UNIT – 2

INTRODUCTION TO OPERATIONS MANAGEMENT

Plant location: Plant location is a strategic decision several factors influence this decision. The main objective of any business is to optimize its cost and revenue that is, minimize its costs and maximize its returns.

The degree of significance for the selection of location for any enterprise mainly depends on its size and nature large scale industries requiring huge amount of investment there are many considerations other than the local demand in the selection proper plant location these plants cannot be easily shifted to other place and an error of judgment in the selection of site can be vary expensive to the organization. However, small-scale industry mainly selects the site where in accordance with its capacity; the local market is available for its products. It can easily shift to other place when there is any change in the market.

Factors affecting plant location:

Nearness to Market: If the plant is located close to the market the cost of transportation can be minimized. This also helps the producers to have direct knowledge of the requirements of the customers.

Nearness to supply of raw materials: As far as possible the site selected should be near the source of raw materials, so that the cost of transportation can be minimized and storing cost can be reduced due to shorter lead time.

Availability of labour: Availability of right kind of labour force in required number at reasonable rates is also a deciding factor in selection of site

Transport and communication facilities: Generally, industries have a tendency to locate the industrial units near the railway station, highway or port areas.

Availability of power and fuel: Coal, electricity, oil and natural gas are the important sources of power in the industries.

Ex: Tata iron and steel industry is established near the coalmines of Bihar.

Climatic conditions: Climatic conditions largely affect certain production processes and also the efficiency of the employees.

Ex: Textile mills require moist climate that why these plant located at Mumbai and Ahmedabad.

Availability of water: Water is used in industries for processing as in paper in chemical industries, for generation of power in hydroelectric power, plants and also required for drinking sanitary purpose also.

Ancillary industries: Many industries such as processing and assembly industries are not producing al the parts of their product but purchase some of the parts from ancillary industries producing it.

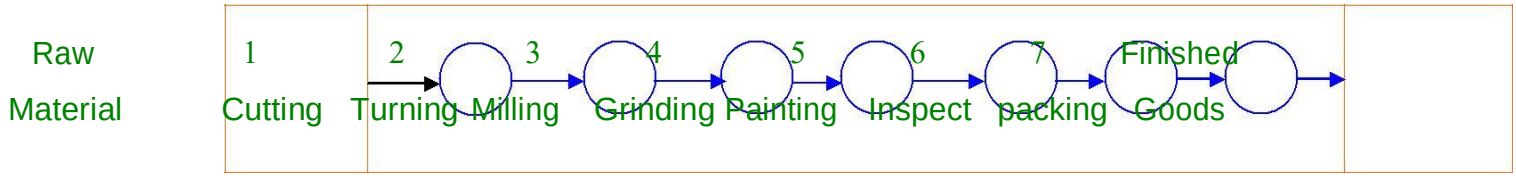
Financial and other aids: For the development of backward regions central as well as state government provide certain incentives and facilities such as cash-subsides, concession financial assistance, land, power and other facilities at cheaper rates, tax concession etc.

Plant Layout: A technique of locating machines, processes and plant services within the factory in order to secure the greatest possible output of high quality at the lowest possible total cost of production

Type of plant layout:

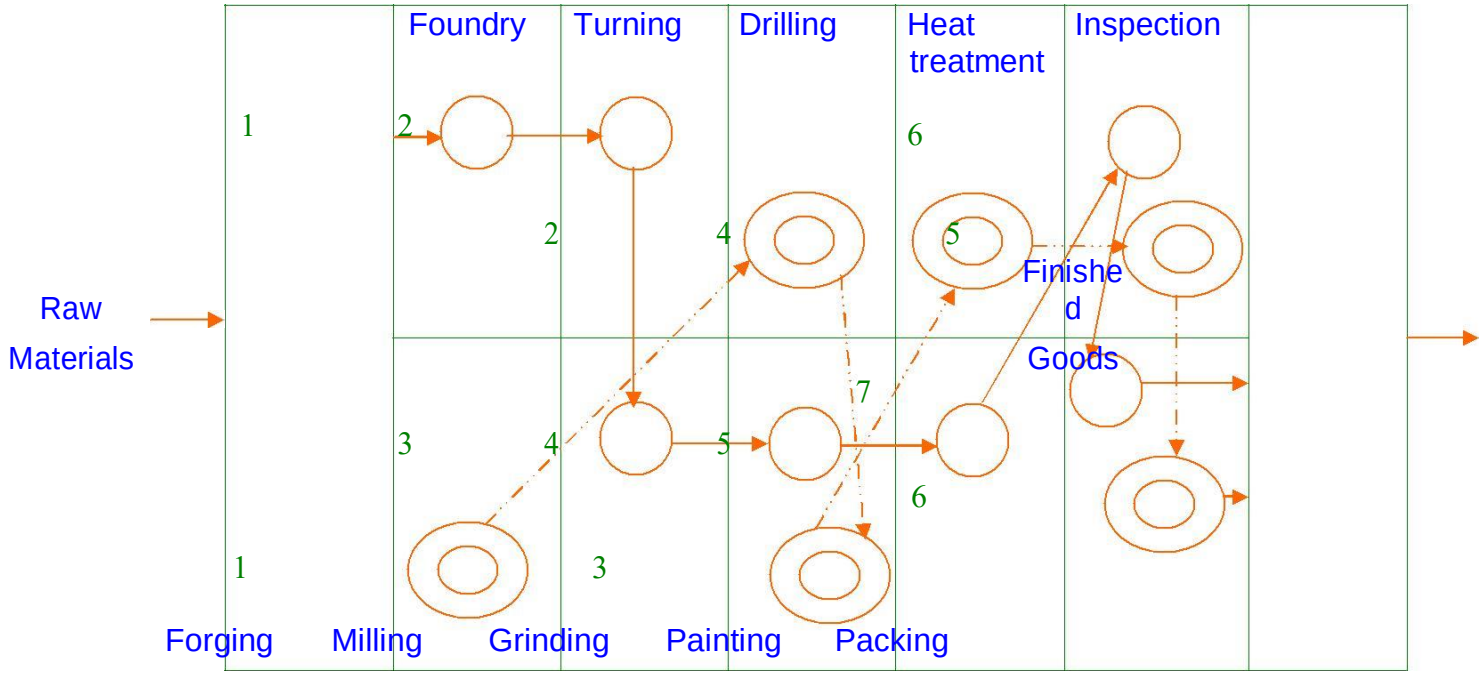
Product or line layout: This type of layout is developed for product-focused systems. In this type of layout only one product, or one type of product, is produced in a given area. In case of product being assembled, this type of layout is popularly known as an assembly line layout.

