each step to be taken in the right place, of the right degree and at the right time, and each operation to be done at maximum efficiency."

The planning process in clothing manufacture
The basic process includes the following stages:
1. Receive the order
2. Plan to check if there is available capacity in sewing to achieve the delivery date required 3. Plan to check the available capacity in non-sewing areas (cut, embroidery; print, wash and pack) 4. Plan to check sufficient lead time to order and receive fabric, trims, approve sample, carry out lab tests etc.
5. Confirm delivery date to customer and reserve capacity
6. Communicate plan to all departments
7. Monitor progress against plan
8. Re-plan as required and return to Point 5.

In an ideal world, this cycle would be carried out in a systematic way. No plan is ever perfect, but all that we have learned about total quality management reminds us that we must aim at the ideal rather than settle for 'Acceptable Quality Levels' that have a built-in failure rate. Although the first priority is the customer delivery date, the factory must also consider the best place to make each product, taking into account both skill and machine constraints. Production efficiency depends upon this. In the clothing industry, planning will typically focus on sewing, as it can account for up to 80% of the skill and resources required. However, the capacity constraints of supporting areas also have to be assessed. In particular, the pre-production events must be planned to ensure that production begins on schedule.

The requirement and functions of production planning is apparel industry can be describes as,

Job or Task Scheduling: - Preparation of time and action calendar for each order from order receiving to shipment. The job schedule contains list of tasks to be processed for the styles. Against

each tasks
planner mentions when to start a task and what is dead line for that task. Name of responsible person (department) for the job is being listed. For example, scheduling planned cut date (PCD), line loading date etc.
Material Resource Planning (Inventory): Preparation of Material requirement sheet according to sample product and buyer specification sheet. Consumption of material (fabric, thread, button, and twill tape) is calculated and estimated cost of each material.
Loading production: Planner defines which style to be loaded to the production line and how much quantity to be loaded.

Process selection & planning: Processes needed to complete an order vary style to style. According to the order (customer) requirement PPC department select processes for the orders. Sometime extra processes are eliminated to reduce cost of production.

Facility location: Where a company has multiple factories (facilities) for production and factories are set for specific product, planner need to identify which facility will be most suitable for new orders. Sometimes there may be a capacity shortage in a factory, in that case planner need to decide which facility will selected for that orders.

Estimating quantity and costs of production: Planner estimate daily production (units) according to the styles work content. With the estimated production figure, production runs and manpower involvement planner also estimate production cost per pieces.

Capacity planning: PPC department plays a major role during order booking. They decide (suggest) how much order they should accept according to their production capacity. Allocating of total capacity or deciding how much capacity to be used for an order out of total factory capacity. Regularly updating factories current capacity (production capacity).

Line planning: Preparing detailed line planning with daily production target for the production line. Most cases line planning is made after discussing with production team and Industrial engineers.

Follow up and execution: Whatever plan is made is executed by PPC department. PPC department keeps close look whether everything is progressing according the plan. Chasing other department heads on daily basis to keep plan on track. They update order wise completed tasks on the Time & action Calendar. When they found something is going to be late they expedite and create an alarm about the delay.

Role of the SAM
SAM value of a garment is defined as how much time it would take to complete a garment in sewing. This is also known as garment work content and standard minutes.

Line Capacity Calculation
The scientific method of calculating production capacity of a line (in production pieces per day) is to use standard time (SAM) of a garment. So, to determine production capacity of a line (for specific products) in pieces you need to know garment SAM.

Lead Time Calculation
Based on the production capacity, order allocation is done for different lines. A planning guy also need to calculate how long a style would run in a line if loaded in a single line. If

you need to complete the order in less time, calculate how many lines to be considered for an order.

Order booking
During order booking, you need to consider capacity availability in a certain period. In such cases you can use how many minutes you need to make the new orders using garment SAM value and compare the same with how many production minutes are available in your factory for the defined period.

Process Scheduling
Time and action calendar or production process scheduling of each order is done by planning department. Again to schedule a list of tasks, you need to know capacity of each process per day (or a predefined period). Based on the capacity of each process you allocate no. of days for the process. Like for sewing department, you determine sewing capacity of your line (or multiple lines) and according to that you set how many days to be given to sewing department for production.

Order Execution and Production Monitoring
Standard minutes help planners to set target for sewing lines. Mutually agreed and calculated target given to line supervisors. On daily basis when you check production status you can compare actual production with target production. In case production is getting delayed you can push production team based on given target.

Labor Cost Estimation
One most important task is labor cost estimation of a specific order. To estimate how much labor cost to be considered for an order (style), you can’t make labor costing without having garment SAM value.

All the above six points is proving that garment SAM plays a big role in production planning and controlling function in garment industry.

Line Planning

Line planning is scheduling and allocating of orders to production lines according to product setting (product is being made in the line) and due dates of production completion. A line plan defines when a style is going to be loaded to the line, how many pieces to be expected (target) from the line and when order to be completed. During booking orders or allocating orders to the production line, planners must check what is running on the line and how many days it will take to complete the running style.

Benefit of Line planning: It helps production manager as well as line supervisor with information such as what is the daily production target for line. They set their line (machines and manpower) accordingly. Line plan also provides information such as how many days style would

run, what is the next style going to be loaded?

Line planning can be prepared to most all the orders. This is easy to compare the available slots to take new orders or not. Also it can give the comparison with achieved production and requirement of additional resources of production improvement like overtime or outsourcing may be required in case of low production happens a day.

	Line 1		Line 2		Total
Date	Daily Prod.	Cumm Prod	Daily Prod.	Cumm Prod	Daily Prod.
1-Dec	loading #2341A, Qty -3000 pieces		300	1200	300
2-Dec	200	200	300	1500	500
3-Dec	250	450	300	1800	550
4-Dec	400	850	200	2000	600
5-Dec	400	1250	loading #Polo , Qty -1500 pieces		400
6-Dec	400	1650	0	0	400
7-Dec	400	2050	100	100	500
8-Dec	400	2450	300	400	700
9-Dec	400	2850	350	750	750
10-Dec	150	3000	350	1100	500
11-Dec	loading #432K, Qty -5500 pieces		400	1500	400
12-Dec	100	100	loading #YK45, Qty -4500 pieces		100
13-Dec	250	350	200	200	450
14-Dec	500	850	250	450	750
15-Dec	500	1350	400	850	900
16-Dec	500	1850	400	1250	900
17-Dec	500	2350	400	1650	900
18-Dec	500	2850	400	2050	900
19-Dec	500	3350	400	2450	900
20-Dec	500	3850	400	2850	900
21-Dec	500	4350	400	3250	900
22-Dec	500	4850	400	3650	900
23-Dec	150	5000	400	4050	550

Daily Prod. – Daily production or line output

Cumm Prod. – Cumulative production of the style till date

Capacity planning

Planning includes determination of how much ling range production capacity is needed, when additional capacity is needed, where production facilities should be located and the

layout and characteristics of the facilities.

Capacity is the maximum production rate of facility or a firm. It is usually expressed as volume of output per period of time. This was explained in earlier chapters
Capacity indicates the ability of a firm to meet customer demand.
Operations managers are concerned with capacity because,
a) They want sufficient capacity to meet customer demand in time.
b) Capacity affects cost efficiency of operations, the ease or difficulty of scheduling output and the cost of maintaining the facility.
c) Capacity requires and investment of capital

Capacity Planning is necessary when an organisation decides to increase its production or introduce a new product. Once capacity is evaluated and a need for new or expanded facilities are determined, decisions regarding facility location and process technology selection are taken.

Capacity requirement Planning (CRP)

Capacity requirement planning is the technique for determining what labour and equipment capacities are needed to meet the production objectives symbolized in *The Master Production Schedule* (MPS) and the *Material Requirement Planning* (MRP-I). The CRP and MRP-I are established specify what materials and capacities are needed and when they are needed.

End item requirements arising from the aggregate plan and MPS (master Production Schedule) are exploded in to tentative planned order for components by the MRP system. The CRP system converts these orders into standard labour and machine hour of load on the appropriate workers and on the machines as identified from the work centers status and shop routing files.

The output is a load projection report work center wise. If the work center capacities are adequate, the planned order releases are verified for the MRP system and release orders become purchase and shop orders. Work leaders are also used for controlling input or output. If the initial load projection reports reveals inadequacy of capacity in any work center, either the capacity must be increased (by using overtime or subcontracting) or the master production schedule must be revised.

Inputs needed are,

Planned orders and released orders from MRP
Loading information from the work center status
Routing information (where the work is doing to be done)
Changes, which modify capacity, give alternative routing or altered planned orders.

A routing is the path that work follows from work center to work center as it is completed. Routing is specified on a route sheet or, in a computer-based system, in a route file. A routing file should exist for every component manufactured and contain the following information: (Operations to be performed, Sequence of operations, Work centers to be used, possible alternate work centers, Tooling needed at each operation, Standard times: setup times and run times per piece.)

Machine requirement.

In a manufacturing concern, substantial part of the financial resources are invested in the plant, machine and equipment. It is same in the case of apparel industry too. The return of these investments can be maximized by

1. Making the optimum investment in the plant and machines, and
2. By making the optimum utilization of the installed production capacity.

The issue of machine requirement is dealt with this session, and the line balancing concerns the second part.
Machine requirement decides the desirable investment in plant and machines. Machine capacity is generally expressed in terms of machine hour.
Let us reduce the formula to, where ST = SAM/ 60

Let us work out with an example,
A job is to be performed, with the following data, find the number of machines required?

SAM per job for the operation
Maximum capacity or order quantity of job Standard capacity of a machine per month
Average utilization of the machine capacity = 6 min
= 70,000 pieces per month = 2,000 pieces per month. = 90%

Then, As per the formula, ST = 6 /60 = 0.1

Total machine required = 3.88 machines, as the machine is an indivisible economic unit, = 4

Or

In the above example, Target = 70,000 pieces in one month SMV = 6 minutes
Capacity of a m/c = 2,000 pcs per month Machine Time available= 2000 x 90% = 1800
Hence,

= = 3.88 = 4 machines.

Line Balancing.

A line is defined as a group of operators under the control of one production supervisor or doing same volume of target.

Line balancing is the equal distribution of work among the workers of a particular line, on the basis of time taken of each operation. Line balancing is a vital key in the efficient running of a line. The object of the process is to “balance the work load” of each operation to make sure that the flow of work is smooth, that no bottlenecks are created and the operators are able to work at peak performance throughout the day. This process is intended to reduce waiting time to a minimum and thereby reducing idle time. Or in fact, with the use of some work in progress to eliminate waiting time completely.

