SANT LONGOWAL INSTITUTE OF ENGINEERING AND TECHNOLOGY

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Course Material

Subject: Production Management

Subject Code: ME-314

DEPARTMENT OF MECHANICAL ENGINEERING

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For ICD Program

ME-314 Production Management

Credit : 03 LTP:2-0-2

	Course Description	Lecture
Unit-I	**Quality Control** Introduction, statistical control of processes, control charts for variables X & R Charts, X & s Charts ,properties of control charts, control charts for attributes – p chart, np chart, 100p chart, c chart.	**06**
	Quality assurance and acceptance control Objectives of acceptance control, hypothesis testing in acceptance control, lot-by-lot acceptance sampling by attributes, acceptance procedures based on AQL.	**06**
	Total Quality Management Evolution of quality improvement techniques, ISO standards, TQM approach,	**05**
Unit-II	**Sales Management and Forecasting** Introduction, types of forecasting, importance of demand planning, methods of sales forecasting, Qualitative and Quantitative methods of demand planning	**05**
	Materials Handling and management Principles of material handling, material handling equipments, material requirement planning, objectives of materials management, purchasing, vendor selection, JIT in purchasing, supply chain management.	**05**
	Business Organization and forms of Ownership Introduction, Organization structure, good organization design, types of organizations, sole proprietorship, partnership.	**05**

List of Experiments

1. Study & practices of various types control charts
2. Study of productivity improvement techniques
3. Value Analysis assessment of the products
4. To study the system of dispatching and scheduling of company/organisation.
5. To study Purchase Procedure for any equipment/instrument in any company/organisation.
6. Study and Preparation of Assembly Chart and Product Structure
7. STOP watch TIME study of a Drill Press Operation/any other operation.
8. Study of Learning curve.
9. To study the Inventory System of any Store.

Subject Code ME -314 **Subject: Production Management**

Chapter 1: Quality Control

Contents:
Quality Control Introduction, statistical control of processes, control charts for variables X & R Charts, X & S- Charts , properties of control charts, control charts for attributes – p chart, np chart, 100p chart, c chart.

1 Introduction

The meaning of "Quality" is closely allied to cost and customer needs. "Quality" may simply be defined as fitness for purpose at lowest cost. The component is said to possess good quality, if it works well in the equipment for which it is meant. Quality is thus defined as fitness for purpose.

- Quality is the 'totality of features and characteristics' both for the products and services that can satisfy both the explicit and implicit needs of the customers.
- "Quality" of any product is regarded as the degree to which it fulfills the requirements of the customer.
- Quality" means degree of perfection. Quality is not absolute, but it can only be judged or realized by comparing standards. It can be determined by some characteristics namely, design, size, material, chemical composition, mechanical functioning, workmanship, finish and other properties.
- Control is a system for measuring and checking (inspecting) a phenomenon. It suggests when to inspect, how often to inspect and how much to inspect. In addition, it incorporates a feedback mechanism which explores the causes of poor quality and takes corrective action.
- Control differs from 'inspection', as it ascertains quality characteristics of an item, compares the same with prescribed quality standards and separates defective items from non-defective ones. Inspection, however, does not involve any mechanism to take corrective action.

1.1 Quality Control

Quality Control is a systematic control of various factors that affect the quality of the product. The various factors include material, tools, machines, type of labour, working conditions, measuring instruments, etc. Quality Control can be defined as the entire collection of activities which ensures that the operation will produce the optimum Quality products at minimum cost.

As per A.Y. Feigorbaum Total Quality Control is: “An effective system for integrating the quality development, Quality maintenance and Quality improvement efforts of the various groups in an organization, so as to enable production and services at the most economical levels which allow full customer satisfaction”

In the words of Alford and Beatly, “Quality Control” may be broadly defined as that “Industrial management technique means of which products of uniform accepted quality are manufactured.” Quality Control is concerned with making things right rather than discovering and rejecting those made wrong.

In short, quality control is a technique of management for achieving required standards of products.

1.2 FACTORS AFFECTING QUALITY

In addition to men, materials, machines and manufacturing conditions there are some other factors which affect the product quality. These are:

- Market Research i.e. into the demands of purchasers.
- Money i.e. capability to invest.
- Management i.e. Management policies for quality level.
- Production methods and product design.

Modern quality control begins with an evaluation of the customer’s requirements and has a part to play at every stage, from goods manufactured right through sales to a customer who remains satisfied.

1.3 OBJECTIVES OF QUALITY CONTROL

- To decide about the standard of quality of a product that is easily acceptable to the customer and at the same time this standard should be economical to maintain.
- To take different measures to improve the standard of quality of product.

1.4 FUNCTIONS OF QUALITY CONTROL DEPARTMENT

- To take various steps to solve any kind of deviations in the quality of the product during manufacturing.
- Only the products of uniform and standard quality are allowed to be sold.
- To suggest method and ways to prevent the manufacturing difficulties.
- To reject the defective goods so that the products of poor quality may not reach to the customers.
- To find out the points where the control is breaking down and to investigate the causes of it.
- To correct the rejected goods, if it is possible. This procedure is known as rehabilitation of defective goods.