The work centers are organized in the sequence of appearance. The raw material centre at one end of the line and goes from one operation to another rapidly with minimum of work-in-process storage and material handling



Process or Functional layout: This type of layout is developed for process focused systems. The processing units are organized by functions into departments on the assumption that certain skills and facilities are available in each department similar equipments and operations are grouped together, e.g., milling, foundry, drilling, plating, heat treatment etc.

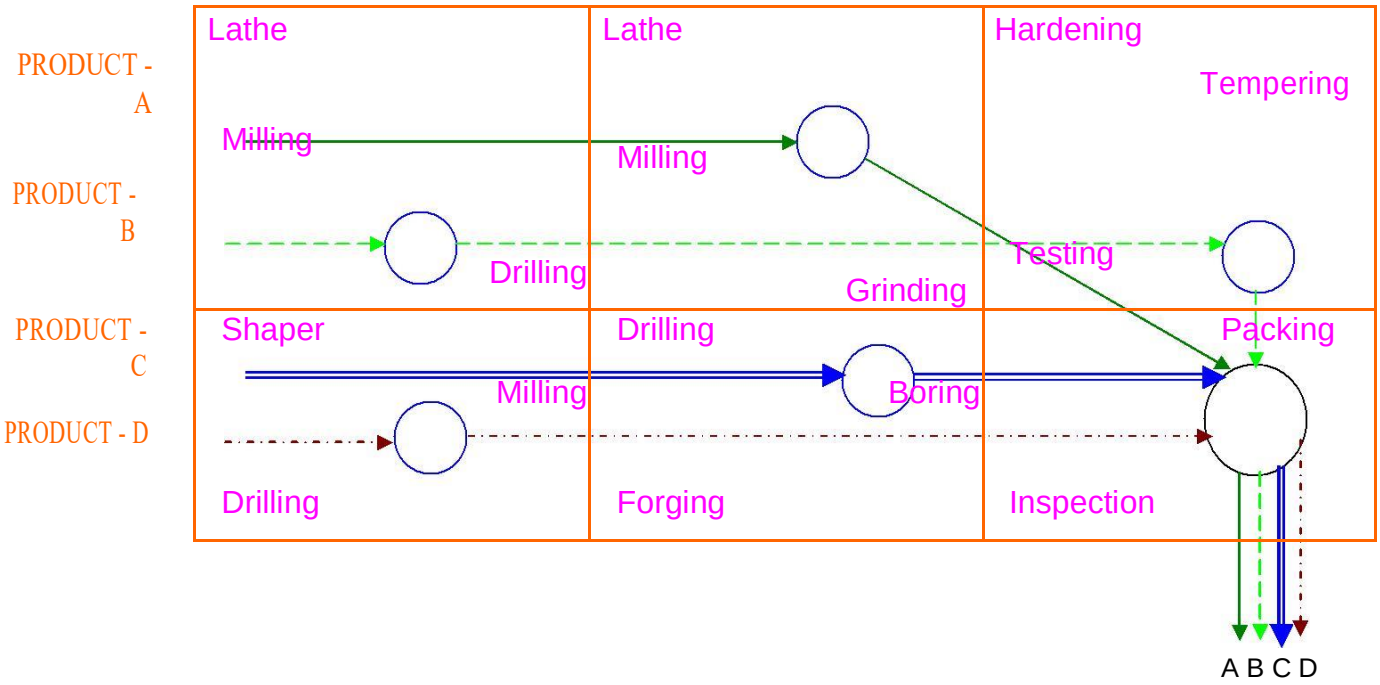
The use of process-focused systems is very wide in both manufacture and other service facilities such as hospitals, large offices, municipal services, etc.



Product - A

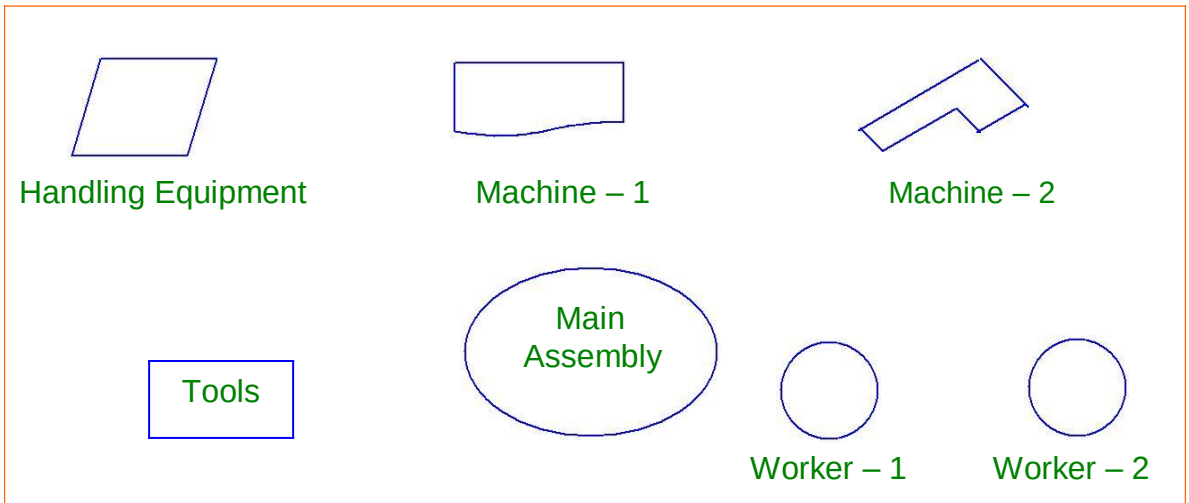
Product – B

Cellular or group layout: It is special type of functional layout in which the facilities are clubbed together into cells. This is suitable for systems designed to use the concepts, principles and approaches of 'group technology'. Such a layout offers the advantages of mass production with high degree of automation even if the numbers of products are more with flexible requirement. In such a system the facilities are group in to cells which are able to perform similar type of functions for a group of products.



Job Shop Layout: It is a layout for a very general flexible system that is processing job production, The preparation of such a layout is dependent on the analysis of the possible populations of orders and is a relatively, complex affair.

Project or Fixed position Layout: This is the layout for project type systems in which the major component is kept at a fixed position and all other materials, components, tools machines, work etc. are brought and assembly or fabrication is carried out. This type of layout is now not used very commonly as the machines required for manufacturing work are big and complicated. The fixed position layout is used only when it is difficult to move the major component and fabrication is to be carried out. Ex: production of ships.