The method of line balancing can vary from factory to factory and depend on the type of garments manufactured but in any instance, line balancing concerns itself with two distinct applications “Setting up” a line and “Running a line”

The problem of line balancing arises due to,
1. The finished garments is the result of may sequential operations
2. The production capacity of each machine is not identical

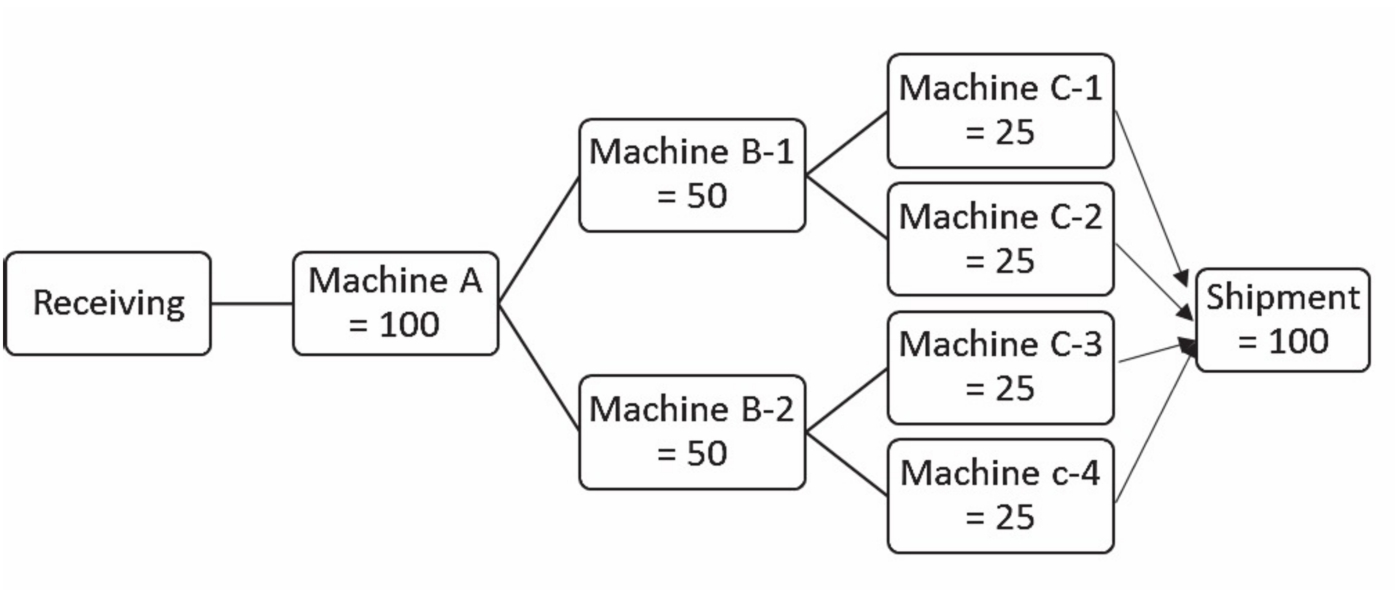
The technique of line balancing reduces the idle time of the installed capacity and

facilitates the intensive use of production capacity. Sometimes line balancing can help in resource planning to calculate how many machines are required for a better line. Etc. let us work with a basic example.

Operation A has 100 pieces per Hr. production in a machine Operation B has 50 pieces per Hr.
Operation c has 25 pieces per Hr.
The operation sequence is A B C
Now if only one machine is provided for the process passing sequential through the machines A, B and C then, the machine production in the line will be decided on the basis of machine with the least production capacity that is machine C having 25 pieces per hour. Hence the line output will also be 25. The production capacity of machines A and B will be confined to the production of 25 units per hour only. So in each hour machine A and B will remain idle for 45 and 30 minutes respectively. It should be Receiving

Machine A (100-75) =25
Machine B(100-50) =50
Machine C =25
Shipping 25

noted that in the process layout such idle time or slacks can be minimized though proper "routing" and scheduling of other operations. However as garment is working as a product layout structure, due to the linear arrangement of the machines, the utilization of such idle capacity would be relatively difficult. The concept of line balancing is to solve the problem. A line balanced mode of the same issue are, Let us



compare both the situations,

Sitaution 1
No of Op Theory Actual Total Machines = 3 Capacity / M/c 1 1 100 25 capacity / M/c 2 1 50 25 capacitu / M/c 3 1 25 25 Total SAM 2.92 capacity / Hr 61.71 Actual out put 25 25 Line efficiency 40.51 idle time 75 Min

Situation 2
No of Op Theory Actual Total Machines = 7 Capacity / M/c 1 1 100 100 capacity / M/c 2 2 50 100 capacitu / M/c 3 4 25 100 Total SAM 2.92 capacity / Hr 144.00 Actual out put

100 100 Line efficiency 69.44

Setting Up a Line. The actual production of the line will be decided on the basis of the machine with the maximum production capacity. The production capacity of the other machines in the line will be adjusted through the increase in the number of machines. We will either how many machines are required to achieve the required rate of production or how many garments can be produced by a given number of operators. Either the way, we are in need of the following data to do the balancing.

a) Number of Operators in line
b) List of operations involved in making the specific garment
c) The standard time for each operation
d) Output required from the given line
e) Type of machines, its attachments, work aids, thread type, colour etc. also in need. f) Operator skill (cross trained operators etc.) & Skill Matrix
g) Needle and seam types etc.
h) Operator movements between machines.

Method of line balancing
1. Add up the operation Times to the sum (whole garment SAM)
2. Establish what percentage each operation is of the total time
3. Work out theoretical balance, by using each operation's percentage of the total number of operators on the line.
4. Round the theoretical balance to near the half of an operator, either up or down.
5. Where you have "half" operator combine it with similar equipment to get "full" operator.
6. If you have an "Odd" half operator, this should be rounded up (the operator could be used to help to balance the line in situations such as absenteeism, machine trouble etc.)
7. Calculate the number of garments that would be produced per hour on each operation. (number of operators multiplied with 60 and divide by the total SMV)
8. List the type of equipment required for each operation.
9. List the Operator token number for the specific operator (this done as per skill matrix for a running line, for better productivity and utilization only.)
10. Calculate theoretical output. (number of operators x 60 divided by SMA)
11. Calculate the balance efficiency. (lowest output divided by theoretical output)
12. Calculate the line forecast. (theoretical output x efficiency)

However, in reality the problem is not simple. The main problem arising out of such simplified line balancing is the disposal of the large volume of production. In such situation, the solution is sought with the help of cost-benefit analysis. If the cost of overprotection exceeds the cost of idle capacity in the unbalanced line, then attempts are made to solve the problem in some other manner. The of idle capacity in the unbalanced line can be solved in some other manner like,
Another product line enabling the use of idle capacity of the first line could be run close to it. However, sometimes such a solution may create more complex issues that it can solve.
By transferring the work elements from overloaded machines to some other machines somewhere else in the line. Such solution may cause more handling cost and increased processing time.
Formulas to remember

An example line balancing sheet is shown below, please read with the above calculation steps in mind.
SN Operation SMV
M/c
% of Theory Actual Pcs / Actual SMV operators Operts Hr output

1 Flat Lock Sleeves
2 Lip Elastic to Neck
3 ZZ Lace
4 Join Shoulder
5 Insert Sleeve
6 Close Sides
7 Flat lock Hem
8 Bartack
9 Labels
0.768 3N FL 13.68 0.96 1.00 625 625 0.304 2NCS 5.41 0.38 0.50 789 625 0.608 2N FL 10.83 0.76 1.00 789 625 0.461 3T O/L 8.21 0.57 0.50 521 521 0.862 3T O/L 15.35 1.07 1.00 557 521 0.958 3T O/L 17.06 1.19 1.50 752 521 0.804 2 N F/L 14.32 1.00 1.00 597 521 0.566 Bartack 10.08 0.71 1.00 848 521 0.29 5.07 0.36 0.50 842 521

TOTAL SMV 5.616 7.00 8.00

Target Production
Minutes available
Total available manpower Salary of operator
598 No of workstations **7 480** No of Indirect NVA **0 7** Planned output / hr. 684 **INR 125** Actual output / hr. 521

Target production @ 75 % efficiency 449 Balancing efficiency 76.1 Total required manpower 8.00 Total m/c Required (…) Total m/c Required (SNLS) Total m/c Required (.) Total m/c Required (……..) Total m/c Required (….)

The problems of line balancing should be solved on the basis of cost-benefit analysis of the incremental problem. Techniques like Linear programming, dynamic programming, PERT, CPM etc. are employed in the analysis. The maximum economic benefit yielding solutions are adopted.

Running a Line
When running a line, the supervisor will be concerned with eliminating any problems which arise throughout the day. As even with the most carefully planned style and best organized production floor, it is impossible to balance the production from operator to operator, so that it remains perfect throughout the day.
Due to factors like machine breakdown, absenteeism, different performance levels between operators. The supervisor will constantly have to reassess the balance between operations. There are certain factors which the supervisor can look for to help the balancing of the line. They are,

There should be a reasonable level of work in Progress. A recommended level is between 30 min to 1 hr. between operations. Anything below 30 minutes will not give the supervisor sufficient time to react to a breakdown. Anything above 60 minute supply is

unnecessary.

Work in progress should always be kept in good order and full view

Have a number of additional machinists trained on many operations so that they can be used where necessary to cover for absenteeism. Therefore if absenteeism is 5%, a squad of skilled operators would be required to cover this amount.

Space should be made available within the line for spare machines in case of a breakdown. Ensure that the mechanics keep the machine regularly serviced.
If a bottleneck keeps occurring at a particular place in the line, improve the method to eliminate the bottleneck. It is most important to establish where this point is on the line. If necessary recheck the line balancing.
Supervisors must know the capabilities and skills of the operators under their control.
Supervisors must learn that the amount of work waiting for each operation will increase or decrease over a period of time, and must plan when to take appropriate action. The supervisor should have in mind a minimum and maximum number of bundles that should be at each operation, and what action to take if the level drops or rises.
Supervision could carry out balancing duty regularly at two hour intervals. Checking every operation on the line to ensure that the work in progress level is within the correct limits.
Balancing duties should be carried out on time irrespective of what else the supervisor is doing. The supervisor should be able to make up his/her mind about what to do if the levels are not correct, and not have to wait for the Apparel engineer to make the decision for him.

Work In Progress (WIP)
Work in progress (WIP) refers to material that has entered the production process but is not yet a finished product. Work in progress (WIP) therefore refers to all materials and partly finished products that are at various stages of the production process. WIP excludes inventory of raw materials at the start of the production cycle and finished products inventory at the end of the production cycle.
Work In Progress (WIP) is a hazard well known to the apparel manufacturing fraternity. Expressed in days, it is most commonly measured by dividing the total WIP in pieces by the average production target for a day. “Most factories have zero control on WIP.
The classic American concept of ‘Cut and Dump’ which advocates that once dumped on the floor, there will be pressure on the worker as they like to see a mountain of goods in and around him/her. Slowly the goods will keep on moving. This WIP build-up actually begins to hurt during style changeovers when for 2 to 4 days the lines are running and the first piece is still not out,” shares Nimish Dave, Director, The IdeaSmith. The company has recently accomplished a WIP management project at Indo-British Garments, popularly known as the uniform sourcing/manufacturing wing of security solutions provider G4S.
When the project commenced, every workstation had 70 pcs, 2 days of WIP in the line and a changeover time of 2 days. Now, the WIP has been reduced to 1 day, the bundle size for every workstation to 10 days (the team is aiming at bringing this figure down to 4 days and the style changeover time has been reduced to 1 to 3 hours.
The ending balance in the WIP account is the value of partially completed inventory as of the end date of the reporting period. Businesses that maintain a perpetual inventory always

know the current value of WIP, but businesses that employ the periodic inventory method, by taking physical counts of finished goods, or can use a formula to determine period-ending WIP.