1.5 ADVANTAGES OF QUALITY CONTROL

- The quality of product is improved which in turn increases sales.
- Scrap rejection and rework are minimized thus reducing wastage. So, the cost of manufacturing is reduced.
- Good quality products improve reputation.
- Inspection cost largely reduces.
- Uniformity in quality can be achieved.
- Improvement in manufacturer and consumer relations.

1.6 STATISTICAL QUALITY CONTROL (S.Q.C)

Statistics: Statistics means data, a good amount of data to obtain reliable results. The science of statistics handles this data in order to draw certain conclusions.

S.Q.C: This is a quality control system employing the statistical techniques to control quality by performing inspection, testing and analysis to conclude whether the quality of the product is as per the laid quality standards.

Using statistical techniques, S.Q.C. collects and analyses data in assessing and controlling product quality. The technique of S.Q.C. was though developed in 1924 by Dr.WalterA.Shewartan American scientist; it got recognition in industry only second world war. The technique permits more fundamental control.

"Statistical quality control can be simply defined as an economic & effective system of maintaining & improving the quality of outputs throughout the whole operating process of specification, production & inspection based on continuous testing with random samples."-YA LUN CHOU

"Statistical quality control should be viewed as a kit of tools which may influence decisions to the functions of specification, production or inspection."-EUGENE L. GRANT

The fundamental basis of S.Q.C. is the theory of probability. According to the theories of probability, the dimensions of the components made on the same machine and in one batch (if measured accurately) vary from component to component. This may be due to inherent machine characteristics or the environmental conditions. The chance or condition that a sample will represent the entire batch or population is developed from the theory of probability.

Relying itself on the probability theory, S.Q.C. evaluates batch quality and controls the quality of processes and products. S.Q.C. uses three scientific techniques, namely.

- Sampling inspection
- Analysis of the data, and
- Control charting

1.7 ADVANTAGES OF S.Q.C

S.Q.C is one of the tools for scientific management, and has following main advantages over 100 percent inspection:

- **Reduction in cost:** Since only a fractional output is inspected, hence the cost of inspection is greatly reduced.
- **Greater efficiency:** It requires less time and boredom as compared to the 100 percent inspection and hence the efficiency increases.
- **Easy to apply:** Once the S.Q.C plan is established, it is easy to apply even by man who does not have extensive specialized training.
- **Accurate prediction**: Specifications can easily be predicted for the future, which is not possible even with 100 percent inspection.

- **Can be used where inspection is needs destruction of items:** In cases where destruction of product is necessary for inspecting it, 100 percent inspection is not possible (which will spoil all the products), sampling inspection is resorted to.
- **Early detection of faults:** The moment a sample point falls outside the control limits, it is taken as a danger signal and necessary corrective measures are taken. Whereas in 100 percent inspection, unwanted variations in quality may be detected after large number of defective items have already been produced. Thus by using the control charts, we can know from graphic picture that how the production is proceeding and where corrective action is required and where it is not required.

2 PROCESS CONTROL

Under this the quality of the products is controlled while the products are in the process of production. ***The process control is secured with the technique of control charts***. Control charts are also used in the field of advertising, packing etc. They ensure that the products confirm the specified quality standard or not. Process Control consists of the systems and tools used to ensure that processes are well defined, performed correctly, and maintained so that the completed product conforms to established requirements. Process Control is an essential element of managing risk to ensure the safety and reliability of the Space Shuttle Program. It is recognized that strict process control practices will aid in the prevention of process escapes that may result in or contribute to in-flight anomalies, mishaps, incidents and non-conformances.

The five elements of a process are:

- People – skilled individuals who understand the importance of process and change control
- Methods/Instructions – documented techniques used to define and perform a process
- Equipment – tools, fixtures, facilities required to make products that meet requirements
- Material – both product and process materials used to manufacture and test products
- Environment – environmental conditions required to properly manufacture and test products

2.1 PROCESS CONTROL SYSTEMS FORMS

Process control systems can be characterized as one or more of the following forms:

- **<u>Discrete</u>** – Found in many manufacturing, motion and packaging applications. Robotic assembly, such as that found in automotive production, can be characterized as discrete process control. Most discrete manufacturing involves the production of discrete pieces of product, such as metal stamping.
- **<u>Batch</u>** – Some applications require that specific quantities of raw materials be combined in specific ways for particular durations to produce an intermediate or end result. One example is the production of adhesives and glues, which normally require the mixing of raw materials in a heated vessel for a period of time to form a quantity of end product. Other important examples are the production of food, beverages and medicine. Batch processes are generally used to produce a relatively low to intermediate quantity of product per year (a few pounds to millions of pounds).
- **<u>Continuous</u>** – Often, a physical system is represented through variables that are smooth and uninterrupted in time. The control of the water temperature in a heating jacket, for example, is an example of continuous process control. Some important continuous processes are the production of fuels, chemicals and plastics. Continuous processes in manufacturing are used to produce very large quantities of product per year (millions to billions of pounds).