Factors influencing plant layout:

Management policy: Management has to decide on many matters e.g. nature and quality of products, size of the plant, integration of production process, plans for expansion, amount of inventory in stock, employee facilities

Manufacturing process: The type of manufacturing process e.g. synthetic/analytical, continuous/intermittent and repetitive/non-repetitive, will govern the type of plant layout.

Nature of product: Small and light products can be moved easily to the machines, whereas for heavy and bulky products the machines may have to be moved.

Type of equipment: The use of single purpose and multi-purpose machine substantially affects the plant layout. Similarly, noisy and vibrating machines require special attention in the plant layout decision.

Types of buildings: The plant layout in a single storey building will be different from that in a multi storey building. The covered areas, the number of storey's, elevators and stairs, parking and storage area all affect the layout.

Availability of total floor area: The allocation of space for machines, work-benches, sub-store aisles etc., is made on the basis of the available floor area use of overhead space is made in case of shortage of space.

Arrangement of materials handing equipment: Provide sufficient aisles for free movement of material handling equipment such as hand truck, fork truck etc.

Service facilities: The layout of factory must include proper service facilities required for the comfort and welfare of workers. These include canteen, lockers, drinking water, first aid etc.

Possibility of future expansion: Plant layout is made in the light of future requirement and installations of additional activities.

Principles of plant layout:

Principle of integration: The best layout is one which integrates the men, materials, machinery, supporting activities and any other such a factors that results in the best compromise.

Principle of minimum movement: The number of movement of workers and materials and the distance moved should be minimized. The materials should be transported in bulk rather than in small amounts.

Principle of smooth and continue flow: It states that bottlenecks, congestion points and bulk tracking should be removed by proper line balancing techniques.

Principle of cubic space: Space of a room, it the ceiling height is also utilized, more materials can be accommodated in the same space.

Principle of satisfaction of safety: Working places-safe, well-ventilated and free from dust, noise fumes, odors and other hazardous conditions, help to increase the efficiency of the workers and improve their morale.

Principle of flexibility: It means the best layout in one which can be adopted and re-arranged at a minimum cost with least inconvenience.

Productivity:

Definition: Productivity is defined as the rate at which the goods and services are produced.

It refers to the relationship between the inputs and the output. It is calculated as a ratio between the amount produced and the amount of resources (land, labour, capital, technology etc.) used in the course of production in other words

PR $oductivity = \frac{Output}{Input}$

And also defined productivity as human efforts to produce more and more with less and less inputs of resources as a result of which the benefits of production are distributed among maximum number of people.

Method of Production:

Job production: In this system, goods are produced according to the orders with this method, individual requirements of the consumers can be met. Each job order stands alone and is not likely to be repeated. This type of production has a lot of flexibility of operation and hence general purpose machines are required. Factories adopting this type of production, are generally small in size.

Advantages:

1. It is the only method, which can meet the individual requirement.
2. There is no managerial problem, because of very less number of workers, and small size of concern.
3. Such type of production requires less money and is easy to start.

Disadvantages:

1. There is no scope for continuous production and demand
2. As the purchase of raw materials is less, hence cost of raw materials per unit will be slightly more.
3. For handling different type of jobs, only skilled and intelligent workers are needed, thus labour cost increases.

Batch production: This type of production is generally adopted in medium size enterprise. Batch production is in between job production and mass production. Batch production is bigger in scale than the job production. While it is smaller than that of mass production, batch production requires more machines than job production and fewer machines that the of mass production.

Advantages:

1. While comparing with mass production it requires less capital
2. Comparing with job production, it is more advantageous commercially.
3. If demand for one product decrease then production, for another product may be increased, thus the risk of loss is very less.

Disadvantages:

1. Comparing with mass production cost of scales and advertisement per unit is more

2. Raw materials to be purchased are in less quantity than that in mass production; therefore it is slightly costlier than that of mass production because less quantity discount is available.

Mass production: This method of production is used by concerns where manufacturing is carried on continuously in anticipation of demand though demand of the product may not be uniform through the year.

In mass production, simplification and standardization of products are made with the help of specialized (one purpose) machine, articles of standardized nature can easily and economically be produced on a large scale.

There is a small difference between mass production and continuous production. This is mainly in the kind of product and its relation to the plant. In mass production plant and equipment are flexible enough to deal with other products, involving same production process. Where as in continuous or process production only standardized product in a sequence produced. In this method layout and requirement of additional tools and equipment

Advantages:

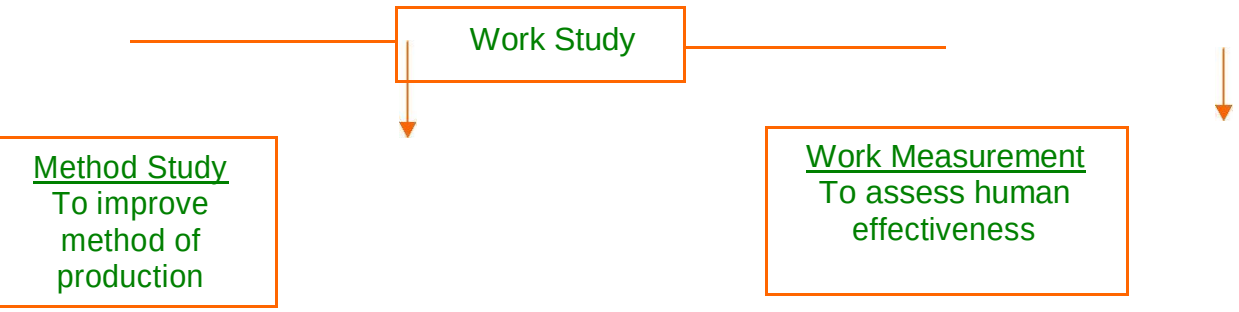
1. A smooth flow of materials from one work station to the next in logical order.
2. Since the work from one process is fed directly into the next, small in process inventories result
3. Total production time per unit short
4. Simple production planning control system are possible
5. Little skill is usually required by operations at the production line, hence training is simple, short and inexpensive.

Disadvantages:

1. A breakdown of one machine may lead to a complete stoppage of the line that follows the machine. Hence maintenance and repair is challenging job.
2. Since the product dictates the layout, changes in product design may require major changes in the layout.
3. Generally high investment are required owing to the specialized nature of the machines and their possible duplication in the line

Work Study: Work study is one of the most important management techniques which is employed to improve the activities in the production. The main objective of work study is to assist the management in the optimum use of the human and material resources.