Let us do with an example,

The SAM of operation = 0.54 Set bundle size = 56 pieces Operators in Line = 12

WIP of the operator = 56 x 0.54 x 12 = 30 minutes
Total Buffer pieces = 56 x 12 = 672 pieces
We should understand that, WIP is normally expressed in form of time only. From the above example, if there is no feed has happened to the operator from his feeder due machine trouble or else, even though he has sufficient buffer pieces for 30 minutes working. The quantity of pieces of raw materials required to keep the operator work for that much time is called as the buffer quantity.

From the above line balancing example, let us find out how much should be the bundle quantity required for each operator as WIP and total WIP required for the line.
SN Operation SMV

1 Fl at Lock Sl eeves 0.77
2 Lip Elastic to Neck 0.30
3 ZZ Lace 0.61
4 Join Shoulder 0.46
5 Insert Sl eeve 0.86
6 Close Sides 0.96
7 Flat lock Hem 0.80
8 Bartack 0.57
9 Label s 0.29
10

Sheet 1 WIP **M/c Operator Planned Pcs / Hr to do 94req W/S**
2N FL 1.3 1.5 117 36 2NCS 0.5 0.5 99 14 2N FL 1.0 1 99 29 3T O/L 0.8 1 99 22 3T O/L **1.4** 1.5 99 41 3T O/L 1.6 1.5 94 45

2 N F/L 1.3 1.5 94 38
Bartack **0.9** 194 27
SNLS 0.5 0.5 94 14

TOTAL SMV 5.62

Target Production **101** Minutes available **60** Total available manpower **10.0** WIP Planned (min) **30.00** Target production @ 75 % efficiency

9.4 10.0 94 264 47 No of workstations **10**
Actual WIP in Line (min) **47**
Planned out put / hr
Actual out put / hr **94**
Balancing efficiency **93**

This shows only a theoretical WIP in the line, but in actual it may be different, little more in quantity because of the unity of bundle sizes. The bundle sizes are generally according to the cut order plan, means, in most cases, cut order plan is prepared after the preparation

of the production schedules only, hence the cut order plan is prepares according to the requirements of the WIP also. In the above situation we have a planned WIP of 30 min but in actual while we see, we are having a theoretical WIP of 47 min. WIP can be calculated in most departments by a simple methods,

Cutting WIP: - When one calculates cutting room WIP only stock cut pieces is considered as cutting WIP. Fabric those are layered on table or received from fabric store for cutting is not considered as WIP.
Sewing Section WIP: - WIP level of sewing section can be calculated for a line, for a floor or WIP between two operations. You have to use specific formula for what you are calculating WIP level.
Finishing Room WIP:
There are primarily three reasons for maintaining WIP between any two sewing operators (for both PBU and UPS system):

To balance the unequal SAM between two operations
To cover absenteeism
To cover machine breakdown

It can be deduced from the above factors that a factory with heavy absenteeism and very old machines will keep more WIP than a factory with lesser absenteeism and newer machines. Further, if the SAM of different operations in the style is closer to pitch time, then balance efficiency will be higher and lesser WIP can be maintained between any two operations. The effect of above three factors can be minimized but the net effect will still remain, and hence the WIP.

Optimum WIP level

There is no magic formula to calculate optimum WIP level for a sewing line. Out of the three above reasons for maintaining WIP, while the first reason is controllable and can be predicted and the WIP calculated, the last two reasons are unpredictable and the calculation is based only on historical data.

For example, if SAM for operation ‘A’ is 0.8 min. and operation ‘B’ is 0.9 min., then ‘A’ is going to produce 75 pieces per hour and operation ‘B’ will produce 66 pieces per hour. If ‘B’ is feeding ‘A’, then every hour there will be 9 pieces of shortfall and unless WIP is maintained between them, ‘A’ cannot work to its full potential. If we maintain around 72 pieces of WIP in-between, then both operators can work to their full potential uninterruptedly for 8 hours (72 divided by 9 = 8)

Scheduling Orders

So far we have assumed that we know when an order should be run on one work center. Most orders are processed across a number of work centers, and it is necessary to calculate when orders must be started and completed on each work center so the final due date can be met. This process is called scheduling. In the ninth edition of the APICS Dictionary, scheduling is defined as “a timetable for planned occurrences.”

a. Back scheduling.
The usual process is to start with the due date and, using the lead times to work back to find the start date for each operation. This process is called back scheduling. To schedule,

we need to know for each order:

The quantity and due date.
Sequence of operations and work centers needed
Setup and run times for each operation.
Queue, wait, and move times.
Work center capacity available (rated or demonstrated).
The information needed is obtained from the following:

Order file:- containing Quantities and due dates.
Route file: describing Sequence of operations, work centers needed, setup time, and run time. Work center file:- status of Queue, move, and wait times and work center capacity.

The process is as follows:
For each work order, calculate the capacity required (time) at each work center. Starting with the due date, schedule back to get the completion and start dates for each operation.
Example Problem,

Suppose there is an order for 150 of gear shaft SG 123. The due date is the day 135. The route sheet, shown in Table 1, gives information about the operations to be performed and the setup and run times. The work center file, shown in Table 2, gives lead time data for each work center. Calculate the start and finish dates for each operation. Use the following scheduling rules.

Operation times are rounded up to the nearest eight hours and expressed as days on a one-shift basis. That is, if an operation takes 6.5 standard hours, round it up to eight hours, which represents one day.
Assume an order starts at the beginning of the day and finishes at the end of a day. For example. If an order starts on day 1 and is finished on day 5, it has taken five days to complete. If move time is one day, the order will be available to the next workstation at the start of day 7.

Table 1.

Operation Work S/U Time
No. Center (standard hours)
10 12 1.5
20 14 0.5
30 17 0.3
40 3 0.45
50 Stores
Run Time/piece Operation (standard hours)

0.2 Turn shaft 0.25 Mill slot 0.05 Drill 2 holes 0.1 Grind

Inventory
Table 2 Work Center

Queue Time (days) 12 4 14 3 17 5 03 8

Answer
Wait Time Move Time (days) (days) 1 1 1 1 1 1 1 1

The calculations for the operation time at each work center are as follows: Setup time + run time = total time (standard hours)
Operation 10: Work center 12:
Operation 20: Work center 14:
Operation 30: Work center 17:
Operation 40: Work center 03: = 1.5 + 0.20 x 150 = 31.5 standard hours = 4 days = 0.50 + 0.25 x 150 = 38.0 standard hours = 5 days = 0.30 + 0.05 x 150 = 7.8 standard hours = 1 day = 0.45 + 0.10 x 150 = 15.45 standard hours= 2 days

The next step is to schedule back from the due date (day 135) to get the completion and start dates for each operation. To do so, we need to know not only the operation times just calculated, but also the queue, wait, and move times. These are in the work center file.

Suppose the information shown in Table 2 is obtained from these files.

The process starts with the last operation. The goods are to be in the stores on day 135. It takes one day to move them, so the order must be completed on operation 40 on day 133. Subtracting the wait, queue, and operation times (11 days), the order must be started on day 123. With a move time of one day, it must be completed on operation 30 on day 121. Using this process, the start and completion date can be calculated for all operations. Figure 5.8 shows the resulting schedule and graph below shows the same thing graphically.

Work
Center
12 Operation 10
14 Operation 20
17 Operation 30
03 Operation 40

90 91 101 Release
Date
105 112 115 121 125 134 135

Due date

Making the Plan

So far we have discussed the data needed for a capacity requirements plan, where the data come from, and the scheduling and loading of shop orders through the various work centers. The next step is to compare the load to available capacity to see if there are imbalances and if so, to find possible solutions.

There are two ways of balancing capacity available and load: alter the load, or change the capacity available. Altering the load means shifting orders ahead or back so the load is leveled. If orders are processed on other work stations, the schedule and load on the other work stations have to be changed as well. It may also mean that other components should be rescheduled and the master production schedule changed.
Consider the bill of material shown in Figure 5.10. If component B is to be rescheduled to a later date, then the priority for component C is changed, as is the master production schedule for A. For these reasons, changing the load may not be the preferred course of action. In the short run, capacity can be adjusted. Some ways that this may be done are as follows:

Schedule overtime or under time. This will provide temporary and quick relief for cases where the load/capacity imbalance is not too large.
Adjust the level of the workforce by hiring or laying off workers. The ability to do so will depend on the availability of the skills required and the training needed. The higher the skill level and the longer the training needed, the more difficult it becomes to change quickly the level of the workforce. Shift workforce from under loaded to overloaded work centers. This requires a flexible cross-trained workforce.
Use alternate routings to shift some load to another work center. Often the other work center is not as efficient as the original. Nevertheless, the important thing is to meet the schedule, and this is a valid way of doing so.
Subcontract work when more capacity is needed or bring in previously subcontracted work to increase required capacity. It may be more costly to subcontract rather than make the item in-house, but again it is important to maintain the schedule.
The result of capacity requirements planning should be a detailed workable plan that meets the priority objectives and provides the capacity to do so. Ideally, it will satisfy the material requirements plan and allow for adequate utilization of the workforce, machinery, and equipment.

Scheduling

The objective of scheduling is to meet delivery dates and to make the best use of manufacturing resources. It involves establishing start and finish dates for each operation required to complete an item. To develop a reliable schedule, the planner must have information on routing, required and available capacity, competing jobs, and *Manufacturing Lead Times* (MLT) at each work center involved.

a. Manufacturing Lead Time
Manufacturing lead time is the time normally required to produce an item in a typical lot quantity. Typically, MLT consists of five elements:

1. Queue time, amount of time the job is waiting at a work center before operation begins.
2. Setup time, time required to prepare the work center for operation.
3. Run time, time needed to run the order through the operation.
4. Wait time, amount of time the job is at the work center before being moved to the next work center.
5. Move time, transit time between work centers.

The total manufacturing lead time will be the sum of order preparation and release plus the MLTs for each operation. Figure 6.3 shows the elements making up manufacturing lead time. Setup time and run time are straightforward, and determining them is the responsibility of the industrial engineering department. Queue, wait, and move times are under the control of manufacturing and PAC.

The largest of the five elements is queue time. Typically, in an intermittent manufacturing operation, it accounts for 85%—95% of the total lead time. Production activity control is responsible for managing the queue by regulating the flow of work into and out of work centers. If the number of orders waiting to be worked on (load) is reduced, so is the queue time, the lead time, and work-in-process. Increasing capacity also reduces queue. Production activity control must manage both the input of orders to the production process

and the available capacity to control queue and work-in-process.