3 STATISTICAL PROCESS CONTROL (SPC)

SPC is an effective method of monitoring a process through the use of control charts. Much of its power lies in the ability to monitor both process center and its variation about that center. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. It has an emphasis on early detection and prevention of problems.

3.1 CONTROL CHARTS

Since variations in manufacturing process are unavoidable, the control chart tells when to leave a process alone and thus prevent unnecessary frequent adjustments. Control charts are graphical representation and are based on statistical sampling theory, according to which an adequate sized random sample is drawn from each lot. Control charts detect variations in the processing and warn if there is any departure from the specified tolerance limits. These control charts immediately tell the undesired variations and help in detecting the cause and its removal.

In control charts, where both upper and lower values are specified for a quality characteristic, as soon as some products show variation outside the tolerances, a review of situation is taken and corrective step is immediately taken.

If analysis of the control chart indicates that the process is currently under control (i.e. is stable, with variation only coming from sources common to the process) then data from the process can be used to predict the future performance of the process. If the chart indicates that the process being monitored is not in control, analysis of the chart can help determine the sources of variation, which can then be eliminated to bring the process back into control. A control chart is a specific kind of run chart that allows significant change to be differentiated from the natural variability of the process.

The control chart can be seen as part of an objective and disciplined approach that enables correct decisions regarding control of the process, including whether or not to change process control parameters. Process parameters should never be adjusted for a process that is in control, as this will result in degraded process performance. In other words, the control chart is:

- A device which specifies the state of statistical control,
- A device for attaining statistical control,
- A device to judge whether statistical control has been attained or not.

3.2 PURPOSE AND ADVANTAGES:

1. A control charts indicates whether the process is in control or out of control.
2. It determines process variability and detects unusual variations taking place in a process.
3. It ensures product quality level.
4. It warns in time, and if the process is rectified at that time, scrap or percentage rejection can be reduced.
5. It provides information about the selection of process and setting of tolerance limits.
6. Control charts build up the reputation of the organization through customer's satisfaction.

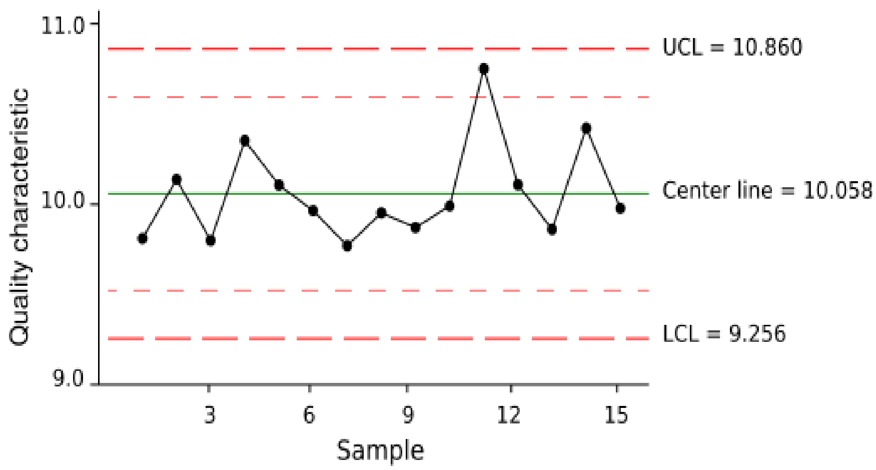
A control chart consists of:

- Points representing a statistic (e.g., a mean, range, proportion) of measurements of a quality characteristic in samples taken from the process at different times [the data]

- The mean of this statistic using all the samples is calculated (e.g., the mean of the means, mean of the ranges, mean of the proportions)
- A center line is drawn at the value of the mean of the statistic
- The standard error (e.g., standard deviation/sqrt(n) for the mean) of the statistic is also calculated using all the samples
- Upper and lower control limits (sometimes called "natural process limits") that indicate the threshold at which the process output is considered statistically 'unlikely' are drawn typically at 3 standard errors from the center line

The chart may have other optional features, including:

- Upper and lower warning limits, drawn as separate lines, typically two standard errors above and below the center line
- Division into zones, with the addition of rules governing frequencies of observations in each zone
- Annotation with events of interest, as determined by the Quality Engineer in charge of the process's quality.



3.3 TYPES OF CONTROL CHARTS

Control charts can be used to measure any characteristic of a product, such as the weight of a cereal box, the number of chocolates in a box, or the volume of bottled water. The different characteristics that can be measured by control charts can be divided into two groups: **variables** and **attributes.**

- A ***control chart for variables*** is used to monitor characteristics that can be measured and have a continuum of values, such as height, weight, or volume. A soft drink bottling operation is an example of a variable measure, since the amount of liquid in the bottles is measured and can take on a number of different values. Other examples are the weight of a bag of sugar, the temperature of a baking oven, or the diameter of plastic tubing.