Definition: Work study refers to the method study and work measurement, which are used to examine human work in all its contexts by systematically investigating into all factors affecting its efficiency and economy to bring forth the desired improvement.



Method Study:

Definition: The systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing cost it is also called motion study.

Work Measurement:

Definition: Work measurement is the application of techniques designed to establish time for a qualified worker to carry out a specified job at a defined level of performance.

Work study has two parts, Method Study and Work Measurement. Method study deals with the techniques of analyzing the way to do a given job better, Work Measurement seeks to measure the time required to perform the job.

Basic procedure for Method Study:

Select: The work to be studied

Record: All the relevant facts of the present or proposed method study by observation

Examine: The recorded facts critically every thing that is done, considering in turn, the purpose of the activity, the place where it is performed, the sequence in which it is done, the person who is doing it and the means by which it is done.

Develop: The most practical, economical and effective method considering all the circumstances.

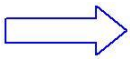
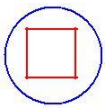
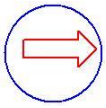
Define: The new method so that it can always be identified.

Install: The method as standard practice

Maintain: That standard practice by regular routine checks.

Recording: The current process of doing the job has to be recorded, while doing so every detail however small it may be, has to be identified.

Where the process is too long, involving many stages of production, inspection or transportation, the present process of doing the job is recorded sufficiently together with all the relevant information, using the process chart symbols.

Symbol	Meanings
	Operation: Operation involving changes in the condition of a product Ex: Assembly of spare parts
	Transport: Something from the location to another Ex: Assemble PC is moved to inspection section
	Storage: (permanent) To store the materials, goods etc. Ex: When PC is put into the store after inspection
	Delay: (Temporary storage) Arises when the product waits for next stage in the process Ex: Machinery breakdown etc.
	Inspection: To check whether the quality and quantity of the product is satisfactory or not
	Operation – cum – Inspection: Inspection is taken place during the production process
	Operation – cum – Transportation: Assemble is taking place while the belt conveyer transports the spares.

Procedure for Work Measurement:

1) Sect: The work to be studied and determine the objectives of the study

2) Record: All the relevant data relating to circumstances in which the work is being done, the methods to be used breakdown the job into its elements

3) Examine: The recorded data and the detailed breakdown critically to ensure the most effective method and motions are being used and that unproductive elements are separated from productive elements.

4) Measure: The time required to complete each element using the appropriate work measurement techniques and calculate the time required to compete the work cycle which is known as basic time.

5) Compile: The standard time for the operation or work place, in case of stop watch time study the various allowances to cover relation, personal needs etc. are added to the basic time to estimate the standard time.

Techniques of work measurement:

1. Time study
2. Synthesis from standard data
3. Predetermined Motion Time System (PMTS)
4. Analytical estimating
5. Work Sampling

1) Time study: It is defined as the art of observing and recording the time required to do each detailed element of all industrial operation.

Time study equipment: Time study equipment can be broadly grouped two categories

A) Time measuring device B) Time study boards and time study chart

A) Time measuring devices:

a) Stop Watch b) Motion picture camera c) Time recording machine

d) Electronic timer.

a) Stop Watch:

i) Decimal minute stop watch: In this type of watch the movements is started and stopped by moving the slide “A”, forward and backward respectively are complete revolution of large hand represents 1 minute and since the dial is divided into 100 parts reading to with in 0.01 minutes can be obtained. Every time the large hand make one revolution the small hand will register 1 minute and is able to register up to 30 minutes.

ii) Decimal hour stop watch: The dial in this watch is divided into 100 parts. The needle completes 10 revolutions in one hour. The least count in this watch is 0.001 hours. The small dial of this watch is divided into 30 equl spaces (representing 0.01 hour) and the small needle makes 31/3 revolutions in one hour.

b) Motion picture camera: Every element of the operation involving motion of the workers is made into film through motion picture camera when this film is run at a slow speed through a projector; the time of each element is recorded using a stopwatch.

c) Time recording machine: A moving tape is run is this machine at a uniform velocity of 10 inches/minutes with the help of electric motor. The machine has two keys: one key, when pressed, indicates starting of an operation, and the other key used to take a print on the scaled tape at the end of elements.

d) Electronic timer: The timing of starting and ending of an operation of an element is automatically recorded through electronic timers.

B) Time study boards and time study charts:

Time study board: These are simple and handy hard wood boards equipped with stopwatch holders and clamps for holding the observation sheets and time study forms. These boards help to see and record the observation and time at the same instant.

Observations forms: Printed or cyclostyled forms are used for recording the observation during that time study. It ensures that time study are made in a

standard manner and that no essential data are omitted. These forms are attached to the study board by means of clip provided

2) Synthesis from standard data: This one technique of work measurement to obtained synthetic times that are synthesis from element times previously obtained from direct time studies. The analysis and measurement stage are thus conducted prior to the actual study.

3) Predetermine motion time system (PMTS): Every element of work is composed of some combination of basic human motions. Apart from mental activity all works can broken down into elements that usually a fundamental movement of the body or body members. After this analysis stage the basic motions that have been isolated have a time allotted to them on the basis of predetermine motion times.

4) Analytical estimation: Analytical estimating serves as best for measuring work. In the analysis stage we find the usually these basic elements or much larger as compared to the elements in PMTS or time study. For measuring stages the time, which will be occupied by the element at a specific speed of working is estimated.

5) Work Sampling: It is work measurement technique which large number of instantaneous observation are made random interval over a specified period of time of a group of workers, machine and processes. Each observation records what is happening at that instantant and the present observations recorded for a particular activity or delay is a measure of the percentage of time during which that activity or delay occurs.

It can also defined as a method of finding the percentage occurrence of a certain activity by statistical sampling and random observations.

Procedure for conducting time study: For conducting time study average workers and average machines are selected. This study id conducted by the time study expert, who should be familiar with all the information related to the job and the conditions in which it is being done.

Time study is performed in the following stages.

A) Analysis of work B) Standardization of methods C) Making time study

A) Analysis of work: It includes all the tasks performed by the workers, not just the effective work. In the end, time required for job preparation, cleaning of machine, etc. should also be included.

B) Standardization of methods: Related to materials, equipment, tools, working conditions to ensure an acceptable method which is easy, safe and the fastest.

C) Making time study: Time study is done on a printed time study record sheet, which is fixed on a board known as time study board. On one corner, a stopwatch is placed.