A term that is closely related to manufacturing lead time is cycle time. The ninth edition of the APICS Dictionary defines cycle time as the length of time from when material enters a production facility until it exits. A synonym is **throughput time.**

Order Release
QUEUE SETUP RUN WAIT^MOVE QUEUE SETUP RUN WAIT^MOVE
QUEUE SETUP RUN WAIT^MOVE QUEUE SETUP RUN WAIT^MOVE
Example Problem

An order for 100 of a product is processed on work centers A and B. The setup time on A is 30 minutes, and run time is ten minutes per piece. The setup time on B is 50 minutes, and the run time is five minutes per piece. Wait time between the two operations is four hours. The move time between A and B is ten minutes. Wait time after operation B is four hours, and the move time into stores is 15 minutes. There is no queue at either workstation. Calculate the total manufacturing lead time for the order.

Answer
Work Center A operation time = 30+ (100 x 10) = 1030 minutes
Wait time
Move time from A to B
Work Center B operation time = 50 + (100 x 5) Wait time
Move time from B to stores
Total manufacturing lead time
= 240 minutes = 10 minutes = 550 minutes = 240 minutes = 15 minutes = 2085 minutes

Lead Time = 34 hours, 45 minutes
b. Scheduling Techniques.
There are many techniques to schedule shop orders through a plant, but all of them require an understanding of forward and backward scheduling as well as finite and infinite loading.

Forward scheduling assumes that material procurement and operation scheduling for a component start when the order is received, whatever the due date, and that operations are scheduled forward from this date. The first line in Figure 6.4 illustrates this method. The result is completion before the due date, which usually results in a buildup of inventory. This method is used to decide the earliest delivery date for a product.

Forward scheduling is used to calculate how long it will take to complete a task. The technique is used for purposes such as developing promise dates for customers or figuring out whether an order behind schedule can be caught up.

Backward scheduling is illustrated by the second line in Figure 9a below. The last operation on the routing is scheduled first and is scheduled for completion at the due date. Previous operations are scheduled back from the last operation. This schedules items to be available as needed and is the same logic as used in the MRP system. Work-in-process inventory is reduced, but because there is little slack time in the system, customer service may suffer.

Order Received

1 2 3 4 5

6 7 8 Due Date 9

Forward Scheduling
Material 1st 2nd 3rd
Ordered Operation Operation Operation
Backward Scheduling
Material Ordered 1st 2nd Operation Operation 3rd
Operation
Fig 9a

Backward scheduling is used to determine when an order must be started. Backward scheduling is common in industry because it reduces inventory.

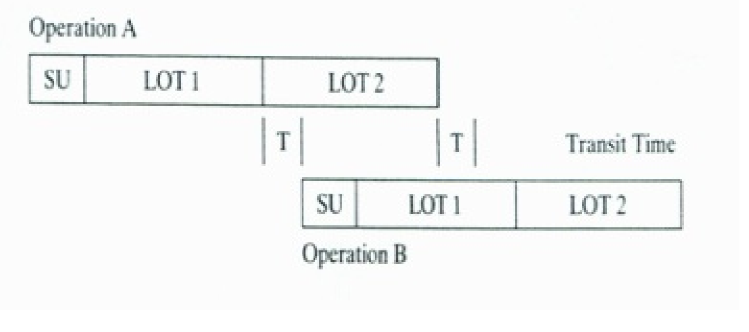
Infinite loading is also illustrated in Figure 9a. The assumption is made that the workstations on which operations 1, 2, and 3 are done have capacity available when required. It does not consider the existence of other shop orders competing for capacity at these work centers. It assumes infinite capacity will be available. Figure 9a shows a load profile for infinite capacity. Notice the over and under load.

Finite loading assumes there is a defined limit to available capacity at any workstation. If there is not enough capacity available at a workstation because of other shop orders, the order has to be scheduled in a different time period. Figure 6.6 illustrates the condition

c. Operation Overlapping

In operation overlapping, the next operation is allowed to begin before the entire lot is completed on the previous operation. This reduces the total manufacturing lead times because the second operation starts before the first operation finishes all the parts in the order. Figure 6.8 shows schematically how it works and the potential reduction in lead time.

An order is divided into at least two lots. When the first lot is completed on operation A, it is transferred to operation B. In Figure on right, it is assumed operation B cannot be set up until the first lot is received, but this is not always the case. While operation A continues with the second lot, operation B starts on the first lot. When operation A finishes the second



lot, it is transferred to operation B. If the lots are sized properly, there will be no idle time at operation B. The manufacturing lead time is reduced by the overlap time and the elimination of queue time.

Operation overlapping is a method of expediting an order, but there are some costs involved. First, move costs are increased, especially if the overlapped operations are not close together. Second, it may increase the queue and lead time for other orders. Third, it does not increase capacity but potentially reduces it if the second operation is idle waiting for parts from the first operation.
The problem is deciding the size of the sub lot. If the run time per piece on operation B is shorter than that on A, the first batch must be large enough to avoid idle time on operation B.
Example Problem
Refer to the data given in the example problem in the section on manufacturing lead time. It is decided to overlap operations A and B by splitting the lot of 100 into two lots of 70 and 30. Wait time between A and B and between B and stores is eliminated. The move times remain the same. Setup on operation B cannot start until the first batch arrives. Calculate the manufacturing lead time. How much time has been saved?

Operation time for A for lot of 70 Move time between A and B Operation time for B for lot of 100 Move time from B to stores
Total manufacturing lead time Total Time saved = 2085 - 1305 = 30 + (70 x 10)

= 50 + (100 x 5)

=1305 minutes = 780 minutes = 30 minutes
= 10 minutes
= 550 Minutes
= 15 minutes
= 2 hr, 45 minutes = 13 hours

d. Operation Splitting

Operation splitting is a second method of reducing manufacturing lead time. The order is split into two or more lots and run on two or more machines simultaneously. If the lot is split in two, the run-time component of lead time is effectively cut in half, although an additional setup is incurred. Fig on right shows a schematic of operation splitting. Operation splitting is practical when:

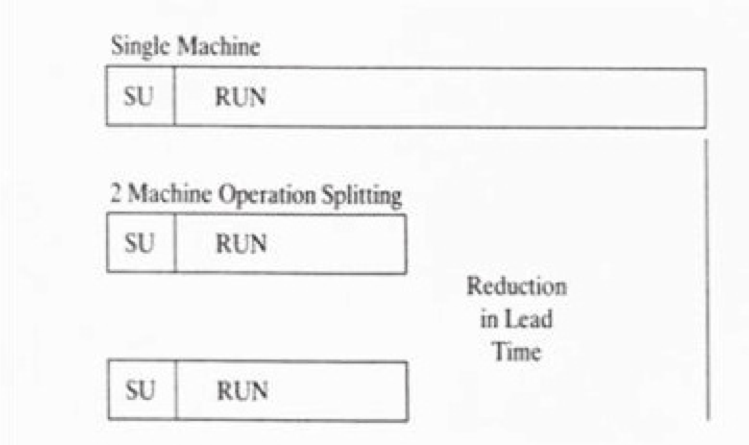
Setup time is low compared to run time. A suitable work center is idle.
It is possible for an operator to run more than one machine at a time

The last condition often exists when a machine cycles through its operation automatically, leaving the operator time to set up another machine. The time needed to unload and load must be shorter than the run time per piece. For example, if the unload/load time was two minutes and the run time was three minutes, the operator would have time to unload and load the first machine while the second was running.

Example Problem

A component made on a particular work center has a setup time of 100 minutes and a run time of three minutes per piece. An order for 500 is to be processed on two machines simultaneously. The machines can be set up at the same time. Calculate the elapsed operation time.

Answer



Elapsed operation time 100 + 3 X 250 = 850 minutes = 14 hours and 10 minutes

Load Levelling

Load profiles were discussed in Chapter 5 in the section on capacity requirements planning. The load profile for a work center is constructed by calculating the standard hours of operation for each order in each time period and adding them together by time period. Figure 6.10 is an example of a load report.

This report tells PAC what the load is on the work center. There is a capacity shortage in week 20 of 30 hours. This means there was no point in releasing all of the planned orders that week. Perhaps some could be released in week 18 or 19, and perhaps some overtime could be worked to help reduce the capacity crunch.

Work Center: 10
Description: Collar Making Number of Machines: 3 Available Time: 120 hours/week
Efficiency: 115%
Utilization 80%

Rated Capacity: 110 standard hours/week

Work center load report Week 18 19 20 21 22 23 Total Released Load 105 100 80 30 0 0 315 Planned Load 60 80 130 80 350 Total Load 105 100 140 110 130 80 665 Rated Capacity 110 110 110 110 110 110 660 (Over)/Under Capacity 5 10 -30 0 -20 30 -5

Scheduling Bottlenecks

In intermittent manufacturing, it is almost impossible to balance the available capacities of the various workstations with the demand for their capacity. As a result, some workstations are overloaded and some under loaded. The overloaded workstations are called bottlenecks and, by definition, are those workstations where the required capacity is greater than the available capacity. In the ninth edition of their dictionary, APICS defines a bottleneck as “a facility, function, department, or resource whose capacity is equal to or less than the demand placed upon it.”

Throughput. Throughput is the total volume of production passing through a facility. Bottlenecks control the throughput of all products processed by them. If work centers feeding bottlenecks produce more than the bottleneck can process, excess work-in-process inventory is built up. Therefore, work should be scheduled through the bottleneck at the rate it can process the work. Work centers fed by bottlenecks have their throughput

controlled by the bottleneck, and their schedules should be determined by that of the bottleneck.

Example Problem

Suppose a manufacturer makes wagons composed of a box body, a handle assembly, and two wheel assemblies. Demand for the wagons is 500 a week. The wheel assembly capacity is 1200 sets a week, the handle assembly capacity is 450 a week, and final assembly can produce 550 wagons a week.

a) What is the capacity of the factory?
b) What limits the throughput of the factory?
c) How many wheel assemblies should be made each week?
d) What is the utilization of the wheel assembly operation?
e) What happens if the wheel assembly utilization is increased to 100%?

Answer

a) 450 units a week.
b) Throughput is limited by the capacity of the handle assembly operation.
c) 900 wheel assemblies should be made each week. This matches the capacity of the handle

assembly operation.
d) Utilization of the wheel assembly operation is 900 ± 1200 75%.
e) Excess inventory builds up.

Some bottleneck principles.
Since bottlenecks control the throughput of a facility, some important principles should be noted:

1. Utilization of a non-bottleneck resource is not determined by its potential, but by another constraint in the system. In the previous example problem, the utilization of the wheel assembly operation was determined by the handle assembly operation.

2. Using a non-bottleneck 100% of the time does not produce 100% utilization. lf the wheel assembly operation was utilized 100% of the time, it would produce 1200 sets of wheels a week, 300 sets more than needed. Because of the buildup of inventory, this operation would eventually have to stop.