- A ***control chart for attributes***, on the other hand, is used to monitor characteristics that have discrete values and can be counted. Often they can be evaluated with a simple yes or no decision. Examples include color, taste, or smell. The monitoring of attributes usually takes less time than that of variables because a variable needs to be measured (e.g., the bottle of soft drink contains 15.9 ounces of liquid). An attribute requires only a single decision, such as yes or no, good or bad, acceptable or unacceptable (e.g., the apple is good or rotten, the meat is good or stale, the shoes have a defect or do not have a defect, the lightbulb works or it does not work) or counting the number of defects (e.g., the number of broken cookies in the box, the number of dents in the car, the number of barnacles on the bottom of a boat).

3.4 CONTROL CHARTS FOR VARIABLES VS. CHARTS FOR ATTRIBUTES

A comparison of variable control charts and attribute control charts are given below:
Variables charts involve the measurement of the job dimensions, and an item is accepted or rejected if its dimensions are within or beyond the fixed tolerance limits, whereas as attribute chart only differentiates between a defective item and a non-defective item without going into the measurement of its dimensions.

- Variables charts are more detailed and contain more information as compared to attribute charts.
- Attribute charts, being based upon go and no go data (which is less effective as compared to measured values) require comparatively bigger sample size.
- Variables charts are relatively expensive because of the greater cost of collecting measured data.
- Attribute charts are the only way to control quality in those cases where measurement of quality characteristics is either not possible or it is very complicated and costly to do so—as in the case of checking colour or finish of a product or determining whether a casting contains cracks or not. In such cases the answer is either yes or no.

3.5 ADVANTAGES OF ATTRIBUTE CONTROL CHARTS

Attribute control charts have the advantage of allowing for quick summaries of various aspects of the quality of a product, that is, the engineer may simply classify products as acceptable or unacceptable, based on various quality criteria. Thus, attribute charts sometimes bypass the need for expensive, precise devices and time-consuming measurement procedures. Also, this type of chart tends to be more easily understood by managers unfamiliar with quality control procedures; therefore, it may provide more persuasive (to management) evidence of quality problems.

3.6 ADVANTAGES OF VARIABLE CONTROL CHARTS

Variable control charts are more sensitive than attribute control charts. Therefore, variable control charts may alert us to quality problems before any actual "unacceptable" (as detected by the attribute chart) occur. Montgomery (1985) calls the variable control charts *leading indicators* of trouble that will sound an alarm before the number of rejects (scrap) increases in the production process.

3.7 COMMONLY USED CHARTS

1. (X-Bar) and R charts, for process control.
2. P chart, for analysis of fraction defectives
3. C chart, for control of number of defects per unit.

3.7.1 Mean (x-Bar) ($\bar{x}$) Charts

A mean control chart is often referred to as an ***x-bar chart.*** It is used to monitor changes in the mean of a process. To construct a mean chart we first need to construct the center line of the chart. To do this we take multiple samples and compute their means. Usually these samples are small, with about four or five observations. Each sample has its own mean. The center line of the chart is then computed as the mean of all sample means, where _ is the number of samples:

1. It shows changes in process average and is affected by changes in process variability.
2. It is a chart for the measure of central tendency.
3. It shows erratic or cyclic shifts in the process.
4. It detects steady progress changes, like tool wear.
5. It is the most commonly used variables chart.
6. When used along with R chart:

a. It tells when to leave the process alone and when to chase and go for the causes leading to variation.
b. It secures information in establishing or modifying processes, specifications or inspection procedures.
c. It controls the quality of incoming material.

7. X-Bar and R charts when used together form a powerful instrument for diagnosing quality problems.

3.7.2 Range (R) charts

These are another type of control chart for variables. Whereas x-bar charts measure shift in the central tendency of the process, range charts monitor the dispersion or variability of the process. The method for developing and using R-charts are the same as that for x-bar charts. The center line of the control chart is the average range, and the upper and lower control limits are computed. The R chart is used to monitor process variability when sample sizes are small (n<10), or to simplify the calculations made by process operators. This chart is called the R chart because the statistic being plotted is the sample range.

1. It controls general variability of the process and is affected by changes in process variability.
2. It is a chart for measure of spread.
3. It is generally used along with X-bar chart.