Different time readings of element are recorded in the corresponding column of the record sheet. Several sets of reading are taken to arrive at an accurate result after noting all these readings, average tome is calculated, neglecting abnormal values, if any.

Standard time: it is the time, which is taken by a normal worker for a specific task or job, working under moderate conditions and including other allowances. Such as fatigue setting of tool and job, repairing of tool and checking of job etc

Standard time is the basis for the calculation of wages and incentives.

Standard time= Average time* Rating factor+ other allowances

Rating factor: the study engineer multiplies actual time with a factor known as Rating factor or leveling factor to set the average time which a normal worker would take. This is expressed as a percentage of the effacing of representative operator, which is in comparison to some of his average fellow workers.

Performance rating: performance rating is that process, during which the time study engineer compares the performance of the operator of normal performance.

$$\text{Performance rating} = \frac{\text{OBSERVED PERSORMANCE}}{\text{NORMAL PERFORMANCE}} \cdot 100$$

STATISTICAL QUALITY CONTROL

Introduction: Quality is the determining factor the success of any product or service large resource are committed in every organization to ensure quality

Definition: It is defined as customer satisfaction in general and fitness for use in particular. Both the external consumer who buy the product and services and the internal consumers that is, all divisions or departments of the business organization are equally interested in the quality.

Statistical quality control: The process of applying statistical principles to solve the problem of controlling the quality control of a product or service is called statistical quality control.

Quality elements: a) Quality design b) Quality conformance

a) Quality design: Quality of design refers to product feature such as performance, reliability durability, ease of use, serviceability

b) Quality conformance: Quality conformance means whether the product meets the given quality specification or not

Inspection: The process of measuring the out put and comparing it to check whether it meets the given specified requirements or not, is called inspection.

Inspection Methods: The following are the methods of inspection based on merits

1) Incoming inspection: In this method, the quality of the goods and services arriving into the organization is inspected. This ensures that the material suppliers adhere to the given specifications with this defective material cannot enter into the production process. This focuses on the vendor's quality and ability to supply acceptable raw materials.

2) Critical point inspection: Inspecting at the critical points of a product manufacture gives valuable insight into the completely functional process. At the points of manufacture that involve high costs or which offer no possibility for repair or rework, inspection is crucial further operation depend on these results critical point inspection helps to drop the defective production, and thereby, facilitate avoiding unnecessary further expenditure on them.

3) Process inspection: This is also called patrolling inspection or floor inspection or roving inspection. Here the inspector goes around the manufacturing points in the shop floor to inspect the goods produced on random sample basis from time to time.

4) Fixed inspection: It provides for a centralized and independent where work is brought for inspection from time to time. This method is followed where the inspection equipment cannot be moved to the points of productions.

5) Final inspection: This is centralized inspection making use of special equipment. This certifies the quality of the goods before they are shipped.

Elements of statistical Quality Control: The technique under SQC can be divided in to two parts a) Process control b) Acceptance sampling

a) Process control: Process control is a technique of ensuring the quality of the products during the manufacturing process itself. If a process consistently produces items with acceptable or tolerable range of specification. It is said to be statically under control. Process control is achieved through control charts. Process control aims to control and maintain the quality of the products in the manufacturing process.

Statistical control charts: A control chart compares graphically the process performance data to computed statistical control limits. These control limits act as limit lines on the chart control chats are the tools to determine whether the process is under control or not.

The quality of the production process may be affected by chance cause or assignable cause.

Chance cause: such causes, which may or may not affect the manufacturing process are called chance cause, chance cause cannot even be identified. It is not possible to always maintain the given specification.

Assignable Cause: Assignable causes affect the quality of the production process. These causes can be identified and specified. Causes such as change in the labour shift, power fluctuations, or excessive tool wear are said to be assignable causes as they affect the quality of manufacturing process in different ways.

Process capability: Process capability refers to the ability to achieve measurable results from a combination of machines, tools, methods, materials and people engaged in production.

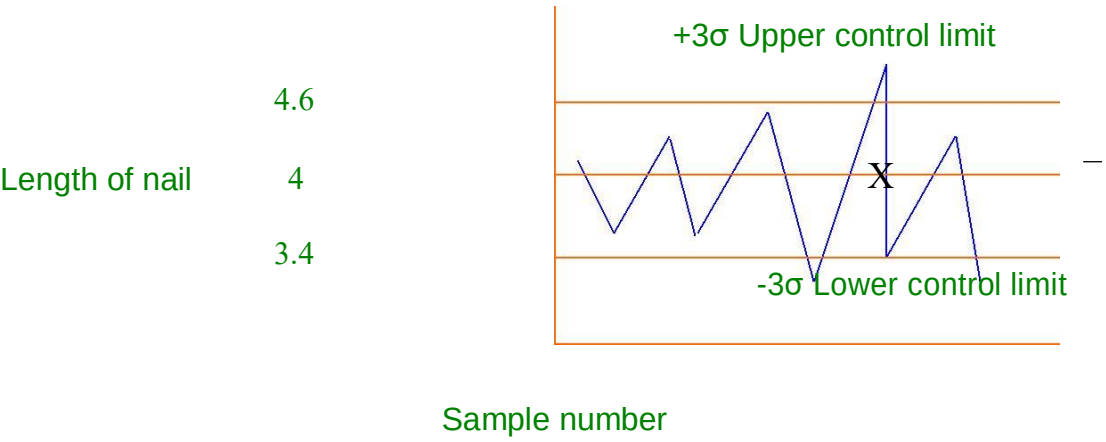
Confidence limits and control limit:

Confidence limit: It indicate the range of confidence level. A confidence level refers to the probability that the value of measurement or parameter, such as length of screw, is correct.

Ex: If a component is required with measurement of 50 mm. across, then the buy accept all components measuring between 48 mm and 52 mm across, considering a five percent confidence level.

Control limit: Control limits are found in the control charts. There are two control limits 1) Upper control limit (UCL) and 2) Lower control limit (LCL). These are determined based on the principles of normal distribution

Ex: In a pilot investigation of the length of the nails produced in the shop floor, it is found that the mean length $\bar{X}$ is cm, the S.D 3σ, the measure of variability of the nails produced 0.2 cm. How do you construct the control chart for this data.



Control charts for variables: A variable is one whose quality measurement changes from unit to unit. The quality of these variables is measured in terms of hardness, thickness, length, and so on. The control charts for variables are drawn using the principles of normal distribution. There are two types of control charts for variables $\bar{X}$ and R chart.