3. The capacity of the system depends on the capacity of the bottleneck. If the handle assembly operation breaks down, the throughput of the factory is reduced.
4. Time saved at a non-bottleneck saves the system nothing. Suppose, in a flash of brilliance, the industrial engineering department increased the capacity of the wheel assembly operation to 1500 units a week. This extra capacity could not be utilized, and nothing would be gained.
5. Capacity and priority must be considered together. Suppose the wagon manufacturer made wagons with two styles of handles. During setup, nothing is produced, which reduces the capacity of the system. Since handle assembly is the bottleneck, every setup in this operation reduces the throughput of the system. Ideally, the company would run one style of handle for six months, then switch over to the second style. However, customers wanting the second style of handle might not be willing to wait six months. A compromise

is needed whereby runs are as long as possible but priority (demand) is satisfied.
6. Loads can, and should, be split. Suppose the handle assembly operation (the bottleneck) produces one style of handle for two weeks, then switches to the second style. The batch size is 900 handles. Rather than waiting until the 900 are produced before moving them to the final assembly area, the manufacturer can move a day's production (90) at a time. The process batch size and the transfer batch size are different. Thus, delivery to the final assembly is matched to usage, and work-in-process inventory is reduced.
7. Focus should be on balancing the flow through the shop. The key is throughput that ends up in sales

Managing bottlenecks
Since bottlenecks are so important to the throughput of a system, scheduling and controlling them is extremely important. The following must be done;

1. Establish a time buffer before each bottleneck. A time buffer is an inventory (queue) place before each bottleneck. Because it is of the utmost importance to keep the bottleneck working, it must never be starved for material, and it can be starved only if the flow from feeding workstations is disrupted. The time buffer should be only as long as the time of any expected delay caused by feeding workstations. In this way, the time buffer ensures that the bottleneck will not be shut down for lack of work and this queue will be held at a predetermined minimum quantity.

2. Control the rate of material feeding the bottleneck. A bottleneck must be fed at a rate equal to its capacity so the time buffer remains constant. The first operation in the sequence of operations is called a gate operation. This operation controls the work feeding the bottleneck and must operate at a rate equal to the output of the bottleneck so the time buffer queue is maintained.

3. Do everything to provide the needed bottleneck capacity. Anything that increases the capacity of the bottleneck increases the capacity of the system. Better uti-lization, fewer setups, and improved methods to reduce setup and run time are some methods for increasing capacity.

4. Adjust loads. This is similar to item 3 but puts emphasis on reducing the load on a bottleneck by using such things as using alternate work centers and subcon-tracting. These may be more costly than using the bottleneck, but utilization of non-bottlenecks and throughput of the total system is increased, resulting in more company sales and increased profits.

5. Change the schedule. Do this as a final resort, but it is better to be honest about delivery promises.

Once the bottleneck is scheduled according to its available capacity and the market demand it must satisfy, the non-bottleneck resources can be scheduled. When a work order is completed at the bottleneck, it can be scheduled on subse-quent operations.

Feeding operations have to protect the time buffer by scheduling backward in time from the bottleneck. If the time buffer is set at four days, the operation immediately pre-ceding the bottleneck is scheduled to complete the required parts four days before they are scheduled to run on the bottleneck. Each preceding operation can be hack-scheduled in the same way so the parts are available as required for the next operation.

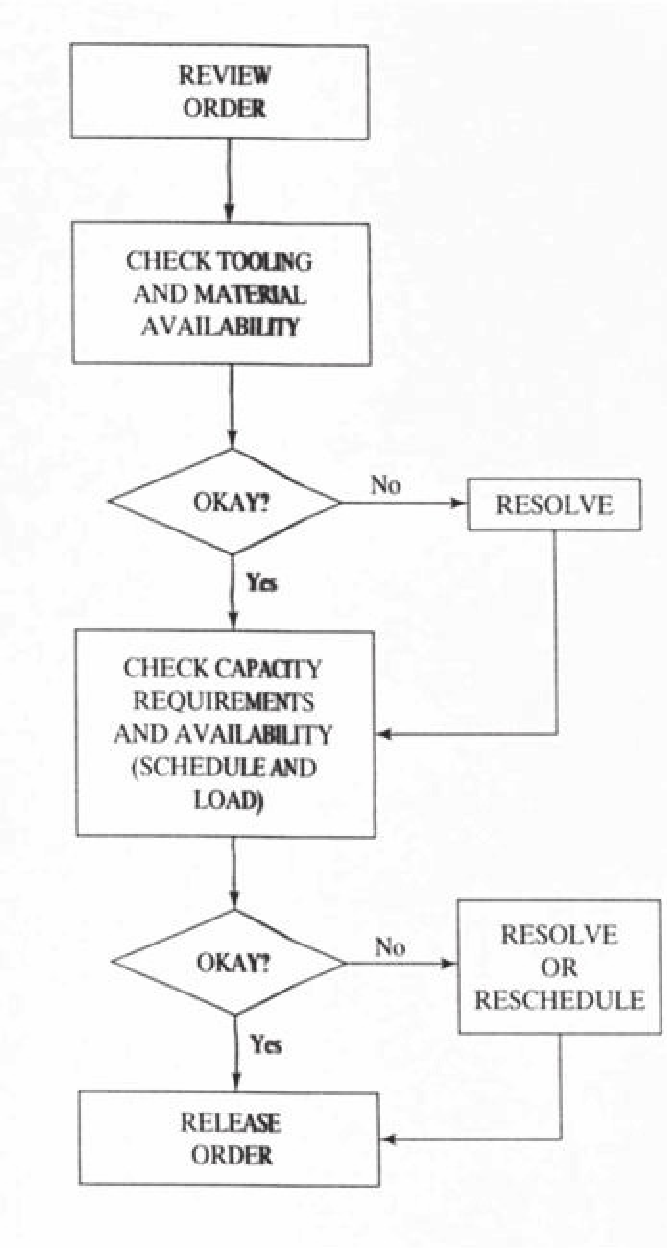
Any disturbances in the feeding operations are absorbed by the time buffer, and throughput is not affected. Also, work-in-process inventory is reduced. Since the queue is limited to the time buffer, lead times are reduced.

Implementation

Orders that have tooling, material, and capacity have a good chance of being completed on time and can be released to the shop floor. Other orders that do not have all of the necessary elements should not be released because they only cause excess work-in-process inventory and may interrupt work on orders that can be completed. The process for releasing an order is shown in Figure 9e

Implementation is arrived at by issuing a shop order to manufacturing authorizing them to proceed with making the item. A shop packet is usually compiled which contains the shop order and whatever other information is needed by manufacturing. It may include any of the following:

Shop order showing the shop order number, the part number, name, description, and quantity. Engineering drawings.
Bills of material.
Route sheets showing the operations to be performed, equipment and accessories needed, materials to use, and the setup and run times.
Material issue tickets that authorize manufacturing to get the required material from stores. These are also used for charging the material against the shop order.
Tool requisitions authorizing manufacturing to withdraw necessary tooling from the tool crib.
Job tickets for each operation to be performed. As well as authorizing the individual operations to be performed, they also can function as part of a reporting system. The worker can log on and off the job using the job ticket, and it then becomes a record of that operation.
Move tickets that authorize and direct the movement of work between operations



ControlFig 9e

Once work orders have been issued to manufacturing, their progress has to be controlled. To control progress, performance has to be measured and compared to what is planned. If what is actually happening (what is measured) varies significantly from what was planned, either the plans have to be changed or corrective action must be taken to bring performance back to plan.

The objectives of production activity control are to meet delivery dates and to make the best use of company resources. To meet delivery dates, a company must control the progress of orders on the shop floor, which means controlling the lead time for orders. As discussed earlier in this chapter, the largest component of lead time is queue. If queue can be controlled, delivery dates can be met. Chapter 1 discussed some characteristics of intermittent operations in which many different products and order quantities have many different routings, each requiring different capacities. in this environment, it is almost impossible to balance the load over all the workstations. Queue exists because of this erratic input and output.

To control queue and meet delivery commitments, production activity control must:

Control the work going into and coming out of a work center. This is generally called input/output control.
Set the correct priority of orders to run at each work center

Input/output Control

Production activity control must balance the flow of work to and from different work centers. This is to ensure queue, work-in-process, and lead times are controlled. The input/output control system is a method of managing queues and work-in-process lead times by monitoring and controlling the input to, and output from, a facility. It is designed to balance the input rate in hours with the output rate so these will be controlled.

The input rate is controlled by the release of orders to the shop floor. If the rate of input is increased, queue, work-in-process, and lead times increase. The output rate is controlled by increasing or decreasing the capacity of a work center. Capacity change is a problem for manufacturing, but it can be attained by overtime or under-time, shifting workers, and so forth. Figure 9f shows the idea graphically

To control input and output, a plan must be devised, along with a method for comparing what actually occurs against what was planned. This in-formation is shown on an input/output report. Figure 6.g is an example of such a report. The values are in standard hours.

Input Rate control
Queue
(Local WIP)

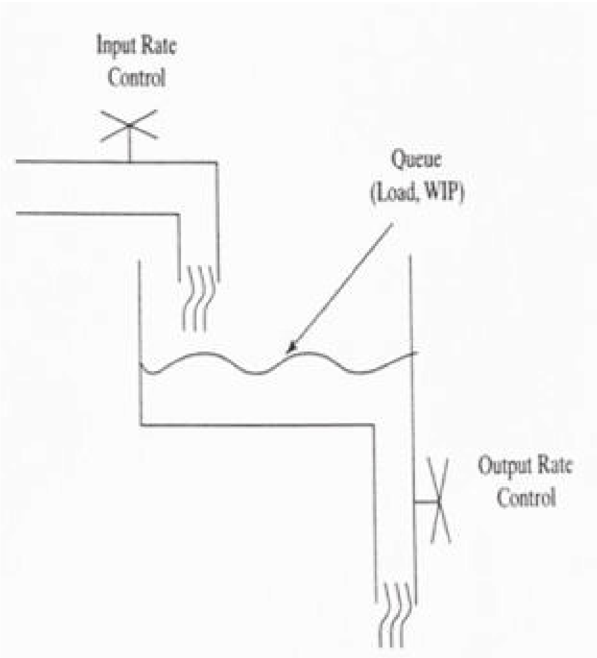


Fig 9f

Period 1 2 3 4 5 Total **Planned Input 38 32 36 40 44 190**
Actual Input 34 32 32 42 40 180

Cumulative -4 -4 -8 -6 -10 -10 Variance
Planned Input 40 40 40 40 40 200 Actual Input 32 36 44 44 36 192
Cumulative -8 -12 -8 -4 -8 -8 Variance

Planned Backlog 32 30 22 18 18 22
Actual Backlog 32 34 30 18 16 20
Fig 9g

Cumulative variance Cumulative variance is the difference between the total planned for a given period and the actual total for that period. It is calculated as follows:
Cumulative variance = previous cumulative variance + actual — planned
Cumulative input variance week 2 = - 4 + 32 - 32 = -4
Backlog is the same as queue and expresses the work to be done in hours. It is calculated as follows:

Planned backlog for period 1 = previous backlog + planned input — planned output = 32 + 38 — 40
= 30 hours

The report shows the plan was to maintain a level output in each period and to reduce the queue and lead time by ten hours, but input and output were lower than expected.