3.8 Plotting of $\bar{X}$ and R charts:

A number of samples of component coming out of the process are taken over a period of time. Each sample must be taken at random and the size of sample is generally kept as 5 but 10 to15 units can be taken for sensitive control charts. For each sample, the average value $\bar{X}$ of all the measurements and the range R are calculated. The grand average $\bar{\bar{X}}$ (equal to the average value of all the average $\bar{X}$) and $\bar{R}$ ($\bar{R}$ is equal to the average of all the ranges R) are found and from these we can calculate the control limits for the $\bar{X}$ and R charts. Therefore,

$$\bar{\bar{x}} = \frac{\bar{x}_1 + \bar{x}_2 + \cdots + \bar{x}_m}{m}$$

$$\overline{R} = \frac{R_1 + R_2 + \cdots + R_m}{m}$$

Variables Data ($\bar{x}$ and R Control Charts)

$\bar{x}$ Control Chart

$$UCL = \bar{\bar{x}} + A_2\bar{R}$$
$$LCL = \bar{\bar{x}} - A_2\bar{R}$$
$$CL = \bar{\bar{x}}$$

R Control Chart

$$UCL = \bar{R}\, D_4$$
$$LCL = \bar{R}\, D_3$$
$$CL = \bar{R}$$

Here the factors A_2, D_4, and D_3 depend on the number of units per sample. Larger the number, the close the limits. The value of the factors A_2, D_4, and D_3 can be obtained from S.Q.C tables. However, for ready reference these are given below in tabular form:

n	A_2	D_3	D_4	d_2
2	1.880	0.000	3.267	1.128
3	1.023	0.000	2.574	1.693
4	0.729	0.000	2.282	2.059
5	0.577	0.000	2.114	2.326
6	0.483	0.000	2.004	2.534
7	0.419	0.076	1.924	2.704
8	0.373	0.136	1.864	2.847
9	0.337	0.184	1.816	2.970
10	0.308	0.223	1.777	3.078

Notation: n or m= sample size

Sample Problem

The following data were obtained over a five-day period to indicate X and R control chart for a quality characteristic of a certain manufacturing product that had required a substantial amount of rework. All the figures apply to the product made on a single machine by a single operator. The sample size was 5. Two samples were taken per day. Comment on the process using X- and R-charts.

Sample Number	Observations 1	2	3	4	5	$\bar{X}$	R
1	10	12	13	8	9	10.4	5
2	7	10	8	11	9	9.0	4
3	11	12	9	12	10	10.8	3
4	10	9	8	13	11	10.2	5
5	8	11	11	7	7	8.8	4
6	11	8	8	11	10	9.6	3
7	10	12	13	13	9	11.4	4
8	10	12	12	10	12	11.2	2
9	12	13	11	12	10	11.6	3
10	10	13	7	9	12	10.2	6

$$\Sigma \bar{X} = 103.2 \quad \Sigma R = 39$$

$$\bar{\bar{X}} = \Sigma \bar{X}/k = 103.2/10 = 10.32$$

$$\bar{R} = \Sigma R/k = 39/10 = 3.9$$

The values for A, B and C for the sample size of 5 are given below.

For $n = 5$, $A = 0.58$, $B = 2.11$ and $C = 0$.

Control limits for $\bar{X}$

$$UCL_{\bar{X}} = \bar{\bar{X}} + A\bar{R} = 10.32 + .58 \times 3.9$$

$$= 10.32 + 2.262 = 12.582$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - A\bar{R} = 10.32 - 0.58 \times 3.9$$

$$= 10.32 - 2.262 = 8.058$$

Control limits for R

$$UCL_R = B\bar{R} = 2.11 \times 3.9 = 8.229$$

$$LCL_R = C\bar{R} = 0 \times 3.9 = 0$$

The above control limits for $\bar{X}$- and R-charts are shown in Figs. 18.5 and 18.6 respectively. The sample $\bar{X}$- and R-values are also plotted on the respective figures.

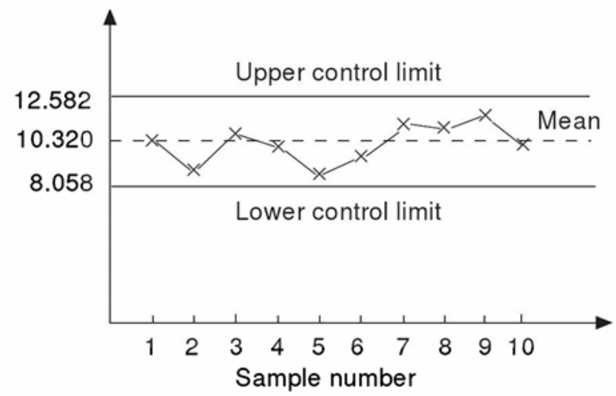
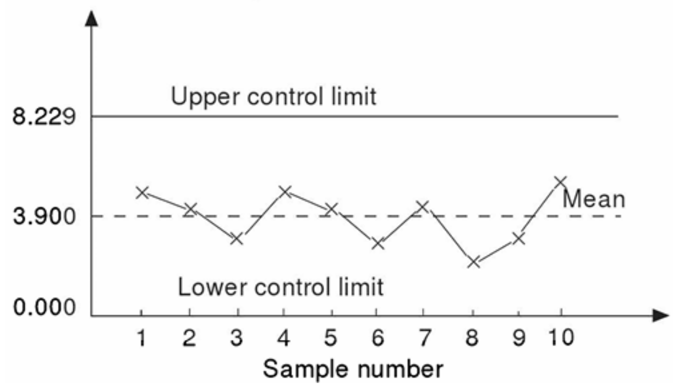


Fig. 18.5 $\bar{X}$-chart.