$\bar{X}$ and R Chart: The $\bar{X}$ chart is used to show the process variations based on the average measurement of samples collected. It shows more light on diagnosing quality problem when read along with R chart. It shows the erratic or cyclic shifts in the manufacturing process. It can also focus on when to take a remedial measure to set

right the quality problems. However, collecting data about all the variables involves a large amount of time and resources.

The R chart is based on the range of the items in the given ample. It highlights the changes in the process variability. It is a good measure of spread or range. It shows better results when read along with the $\bar{X}$ chart.

For $\bar{X}$ charts: UCL = $\bar{\bar{X}} + A_2 \bar{R}$ When $\bar{\bar{X}}$ = Mean of Means

LCL = $\bar{\bar{X}} - A_2 \bar{R}$ $\bar{R}$ = Mean of sample range A_2= Constant

For R chart: UCL = $D_4 \bar{R}$ D_4, D_3 are constants

LCL = $D_3 \bar{R}$

$\bar{R}$ is the average of sample ranges (Ranges is the difference between the maximum variable and minimum variable)

EX: Construct $\bar{X}$ and R charts from the following information and state whether the process is in control for each of the following $\bar{X}$ has been computed from a sample of 5 units drawn at an interval of half an hour from an ongoing manufacturing process.

Samples	1	2	3	4	5	6	7	8	9	10
$\bar{x}$	24	34	35	39	26	29	13	34	37	29
R	23	39	14	5	20	17	21	11	40	10

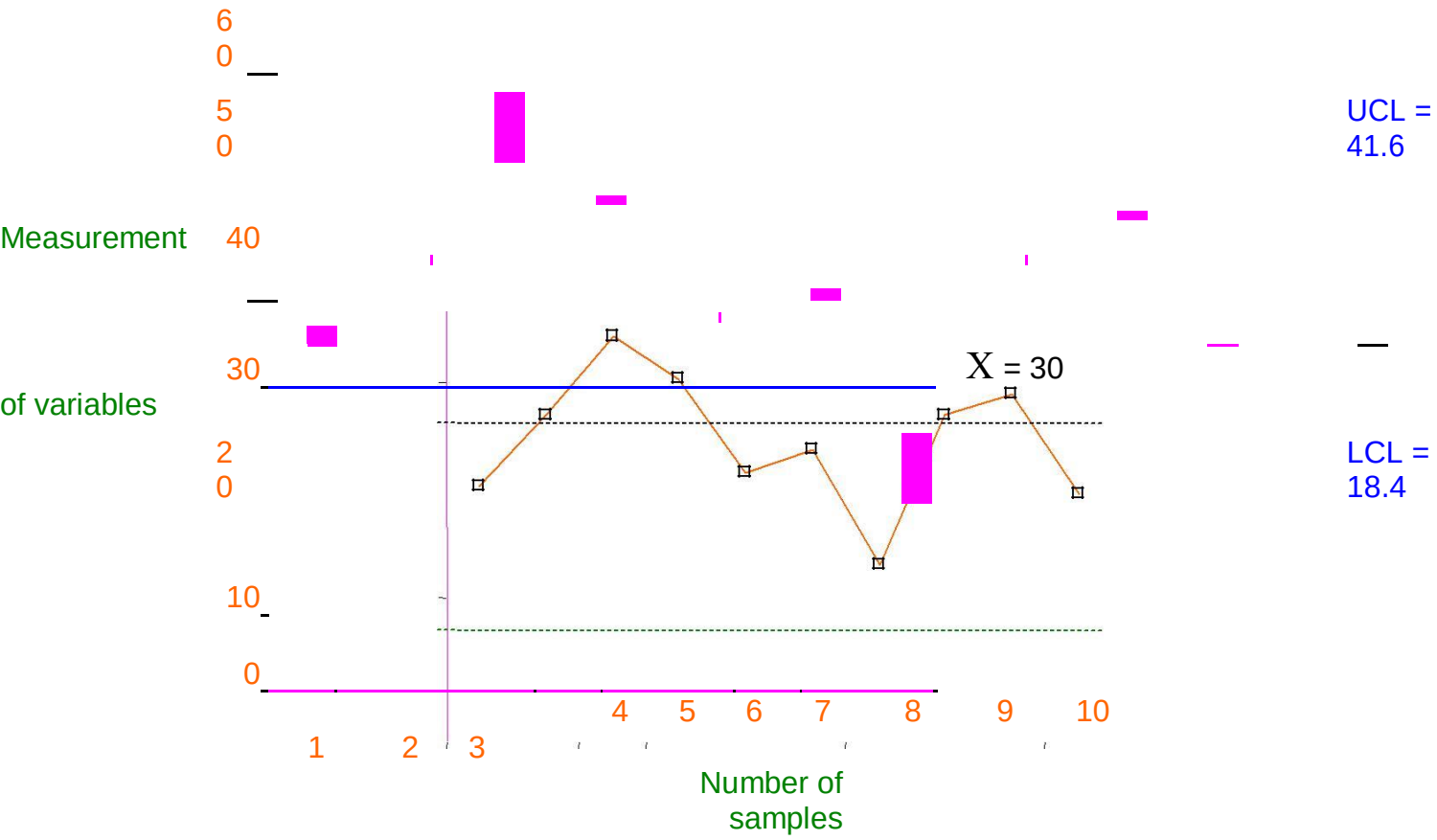
Solution: The mean of means $\bar{\bar{X}} = \frac{\sum \bar{X}}{N} = \frac{300}{10} = 30$

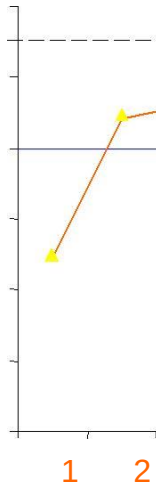
$\bar{R}$ is calculated as $\bar{R} = \frac{\sum R}{N} = \frac{200}{10} = 20$

$\bar{x}$ Chart: $\bar{x}$ hartc UCL and LCL compute at sample size 5 A 2 table value is 0.58

UCL= $\bar{\bar{X}} + A_2 \bar{R}$ = 30 + (0.58x20) =41.6

LCL = $D_3 \bar{R}$ = 30 – (0.58x20) = 18.4





R Chart: R chart UCL and LCL compute at sample size 5, D_4 table value is 2.11 and D_3 table value is 0

UCL = $D_4 \bar{R}$ = 2.11 x 20 = 42.2

LCL = $D_3 \bar{R}$ = 0 x 20 = 0

Measurement of variables

45
25
20
15
10
5
0

LCL = 0

UCL = 42.6

$\bar{R}$ = 42.6

Therefore 3, 7 points the process is out of control.