Planned and actual inputs monitor the flow of work coming to the work center. Planned and actual outputs monitor the performance of the work center. Planned and actual backlogs monitor the queue and lead time performance.
Example Problem

Complete the following input/output report for weeks 1 and 2. **Week 1 2** Planned Input 45 40 Actual Input 42 46 Cumulative Variance
Planned Output 40 40 Actual Output 42 44 Cumulative Variance
Planned Backlog 30

Actual Backlog 30

Answer
Cumulative input variance week 1 = 42 — 45 = —3 Cumulative input variance week 2 = —3 + 46 — 40 = 3 Cumulative output variance week 1 = 42 — 40 = 2 Cumulative output variance week 2 = 2 + 44 — 40 = 6

Planned backlog week 1 = 30 + 45 — 40 = 35
Planned backlog week 2 = 35 + 40 — 40 = 35
Actual backlog week 1 = 30 + 42 — 42 = 30
Actual backlog week 2 = 30 + 46 — 44 = 32

Operation Sequencing

The ninth edition of the APICS Dictionary defines operation sequencing as a technique for short-term planning of actual jobs to be run in each work center based on capacity and priorities. Priority, in this case, is the sequence in which jobs at a work center should he worked on.

The material requirements plan establishes proper need dates and quantities. Over time, these dates and quantities change for a variety of reasons. Customers may require different delivery quantities or dates. Deliveries of component parts, either from vendors or internally, may not be met. Scrap, shortages, and overages may occur, and so on. Control of priorities is exercised through dispatching.

Dispatching.

Dispatching is the function of selecting and sequencing available jobs to be run at individual work centers. The dispatch list is the instrument of priority control. It is a listing by operation of all the jobs available to be run at a work center with the job listed in priority sequence. It normally includes the following information and is updated and published at least daily:

Plant, department, and work center.
Part number, shop order number, operation number, and operation description of jobs at the work center.
Standard hours.
Priority information.
Jobs coming to the work center.

Dispatching rules.

The ranking of jobs for the dispatch list is created through the application of priority rules. There are many rules, some attempting to reduce work-in-process inventory, others attempting to minimize the number of late orders or maximize

DISPATCH LIST
Work Center 10
Shop Date 250
Rated Capacity 16 standard hours per day
Order$_{\text{Part No}}$ Order Setup Run Total Qty Load Operation Dates No Qty Hr Hr Hr Completed Remaining Stard Finish 123 6554 100 1.5 15 16.5 75 3.75 249 250 121 7345 50 0.5 30 30.5 10 24 249 251 142 2687 500 0.2 75 75.2 0 75 250 259 Total Available Load in Std Hrs. 102.75
Jobs Coming
145 7745 200 0.7 20 20.7 0 20.7 251 253 135 2832 20 1.2 1 2.7 0 2.7 253 254 Total Future Load in Standard Hours 23.4
Figure 9g Dispatch list (based on 2 machines working one 8-hour shift per day

The output of the work center. None is perfect or will satisfy all objectives. Some commonly used rules are,

First come, first served (FCFS). Jobs are performed in the sequence in which they are received. This rule ignores due dates and processing time.
Earliest job due date (EDD). Jobs are performed according to their due dates. Due dates are considered, but processing time is not.
Earliest operation due date (ODD). Jobs are performed according to their operation due dates. Due dates and processing time are taken into account. As well, the operation due date is easily understood on the shop floor.
Shortest process time (SPT). Jobs are sequenced according to their process time. This rule ignores due dates, but it maximizes the number of jobs processed. Orders with long process times tend to be delayed.

Figure 9h illustrates how these sequencing rules work. Notice that each rule usually produces a different sequence.

One other rule that should be mentioned is called critical ratio (CR). This is an index of the relative priority of an order to other orders at a work center. It is based on the ratio of time remaining to work remaining and is usually expressed as:

Lead time remaining includes all elements of manufacturing lead time and expresses the amount of time the job normally takes to completion.

If the actual time remaining is less than the lead time remaining, it implies there is not sufficient time to complete the job and the job is behind schedule. Similarly, if lead time remaining and actual time remaining are the same, the job is on schedule. If the actual time remaining is greater than the lead time remaining,

Job Process Arrival Due Time (days) Date Date Operation Sequencing Rule Due Date

A 4 223 245
B 1 224 242
C 5 231 240
D 2 219 243
FCFS EDD ODD SPT 233 2 4 1 3 239 3 2 2 1 240 4 1 3 4 242 1 3 4 2 Fig 9h. Application of Sequencing

The job is ahead of schedule. If the actual time remaining is less than one, the job is late already. The following table summarizes these facts and relates them to the critical ratio:

CR less than 1 (actual time less than lead time). Order is behind schedule.
CR equal to 1 (actual time equal to lead time). Order is on schedule.
CR greater than 1 (actual time greater than lead time). Order is ahead of schedule. CR zero or less (today's date greater than due date). Order is already late.

Thus, orders are listed in order of their critical ratio with the lowest one first. Critical ratio considers due dates and process time. However, it is not easily understood.
Example Problem
Today's date is 175. Orders A, B, and C have the following due dates and lead time remaining. Calculate the actual time remaining and the critical ratio for each.

Lead Time
Order Due Date Remaining (days) A 185 20
B 195 20
C 205 20

Answer
Order A has a due date of 185, and today is day 175. There are 10 actual days remaining. Since the lead time remaining is 20 days,
Critical Ratio = (10/20) = 0.5
Similarly, the actual time remaining and the critical ratios are calculated for orders B and C. The following table gives the results:

Lead Time . Actual Time . Order Due Date Remaining (days) Remaining (days) CR A 185 20 10 0.5 B 195 20 20 1.0 C 205 20 30 1.5

Order A has less actual time remaining than lead time remaining, so the CR is less than 1. It is, therefore, behind schedule. Order B has a CR of 1 and is exactly on schedule. Order

C has a CR of 1.5—greater than 1—and is ahead of schedule.

Dispatching rules should be simple to use and easy to understand. As shown in the preceding example, each rule produces a different sequence and has its own advantages and disadvantages. Whichever rule is selected should be consistent with the objectives of the planning system.

Production Reporting

Production reporting provides feedback of what is actually happening on the plant floor. It allows PAC to maintain valid records of on-hand and on-order balances, job status, shortages, scrap, material shortages, and so on. Production activity control needs this information to establish proper priorities and to answer questions regarding deliveries, shortages, and the status of orders. Manufacturing management needs this information to make decisions about plant operation. Payroll needs this information to calculate employees' pay.

Data must be collected, sorted, and reported. The particular data collected depend upon the needs of the various departments. The methods of data collection vary. Sometimes the operator reports the start and completion of an operation, order, movement, and so on, using an on-line system directly reporting events as they occur via data terminals. In other cases, the operator, supervisor, or timekeeper reports this information on an operation reporting form included in the shop packet. Information about inventory withdrawals and receipts must be reported as well.

Once the data are collected, they must be sorted, and appropriate reports produced. Types of information needed for the various reports include:
Order status.
Weekly input/output by department or work center.
Exception reports on such things as scrap, rework, and late shop orders.
Inventory status.
Performance summaries on order status, work center and department efficiencies, and so on

Follow-ups.

Here, let us cheek some key interesting values which have to be checked in a production line to verify the situation in each section. The key formulas for better reference only are listed here, most are already been explained or will be added in particular sections.

Material Productivity: This is an indicator of the output or value generated per unit of material used. This is a fundamental re-examination of how, when and why materials are used. This measure shows how effectively material is used through the system. Any material left in the fabric store is also a waste as it will be disposed of at a much cheaper rate.

Marker Efficiency: This is the ratio of fabric actually used on the marker to total available fabric. Marker efficiency is calculated for one marker at a time and cannot be generalized for the entire order. This metric is mostly automatically calculated by CAD machines. Marker efficiency above 80% to 85% is considered good.

Marked Consumption: Consumption of a garment calculated as per the markers made by

the CAD department. In order to calculate this metric the following steps have to be followed:

Make a cut order plan stating markers and no. of plies for each lay.
Make all the markers.
Calculate total length of fabric being used on the lays.
Divide this value by total garments to be produced.

Achieved Consumption: This is the actual consumption achieved per garment after the whole production process is completed. This requires extensive calculation but the result gives a realistic image of loss of material in the system.

The above formula will show final achieved consumption. The losses on material incurred by the whole factory in terms of dead stock, end bits and cutting room losses, part change and rejection in sewing, rejection in finishing as well as unshipped garments are included in this calculation.

If user wants to measure only cutting room achieved consumption then the formula should be slightly altered. Total fabric issued to cutting divided by total cut garments issued to sewing department will show the achieved consumption of cutting room.

Fabric Utilization: This is the ratio of fabric used on garments to fabric available to be used. This metric tells us the fabric utilization status of the entire order. Fabric generally costs 60% to 70% of the cost of the garment. Strict controls should ensure that every inch of the fabric is used properly and is accounted for.

Total fabric available Fabric used on garment

a. By weight i. Weigh one garment of each size (garment should be weighed before sewing) ii. Multiply weight with number of garments cut in each size
iii. Divide total weight by GSM and fabric width to get total meters used in garments.

b. By Length
i. Multiply Marker length with its Marker efficiency and number of plies laid in the marker.
ii. The above calculation is done for each marker in the order and then sum of all gives the total meters used in garments.
The above will give fabric utilization for the order. The formula can be extended to calculate overall fabric utilization for the factory in a month.
= Fabric allocated or bought for the order. = this can be calculated in following ways.
Cut order Plan

Cut to Ship Ratio - This shows the percentage of garments shipped out of total number of garments cut for the order. It shows a bird's eye view of the entire system. A number close to 98% will be considered very well. This means only 2% of garments are rejected or lost in the system.

Total pieces shipped: This should be taken from final packing list.
Total pieces cut: This should be all the garments cut for this order. This should be taken from cutting room daily records.

Many factories collect this information as monthly average as well as a percentage for

individual orders. This gives a general performance level of the company. There may be various reasons for an ambiguous result and further investigation may be required.

Labour Cost per minute: This is a very important metric while calculating the price of a garment. It helps to quickly calculate the labour cost that will be incurred in production of the given garment. This can be calculated over a month or a year to give an accurate value to cost per minute. To calculate labour cost of a new order, its standard minute is calculated and then multiplied to cost per minute and efficiency to get the actual labour cost that will be incurred during its production.

Plan Performance Index: This shows the percentage of variation between the planned work and the actual work done. This helps in evaluating how efficient is your factory plan in order to meet your delivery dates. The ideal value is 100% but a 97% hit rate should be considered good.

This is just a representative figure and further investigation is required to investigate the results. Overtime, work outsourcing, vendor delay, quality can affect this index value and the result may need further investigation. For example a 100% PPI may have been achieved by doing a lot of overtime which is not the expected result.

On-time Delivery: This represents the percentage of deliveries that a factory is able to make on-time without any delays or extensions.

An on-time delivery means that the products are delivered exactly on the date the exporter has promised to the customer. A before time delivery is equally bad as a late delivery as it needs the buyer to spend on warehouse space and money. This simple indicator is a very important factor in most buyers' books to evaluate their factory performances.
Capacity Utilization: Extent or level to which the productive capacity of a factory is being used in generation of goods. Therefore, it refers to the relationship between actual output that 'is' produced with the installed equipment and manpower, and the potential output which 'could' be produced with it, if capacity was fully used.