Comment: All the points in X-chart are within the control. All the points on the R-chart are also within the control limits. But, there is a dominant up-trend towards right hand side of X-chart. So, we will have to hunt for reasons for variations. This may be due to tool wear, operator fatigue, etc

4 PROCESS OUT OF CONTROL

After computing the control limits, the next step is to determine whether the process is in statistical control or not. If not, it means there is an external cause that throws the process out of control. This cause must be traced or removed so that the process may return to operate under stable statistical conditions. The various reasons for the process being out of control may be:

1. Faulty tools
2. Sudden significant change in properties of new materials in a new consignment
3. Breakout of lubrication system
4. Faults in timing of speed mechanisms.

5 PROCESS IN CONTROL

If the process is found to be in statistical control, a comparison between the required specifications and the process capability may be carried out to determine whether the two are compatible.

6 Conclusions:

When the process is not in control then then the point fall outside the control limits on either $\bar{x}$ or R charts. It means assignable causes (human controlled causes) are present in the process. When all the points are inside the control limits even then we cannot definitely say that no assignable cause is present but it is not economical to trace the cause. No statistical test can be applied. Even in the best manufacturing process, certain errors may develop and that constitute the assignable causes but no statistical action can be taken.

7 CONTROL CHARTS FOR ATTRIBUTES

Control charts for attributes are used to measure quality characteristics that are counted rather than measured. Attributes are discrete in nature and entail simple yes-or-no decisions. For example, this could be the number of nonfunctioning lightbulbs, the proportion of broken eggs in a carton, the number of rotten apples, the number of scratches on a tile, or the number of complaints issued. Two of the most common types of control charts for attributes are p-charts and c-charts.

7.1 P-charts

P-charts are used to measure the proportion of items in a sample that are defective. Examples are the proportion of broken cookies in a batch and the proportion of cars produced with a misaligned fender. P-charts are appropriate when both the number of defectives measured and the size of the total sample can be counted. A proportion can then be computed and used as the statistic of measurement.

1. It can be a fraction defective chart.
2. Each item is classified as good (non-defective) or bad (defective).
3. This chart is used to control the general quality of the component parts, and it checks if the fluctuations in product quality (level) are due to chance alone.

<u>Plotting of P-charts</u>: By calculating, first, the fraction defective and then the control limits. The process is said to be in control if fraction defective values fall within the control limits. In case the process is out of control an investigation to hunt for the cause becomes necessary.

The mean proportion defective ($\overline{p}$):

$$\overline{p} = \frac{\text{Total Number of Defectives}}{\text{Total Number Inspected}}$$

The standard deviation of p:

$$\sigma_{\overline{p}} = \sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$

where n = sample size.

Control Limits are:

$$UCL = \overline{p} + Z^* \sigma_{\overline{p}} \qquad LCL = \overline{p} - Z^* \sigma_{\overline{p}}$$

or

$$UCL = \overline{p} + Z^* \sqrt{\frac{\overline{p}(1-\overline{p})}{n}} \qquad LCL = \overline{p} - Z^* \sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$

Usually, the Z value is equal to 3 (as was used in the X and R charts), since the variations within three standard deviations are considered as natural variations. However, the choice of the value of Z depends on the environment in which the chart is being used, and on managerial judgment.

Sample Problems (adopted from R. PANNEERSELVAM)

Alpha electronic company manufactures cathode ray tubes on mass production basis. At some intermediate point of production line, 15 samples of size 50 each have been taken. Tubes within each sample were classified into good or bad. The related data are given in the following table. Construct a P-chart with 3 sigma limits and comment on the process.

Sample Number	Number of Defective Tubes	Percentage of Defective Tubes
1	10	0.20
2	10	0.20
3	9	0.18
4	10	0.20
5	4	0.08
6	6	0.12
7	2	0.04
8	3	0.06
9	9	0.18
10	4	0.08
11	8	0.16
12	11	0.22
13	8	0.16
14	10	0.20
15	9	0.18