Control charts for attributes: The quality of attributes can be determined on the basis of 'Yes' or 'No', 'Go' or 'No go'. In other words, in case of a mirror glass, even if there is one scratch it is not considered to be a quality mirror, in such a case quality is decided base on whether the mirror has any scratch or not.

The control charts for attributes are 'C' chart and 'P' charts

'C' Chart: 'C' chart is use where there a number defects per unit. This control charts controls the number of defects per unit. Here the sample size should be constant. This calculate as below.

UCL = $\bar{c} + 3\sqrt{\bar{c}}$ and LCL = $\bar{c} - 3\sqrt{\bar{c}}$

Where the $\bar{c} = \frac{\textit{Total number of defects in all the samples}}{\textit{Total number of samples inspected}}$

Ex:

Sample Number	No. of defects	Sample Number	No. of defects
1	5	11	4
2	4	12	6
3	9	13	7
4	7	14	3
5	8	15	5
6	9	16	3
7	4	17	3
8	5	18	1
9	2	19	7
10	6	20	2

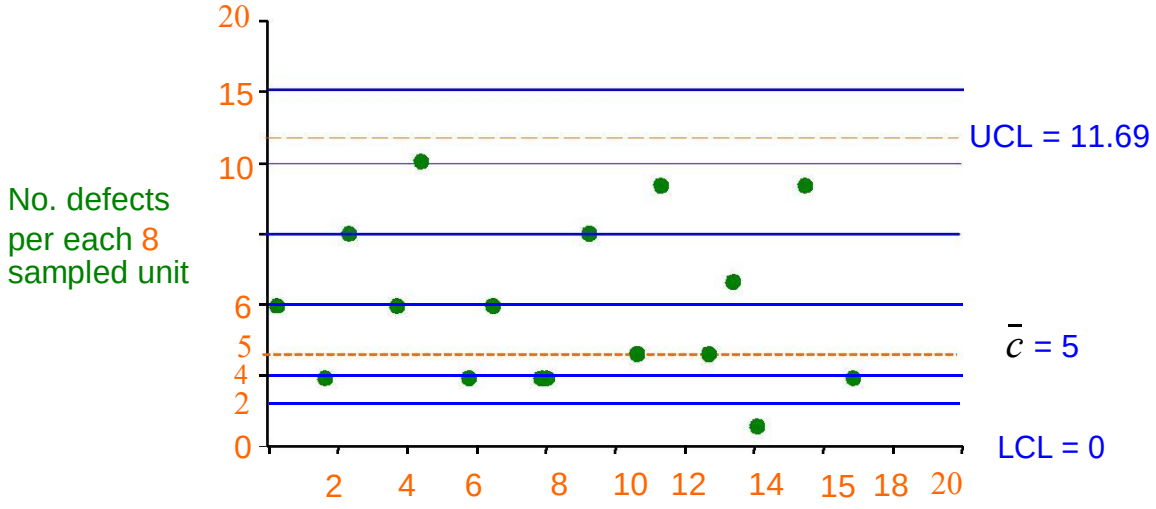
Total number of defects = 100

$$\bar{c} = \frac{100}{20} = 5$$

$$UCL = \bar{c} + 3\sqrt{\bar{c}} = 5 + 3\sqrt{5} = 11.69$$

$$LCL = \bar{c} - 3\sqrt{\bar{c}} = 5 - 3\sqrt{5} = 0$$

LCL = 0 means, LCL got negative value, take it as equal to zero



Number of samples

'P' Chart: 'P' Chart is used where there is date about the number of defectives per sample. It is also called fraction defective chart or percentage defectives chart. Here each item is classified on 'go or no go' basis that is good or bad. Hence if the sample size is larger, the results could be better.

UCL =

LCL =

Where average defective ($\bar{p}$) = $\frac{Total\ no.\ of\ defective\ found}{Total\ no.\ of\ pieces\ inspected}$

'n' = Number of pieces inspected per day

Ex: For each of the 14 days a number of magnets used in electric relays are inspected and the number of defectives is recorded. The total number of magnets tested is 14,000. The following are the particular of the number of defectives found every day.

Day number	Number of defective	Day number	
1	100	8	
2	50	9	
3	150	10	
4	200	11	
5	150	12	
6	50	13	
7	80	14	

Solution:

Total number of defectives = 14000

The average sample size(n) per day= 14000/14 days = 1000

Percentage of defective per day = $\frac{Total\ no.\ of\ defective\ found\ per\ day}{Total\ no.\ of\ pieces\ inspected\ per\ day}$

Day number	Percentage of defectives	Number of defective	Percentage of defectives	Day number	Day defective	Number of
1	100/1000=0.10	100	120/1000=0.12	8	120	

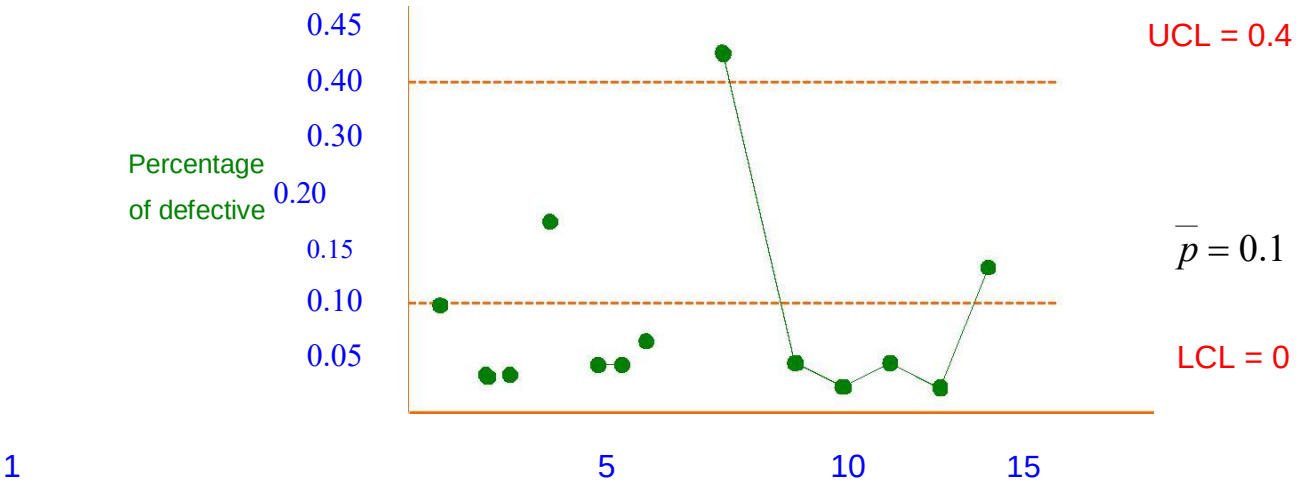
	50/100		60/100		
2	0 =0.05	50	0 =0.06	9	60
3	150/1000=0.15	150	140/1000=0.14	10	140
			50/100		
4	200/1000=0.20	200	0 =0.05	11	50
5	150/1000=0.15	150	70/1000 =0.07	12	70
	50/100		40/100		
6	0 =0.05	50	0 =0.04	13	40
7	80/1000 =0.08	80	140/1000=0.14	14	40

$$(\bar{p}) = \frac{\text{Total no. of defective found}}{\text{Total no. of pieces inspected}}$$