If the factory makes standard product, capacity can be expressed in terms of number of pieces. However, if there is a huge variation in the products produced, then the unit of measure should ideally be number of minutes produced. This is summation of each garment produced multiplied by its standard minute value. Capacity should also be expressed in number of minutes.

Overtime Percentage: The percentage of overtime being used over total working time. As overtime costs considerable amount of money to the company, a tight control should be kept on overtime percentage. This can be calculated over days, weeks or months, representing the overtime being used in the factory. Planning department can improve their plan in future and keep a check on their plan based on these overtime trends.

OTIF: OTIF **(On Time in Full),** or DIFOT (Delivered in Full on Time), is one of the fundamental measurements for logistics performance. It measures, weather the Supply Chain was able to deliver or not

The expected product (reference and quality)
In the quantity ordered (with the tolerance defined by the customer)
At the place agreed

At the time expected by the customer

To reach a good OTIF level, all the functions of the supply chain (among which orders taking, procurement, suppliers, warehouses, transport…) have to work at their best level. OTIF allows seeing at a glance; how the company delivers its customers.

Process, Ranking, Grading, Wage Structure, incentive plans

10 Job Evaluation & Compensation

There is a conservable uncertainty among the terms job evaluation, job analysis, job description and job specification.

Job analysis or job evaluation is the collection of data and critical evaluation of the operations, duties, responsibilities and relationships. Job description is the written record of duties, responsibilities and requirements of particular job. Job specification is written statement showing the aptitude, qualification, experience etc. that would be necessary to perform a particular job.

The rationale behind the job evaluation is to reward employees fairly, which helps the organisation to attract and retain them. On the part of employees it provides them the motivation for the betterment of performance and their effectiveness. Equitable compensation relates to the problem of attracting and retaining employees which motivation directly refers to the monetary and no monetary incentives.

Equity and justice coincide according to natural law. It is clearly experienced that greater feelings of equity, the more will be the equilibrium. When employee receives compensation, his equity perception is affected by two factors,

1) Effort – output ratio; i.e. what are the inputs given by employee in terms of physical and mental effort, training, education and how he works and furnishes task and how they are rewarded. Thus compensation to the work accomplished by employee has great impact in the future performance and it also shows an impact on the mental adjustment. Simply if numerator is low and denominator is high,

if the ratio is low, it leads to dissatisfaction which result in low performance, less effectiveness and low productivity. On the other hand, high ratio can also lead to overall dissatisfaction arising out of overpayment. Employee will feel guilty and try to work more to show that he actually deserves, so equity concept balances these two extremes and accordingly gives a rational basis to work out the wages and salaries.

2) The comparison of above ratio with other person's ratio with whom he has direct contact.

HIGH **over rewarded Moderate Over rewarded**
MEDIUM
Moderate Over

rewarded Moderate Over rewarded

LOW
Moderate Under rewarded
Under Rewarded
LOW

Well-designed job evaluation helps business firm in more than one way,

a) Being a systematic process, job evaluation fixes the wage rate for each job. b) It is considered to be simple as it is easily understood by all. c) It establishes the equitable wage rate for all the jobs, according to the job requirements. d) Company training program, placement, recruitment selection and long range manpower planning

always follow job evaluation.
MEDIUM HIGH **RELATIVE CONTRIBUTION**

e) It enables company to get data for incorporation in local wage surveys to establish job classification. All of these contribute to healthy, sound and equitable wage structure in organisation. But in practice, the role of trade union varies from outright opposition to complete participation. In many cases unions involve and provide full participation. In such cases, local unions select members who are trained by management and form a joint union-management committee to work out and install job evaluation system.

Process
The process of job evaluation involves the following steps:

Gaining acceptance: Before undertaking job evaluation, top management must explain the aims and uses of the programme to the employees and unions. To elaborate the program further, oral presentations could be made. Letters, booklets could be used to classify all relevant aspects of the job evaluation programme.
Creating job evaluation committee: It is not possible for a single person to evaluate all the key jobs in an organization. Usually a job evaluation committee consisting of experienced employees, union representatives and HR experts is created to set the ball rolling.
Finding the jobs to be evaluated: Every job need not be evaluated. This may be too taxing and costly. Certain key jobs in each department may be identified. While picking up the jobs, care must be taken to ensure that they represent the type of work performed in that department. **Analyzing and preparing job description:** This requires the preparation of a job description and also an analysis of job needs for successful performance.
Selecting the method of evaluation: The most important method of evaluating the jobs must be identified now, keeping the job factors as well as organizational demands in mind.
Classifying jobs: The relative worth of various jobs in an organisation may be found out after arranging jobs in order of importance using criteria such as skill requirements, experience needed, under which conditions job is performed, type of responsibilities to be shouldered, degree of supervision needed, the amount of stress caused by the job, etc. Weights can be assigned to each such factor. When we finally add all the weights, the worth of a job is determined. The points may then be converted into monetary values

Techniques of Job Evaluation
All forms of job evaluation methods are designed to enable management to determine how much one job should be paid as compared to others. The systems are classified under two categories.

1) Non –quantitative
a. Simple ranking
b. grading

2) Quantitative
a. Point system
b. Factor comparison

The most widely used system is point system and the least is ranking system. One company can apply two methods for two different jobs.

Simple Ranking

This method is widely used in small organisation. Being a very simple and not expensive method, it also consumes less time and promises enough potential. Before actual ranking, brief job description of all the jobs are taken. Then arranges all the jobs in order of their relative worth, without any other consideration. Then, the highest and the lowest jobs are determined which serve as the ranking reminder. The second method is the paired comparison, where each job is compared with all other jobs.
Once the comparison is done, jobs are arranged according to their worth. The main idea of this technique is to rank the jobs in order of their worth. The simplicity of this method is rather misleading. Defects of the simple ranking method are;
a) Simplicity is one of the disadvantages as it tends to make Rank Job

measurement somewhat crude. 1A b) Measurement of whole job i.e. all the factors affecting the job are 2B
not considered.[3C] c) Absence of predetermined yardsticks leads to personal partiality[4D]
The end product of this method is a list of jobs in order of their worth,[5E]

Job Grading

In ranking, we don’t have pre decided scale of value, but here is one yardstick consisting of job class. In this approach, job factors approach is not considered rather they are measured as a whole. According to this method, a predetermined number of job groups or job classes are established and jobs are assigned to these classifications. This method places groups of jobs into job classes or job grades. Separate classes may include office, clerical, managerial, personnel, etc. Following is a brief description of such a classification in an office.

1. Class I - Executives: Further classification under this category may be Office Manager, Deputy office manager, Office superintendent, Departmental supervisor, etc.

2. Class II - Skilled workers: Under this category may come the Purchasing assistant, Cashier, Receipts clerk, etc.
3. Class III - Semiskilled workers: Under this category may come Steno typists, Machine-operators, Switchboard operator etc.

4. Class IV - Unskilled workers: This category may comprise peons, messengers, housekeeping staff,

Daftaris, File clerks, Office boys, etc.
The job grading method is less subjective when compared to the earlier ranking method. The system is very easy to understand and acceptable to almost all employees without hesitation. One strong point in favor of the method is that it takes into account all the factors that a job comprises. This system can be effectively used for a variety of jobs. The weaknesses of the Grading method are:

Even when the requirements of different jobs differ, they may be combined into a single category, depending on the status a job carries.
It is difficult to write all-inclusive descriptions of a grade.
The method oversimplifies sharp differences between different jobs and different grades. When individual job descriptions and grade descriptions do not match well, the evaluators

have the tendency to classify the job using their subjective judgments.

Factor comparison method or Point method

This method is widely used and is considered to be one of the reliable and systematic approach for job evaluation in mid and large size organisations. Most consulting firms adopt this method, which was pioneered by Edward Hay in 1943. Here, jobs are expressed in terms of key factors. The key factors are, (i). Efforts, (ii) Responsibility, (iii) Skill and (iv) Working conditions.
Points are assigned to each factor after prioritizing each factor in order of importance. The points are summed up to determine the wage rate for the job. Jobs with similar point totals are placed in similar pay grades. The procedure involved may be explained thus:

1. Select key jobs. Identify the factors common to all the identified jobs such as skill, effort, responsibility, etc.
2. Divide each major factor into a number of sub factors. Each sub factor is defined and expressed clearly in the order of importance, preferably along a scale.

The most frequent factors employed in point systems are
(i) Skill (key factor); Education and training required, Breadth/depth of experience required, Social skills required, Problem-solving skills, Degree of discretion/use of judgment, Creative thinking

(ii) Responsibility/Accountability: Breadth of responsibility, Specialized responsibility, Complexity of the work, Degree of freedom to act, Number and nature of subordinate staff, Extent of accountability for equipment/plant, Extent of accountability for product/materials;

(iii) Effort: Mental demands of a job, Physical demands of a job, Degree of potential stress
The educational requirements (sub factor) under the skill (key factor) may be expressed thus in the order of importance.

3. Find the maximum number of points assigned to each job (after adding up the point values of all sub-factors of such a job).
This would help in finding the relative worth of a job. For instance, the maximum points assigned to an
officer's job in a bank come to 540. The manager's job, after adding up key factors + sub factors points,
may be getting a point value of say 650 from the job evaluation committee. This job is now priced at a
higher level.

4. Once the worth of a job in terms of total points is expressed, the points are converted into money values keeping in view the hourly/daily wage rates. A wage survey is usually undertaken to collect wage rates of certain key jobs in the organization.

Market pricing is the process for determining the external value of jobs, allowing you to establish wage and salary structures and pay rates that are market sensitive. Job matching session is conducted.

Construction of Yardsticks.

It is done by deciding the total points assigned or to be utilized in a system. The most

important decision to be taken is what proportion of total points to be allocated to skill, effort, responsibility, and working condition. That to say, a decision is taken that if the total point in a system would be 1,000, then what could be the percentage contribution of each factor. The determination of this will depend upon the nature of the organisation. If the industry is with high automation like etone production systems etc. should assign more points for responsibility since the manual skill is translated into machine skill. But generally in garments skill is given more importance. If we decide 1,000 points for the system then it could be as shown in the table.1

Table 1
Factor Number of Points Percentage Skill 500 50 Responsibility 200 20 Effort 150 15 Working Condition 150 15

Total 1000 100

Skill and responsibility will vary with the situation. Assignment of points to the various factors is subjective. After the yardstick is developed the composition of points and degrees of the particular factors are worked out.
For example, let us consider that of the total value 140 points are allocated to education. Then a seven point scale could be developed as follows,

Table 2
Education Point 1 Read, Write, add and subtract 20 2 Two Years high school or equivalent 40 3 Four Years high school or 2 years Univ. or equivalent 60 4 Four Years high school, plus 2-3 year trade training 80 5 Four Years high school, plus 4 year trade training 100 6 two or Three year college plus 4 year trade training 120 7 four years degree plus 4 year trade rtaining 140

Evaluation of the job

It demands the construction of reliable yardstick and detailed job specifications, the process of evaluation is very simple. The process consist of comparing the job specifications very carefully and placing it according to the yardsticks. Adding up all the points will give the point worth of that job. The more detail the job specification, the higher the accuracy.