$$\bar{p} = 113/(15 \times 50) = 0.151$$

$$UCL_p = \bar{p} + 3\sqrt{\bar{p}(1-\bar{p})/n}$$

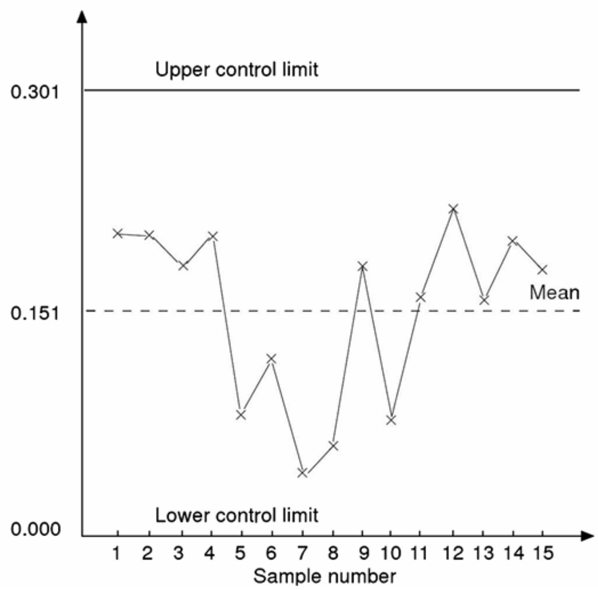
$$UCL_p = 0.151 + 3\sqrt{0.151(1-0.151)/50}$$

$$= 0.301$$

$$LCL_p = 0.151 - 3\sqrt{0.151(1-0.151)/50}$$

$$= .001 = 0 \text{ (Approx.)}$$

The limits are incorporated in the following Fig. 18.7 along with the sample observations.



7.2 C-Chart

C-charts count the actual number of defects. For example, we can count the number of complaints from customers in a month, the number of bacteria on a petri dish, or the number of barnacles on the bottom of a boat. However, we cannot compute the proportion of complaints from customers, the proportion of bacteria on a petri dish, or the proportion of barnacles on the bottom of a boat.

7.3 Defective items vs individual defects

Literature differentiates between *defect* and *defective*, which is the same as differentiating between *nonconformity* and *nonconforming units*. This may sound like splitting hairs, but in the interest of clarity let's try to unravel this man-made mystery.

Consider a wafer with a number of chips on it. The wafer is referred to as an "item of a product". The chip may be referred to as "a specific point". There exist certain specifications for the wafers.

When a particular wafer (e.g., the item of the product) does not meet at least one of the specifications, it is classified as a nonconforming item. Furthermore, each chip, (e.g., the specific point) at which a specification is not met becomes a defect or nonconformity. So, a nonconforming or defective item contains at least one defect or nonconformity. It should be pointed out that a wafer can contain several defects but still be classified as conforming. For example, the defects may be located at noncritical positions on the wafer. If, on the other hand, the number of the so-called "unimportant" defects becomes alarmingly large, an investigation of the production of these wafers is warranted.

Control charts involving counts can be either for the *total number* of nonconformities (defects) for the sample of inspected units, or for the *average number* of defects per inspection unit.

Defect vs. Defective

- 'Defect' – a single nonconforming quality characteristic.
- 'Defective' – items having one or more defects.

C charts can be plotted by using the following formulas:

$$UCL_c = \bar{c} + 3\sqrt{\bar{c}}$$

$$LCL_c = \bar{c} - 3\sqrt{\bar{c}}$$

$$\bar{c} = \frac{\text{total number of defects}}{\text{total number of samples}}$$

Sample Problem

Example 18.3. The following table gives the number of missing rivets noted in a newly fabricated bus. Construct a ***C***-chart

Bus Number	1	2	3	4	5	6	7	8	9	10
Number of missing rivets (c)	14	13	26	20	9	25	15	11	14	13

Solution.

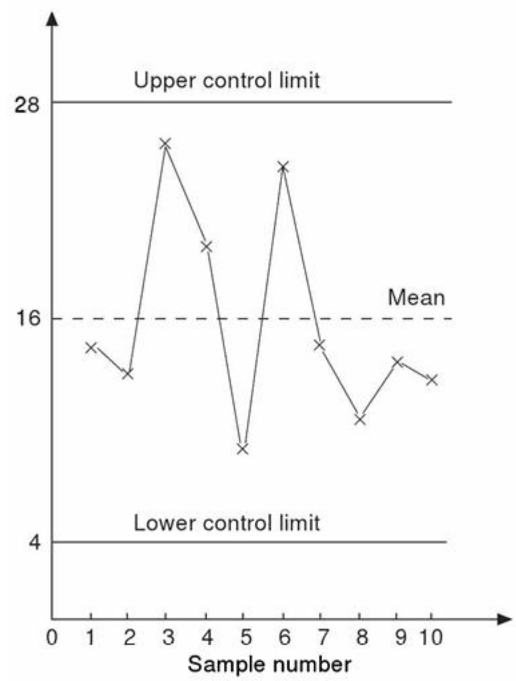
$$\Sigma c = 160$$

$$\bar{c} = 16$$

$$\begin{aligned} UCL_c &= \bar{c} + 3\sqrt{\bar{c}} \\ &= 16 + 3 \times \sqrt{16} = 16 + 3 \times 4 = 28 \end{aligned}$$

$$\begin{aligned} LCL_c &= \bar{c} - 3\sqrt{\bar{c}} \\ &= 16 - 3\sqrt{16} = 16 - 3 \times 4 = 4 \end{aligned}$$

These are plotted as shown in Fig. 18.8. The observations are scattered in the figure. This may be due to very frequent change of workers in the fabrication section or improper markings before performing riveting operation.