1400/14000 = 0.1

$$UCL = 0.1 + 3\sqrt{\frac{0.1(1-0.1)}{1000}} = 0.4$$

$$LCL = 0.1 - 3\sqrt{\frac{0.1(1-0.1)}{1000}} = 0$$

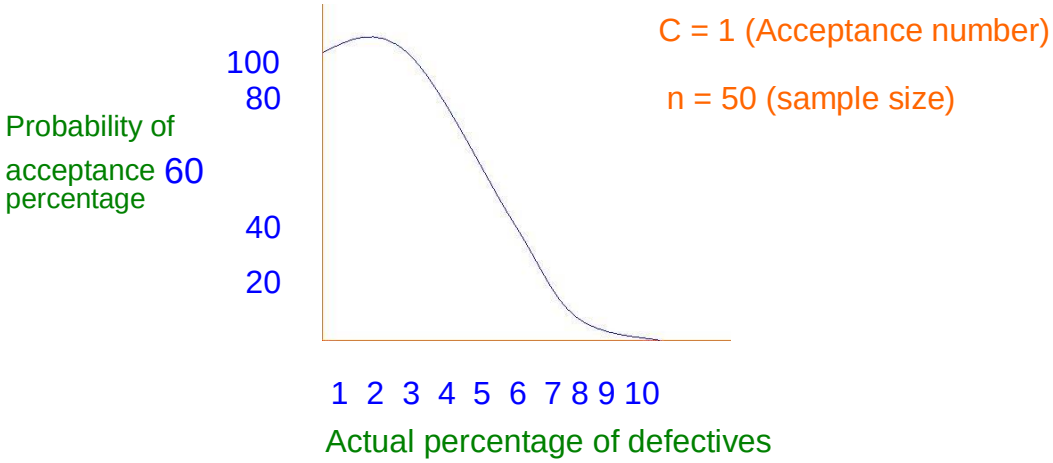


Acceptance Sampling: Acceptance sampling is a technique of deciding whether to accept the whole lot or not based on the number of defectives from a random drawn sample.

It is widely use in buying food products, such as rice, wheat etc. Before buying the random samples drawn from the bags of say rice are tested. If the quality of sample drawn looks good or free from defects then according to the requirement the entire bag or part of it can be brought

The process of acceptance sampling through operating characteristic curve (OCC)

Operating characteristic curve (OCC): The graphical relationship between percentage defective in the lots being submitted for inspection and the probability acceptance is termed as “operating characteristic of a particular sampling plan”



It gives a clear picture about the probability of acceptance of lot for various values of percent defectives in the lot. The probability of acceptance of a lot is high for low values of actual percentage decrease and it is low for high values of actual percentage defectives.

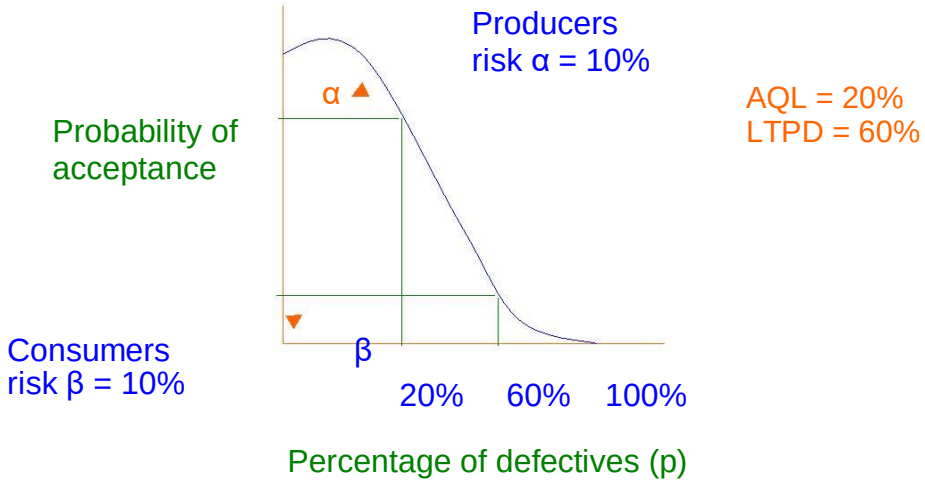
Construction of OC curve: To develop a sampling plan for acceptance sampling, an appropriate O.C curve must be selected to construct an OC curve an agreement has to be reached between the producer and the consumer on the following four point.

1) Acceptable quality level (AQL): This is the maximum proportion of defectives that will make the lot definitely acceptable.

2) Lot tolerance percentage defective (LTPD): This is the maximum proportion of defectives that will make the lot definitely unacceptable.

3) Producers risk (α): This is the risk, the producer is willing to take that lots of the quality level AQL will be rejected, even though, they are acceptable usually α = 5%

4) Consumer risk (β): This is the risk, the consumer is willing to take that lots of the quality level LTPD will be accepted, event though, they are actually unacceptable usually β = 10%.



Sampling plans: Based on the number of samples drawn for taking accept/ reject decisions, the sampling methods are used. There are four methods of acceptance samplings.

1) Single sampling plan: A lot is accepted or rejected on the basis of a single sample drawn from that cost

2) Double sampling plan: If it is not possible to decide the fate of the lot on the basis of first sample, a second sample is drawn and the decision is taken on the basis of the combined results of first and second sample.

3) Multiple sampling plan: A lot is accepted or rejected based upon the result obtained from several samples (of parts) drawn from the lot.

4) Sequential sampling plan: (Item by item analysis)

Sequential sampling involves increasing the sample size by one part at a time till the sample becomes large enough and contains sufficient number of defectives to decide intelligently whether to accept or reject the lot.