Wage survey.

Once the jobs have been evaluated and jobs points have been summed up, then place them according to the terms of money. This is where the rated job are translated into monetary values.
For the wage survey, two types of samples are needed. First, sample of key jobs and second, a sample of firms in the labour market. Jobs require different personnel, in terms of skill, ability etc. and thus it varies from local to regional level.
The job content and available data are carefully analyzed and averaged out, and this way the money values of jobs are prepared and plotted on the chart.

Designing the wage structure.

Similar jobs are grouped and treated as a job class. All the jobs, which comes under that job class are paid the same wage. In the point system, suppose, 120 points to 150 points make a job class. In such case, all the jobs which fetch total between 120 and 150 would carry the same monetary compensation. The purpose of grouping of jobs is to facilitate wage administration.
Factors affecting the designing of wage structure are,

a) Labour market condition: if supply of labour is higher than demand, the wage would be

relatively low.
b) Economic Condition of the country: that is, if standard of living is high it calls for higher wage.
c) Wage structure of other firms in the same industry directly affects the company's wage structure.
d) Sometimes, even though the competitors pay relative higher wage, due to weak collective bargaining power of the trade union, management may settle wage at a relative low rate.

Factor Comparison System
This is an improved method of ranking system. Where job factors are compared rather than the whole job. The steps are,

a) Selection of job characteristics
b) Selection of key jobs
c) Determination of correct rates of key jobs
d) Ranking of key jobs under each job factor
e) Allocation of correct rate to each key job
f) Evaluation of all other jobs.
g) Designing, adjusting and operating the wage structure.

The first three steps are quite similar to that of point system. While the fourth one, is the ranking of all the key jobs, to a particular factor at a time.
For example,

Suppose A, B, C, D, and E consist of key jobs. They are ranked in such a way that one factor is considered at a time.

Skill Responsibility effort Working Condition AB D D BA C E CC E C DDA B EE B A

After preparing this table the key jobs are to be rated in money worth. How much worth should be given to job A for say skill factor is determined by evaluation committee.

Yardstick for monetory rates
Correct Job Rates Skill responsibility Efforts Working Condition A 20.00 A 12.00 B 8.50 D 2.50 D 3.00 B 18.00 B 7.00 A 5.50 C 2.00 E 2.80 C 14.00 C 5.20 C 4.40 E 1.80 C 2.40 D 10.00 D 3.20 D 1.30 A 1.50 B 1.50 E 7.00 E 1.40 E 1.00 B 1.00 A 1.00

The next step is to compare other jobs against these factors that is if job Z is to be evaluated, then how much skill is required.
If Then, its skill equality similar to A, responsibility similar to C, efforts similar to B, and working condition similar to E, then while we converts to monetary terms,

Z = Skill A (12.00) +Responsibility C (4.40) +Efforts B (1.00) +Working Condition E (2.00) = 12+4.40+1.80+2.80
= 21.00

Wage Incentive Plans
Wage as a monetary reward is paid to an employee for the service by him. One of the important components of any wage plan is the incentive hours paid to the operative personnel. There are a good number of incentive plans that have been devised. All the incentive plans are based on the fundamental factors such as the standard time, time

actually worked, time saved and the output level attained. Some of the wage incentive plans are,

a) Halsey premium wage plan b) The Rowan plan
c) Straight Piecework plan
d) Taylor Differential piecework plan e) D'Gant Incentive plan
f) Emerson Premium Plan
g) 100 per cent Time Premium Plan h) The Bedaux plan

Abbreviations
r Rate Per unit
T Actual Time Worked
S Standard Time
N Total Number of Units Produced **P** Premium Percentage
E Total Employee Earnings

Halsey Plan: it takes into account the total time saved by the employee, when accurate performance standards have not been established. The value of time saved by the employee is computed and the earnings is shared by the employee and the organisation. The total earning of the worker is computed by the formula

i.e.
Total Employee Earning = (Rate Per Unit X Actual Time Worked) + Premium Percentage X (Standard Time – Actual Time Worked) x Rate per unit.
Suppose, a worker should produce 50 units in 8 hours and he is paid at the rate of $3 per hour. If he produces 100 units in 8 Hours, his total earnings for the day would be,

E = 3 x 8 + 0.5 (16-8) x 3 = 24 + 12 = $36
Where , r = 3, T = 8 Hr., P=50%, S = (8x100)/50 = 16hrs.
Rowan Plan: it was devised in Glasgow, Scotland. In this plan the bonus is calculated on the basis of the time worked. Thus the premium paid to the worker is a percentage of the time worked.
If we consider our previous example, then the total earning of the worker under the rowan plan should be,

E = 3 x 8 + (16-8)/16 x 3 x 8
= 24 + 8/16 x 24
= 24 + 12
= 36

It is worth noting that, this plan is not easy to understand by the operative personnel and it also involves more clerical work.
Straight Piecework Plan: This is a common system and is easy to understand. The rate per unit, at which the worker should be paid for the number of units produced, is determined by past records. The total earning would be,

From the previous example, here r is the piece rate and is equal to 48 pieces Therefore,

E = rN = 0.48 x 100
= $ 48
Taylor's Differential Piece Rate Plan: - this can be applied when the job is clearly defined and when the conditions are such that it would be possible for the average worker

to attain the performance target. The important features of Tylor's Plan are,

a) It does not guarantee a day rate.
b) It calls for two piece rates.
A high one when the worker attain or exceeds the standard and a low one when he fails to attain the
standard. It means worker would be paid high for achieving the standard and would receive a low pay in
case he fails to achieve the standard.
The one average of this plan is that, it motivates the worker to exceed or at least maintain the standard.
At the same it also places a heavy responsibility on management to establish the work standard. Carefully
so that the worker would not feel that he is unjustly penalized. The formula for computing his earnings
under this system is same as the straight piece rate system, the only difference is that it provides for two
rates,
$E = rN$ - when worker fails to attain standard
$E = r_1N$ - When the worker exceeds or attains the work standard.

Calculate the earnings of workers A and B under Straight Piece-rate System and Taylor's Differential Piece-rate System from the following particulars:
Normal rate per hour = 1.80
Standard time per unit = 20 seconds

Differentials to be applied:
80% of piece rate below standard
120% of piece rate at or above standard.
Worker A produces 1,300 units per day and worker B produces 1,500 units per day.
Standard Production per 20 sec = 1 unit
Standard Production per Minute = 60/20 = 3 Standard production Per hour = 3 x 60 = 180 pieces Standard Production per day of 8hr = 180 x 8 = 1440 Normal rate Per Production = 1.80
Normal Piece rate = 1.80/180 = 0.01 Low Piece rate below std production = 0.01 x 80/100 = 0.008 High Piece rate at or over std = 0.01 x 120/100 = 0.012 =
Worker A = 1300
1300 units production = 1300 x 0.008 = 10.40 if @ n straight piece sytem = 1300 x0.01 = 13.00 =
Worker B = 1500
1500 units production = 1500 x 0.012 = 18.00 if @ n straight piece system = 1500 x0.01 = 15.00

D' Grand Incentive plan : - this is the only plan that pays an incentive percentage multiplied by the value of standard plan. This also provides two different rate plans for standard and substandard work. However it does guarantee a day rate to the worker. The Gant's system allows various premium percentage for bonus payments, it allow worker to draw more than what he would receive under straight system or 100 percentage premium

plan. The formula used is,

Using the first problem the total earnings of the worker in this cause would be equal to, E = 3 x 16 + 1/3 x 3 x 16
= 48 + 16
= $ 64

Emerson Premium plan : - Under the 100% time premium plan the worker is paid the full value of the time saved. This plan calls for the determination of accurate time standards through time and motion study. This plan also guarantee day rate to the worker.

And when the worker fails to attain the standard E = r S will be used.
Taking the original example,
E = 3 x 8 = 24 at or below standard E = 3 x 16 = 48 above standard.

Bedaux Plan :- this is also time saving bonus plan, under this plan the basic unit of time is the unit. Each job is rated on the basis of standard work unit allowed for its performance. The base rate for each job is guaranteed and incentive is paid for performance above standard. When the worker is paid for the full allowed time, the computation of earnings would be,

No one incentive system of itself is the safe instrument for increasing efficiency.
Some conditions which must prevail before installing a bonus system.

1. If individual schemes are to be used it is important that the Standard Times are accurate and consistent
2. There must be sufficient WIP to allow the workers to work at their own speed and not be dependent on others supplying them.
3. Group schemes do not have the same “incentive Pull” as an individual scheme.

4. An incentive scheme will not solve production problems. If production is not running smoothly do not attempt to introduce an incentive scheme.
5. Operator’s performance records, section reports and lost time reports, should all be running satisfactorily and have been running for a reasonable period of time before installing incentives.
6. Bonus payments should be made over as short a period as possible. If practical, operators should be informed of their earnings on daily basis.
7. Bonus payments should be paid daily when achievement is over the starting level. Bonus earnings should not be reduced if the operator falls below the starting rate on some days, however, it is important to monitor operators performance carefully to ensure that they are not “keeping back tickets” on the poor days, and releasing them on good days, thereby artificially inflating their bonus payments.

8. Bonus should not be paid unless it is earned. Wherever possible, average bonus rates should not be paid for “off standard time”, otherwise the operator is encouraged to remain “off standard” for as long as is possible.

9. If the level of basic wage increases, it is necessary to push up the levels of bonus earnings, so that the percentage of bonus earned will remain the same, otherwise the motivating factors of a bonus scheme will be reduced.

10. If an attendance bonus is in operation, it makes sense that the last day of the time

period should come inside with the traditionally worst day of absenteeism normally this a Monday.
Let us do,

1. Christine has an attended time of 525 minutes, lost time of 37 minutes and produced 300 mins. What is her efficiency?
2. Janet has attended time of 525 mins, lost time of 27 mins for machine trouble, and 62 mins on samples. The minutes on her ticket for the day amounted to 400. The bonus scheme in this factory pays 0.018 cents per minute on standard for every percentage increase above 70%. What is Janet's bonus?
3. The normal day has a total attended time of 525 minutes, operator 163 left 45 minutes early to go to the doctor. Before she left she did:
25 bundles of join shoulders

16 bundles of set sleeves 3 bundles of side seams 8 mins per bundle 10 mins per bundle 15 mins per bundle

Her machine was broken from 08:30 until 08:45 and she worked on samples from 12:00 until 12:30. What is her efficiency?
4. Company B wishes to start a bonus scheme at 70% and pay R15.30 for 100%. What is the bonus rate? (Working week is 42,5 hours).
Answer,
1) Efficiency = 300/(525-37) = 61.4 %

2) 525 – 89 = 436 Mins produced = 400 Efficiency = 91.7%

3) Attended time = 525 – 45 = 480 Lost time:

MT = 15
Samples = 30
Total = 45

Time on standard = 435

Minutes produced:
25 x 8 = 200
16 x 10 = 160
3 x 15 = 45
Total = 405

Efficiency = 405 / 435 x 100 = 93% 4)
Bonus Rate = 1530 x 1
2550 30 = 0.02 cents