7.4 THE PRIMARY DIFFERENCE BETWEEN USING A P-CHART AND A C-CHART

A P-chart is used when both the total sample size and the number of defects can be computed. A C-chart is used when we can compute *only* the number of defects but cannot compute the proportion that is defective.

Subject Code ME -314 **Subject: Production Management**

Chapter 2: Quality Assurance and Acceptance Control

Contents:
Objectives of acceptance control, hypothesis testing in acceptance control, lot-by-lot acceptance sampling by attributes, acceptance procedures based on AQL.

2 Introduction

Acceptance Sampling is concerned with the decision to accept a mass of manufactured items as conforming to standards of quality or to reject the mass as non-conforming to quality. The decision is reached through sampling.

It uses statistical sampling to determine whether to accept or reject a production lot of material. It has been a common quality control technique used in industry and particularly the military for contracts and procurement. It is usually done as products leave the factory, or in some cases even within the factory. Most often a producer supplies a consumer a number of items and decision to accept or reject the lot is made by determining the number of defective items in a sample from the lot. The lot is accepted if the number of defects falls below where the acceptance number or otherwise the lot is rejected.

For the purpose of acceptance, inspection is carried out at many stages in the process of manufacturing. These stages may be: inspection of incoming materials and parts, process inspection at various points in the manufacturing operations, final inspection by a manufacturer of his own product and finally inspection of the finished product by the purchaser.

Inspection for acceptance is generally carried out on a sampling basis. The use of sampling inspection to decide whether or not to accept the lot is known as Acceptance Sampling. A sample from the inspection lot is inspected, and if the number of defective items is more than the stated number known as acceptance number, the whole lot is rejected. The purpose of Acceptance Sampling is, therefore a method used to make a decision as to whether to accept or to reject lots based on inspection of sample(s).

Thus it can be said that Acceptance sampling is the process of randomly inspecting a sample of goods and deciding whether to accept the entire lot based on the results. Acceptance sampling determines whether a batch of goods should be accepted or rejected.

Acceptance Sampling is very widely used in practice due to the following merits:

1. Acceptance Sampling is much less expensive than 100 percent inspection.
2. It is general experience that 100 percent inspection removes only 82 to 95 percent of defective material. Very good 100 percent inspection may remove at the most 99 percent of the defectives, but still cannot reach the level of 100 percent. Due to the effect of inspection fatigue involved in 100 percent inspection, a good sampling plan may actually give better results than that achieved by 100 percent inspection.
3. Because of its economy, it is possible to carry out sample inspection at various stages.

Inspection provides a means for monitoring quality. For example, inspection may be performed on incoming raw material, to decide whether to keep it or return it to the vendor if the quality level is not what was agreed on. Similarly, inspection can also be done on finished goods before deciding whether to make the shipment to the customer or not. However, performing 100% inspection is generally not economical or practical, therefore, sampling is used instead.

Acceptance Sampling is therefore a method used to make a decision as to whether to accept or to reject lots based on inspection of sample(s). The objective is not to control or estimate the quality of lots, only to pass a judgment on lots.

Using sampling rather than 100% inspection of the lots brings some risks both to the consumer and to the producer, which are called the consumer's and the producer's risks, respectively. We encounter making decisions on sampling in our daily affairs.

3 Operating Characteristic Curve

The concepts of the two types of risk are well explained using an operating characteristic curve. This curve will provide a basis for selecting alternate sample plans. For a given value of sample size (n), acceptance number (C), the O.C. curve is shown in the following figure.

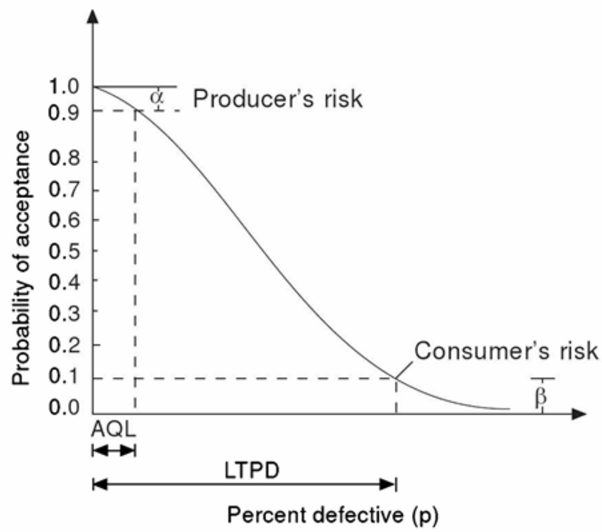


Fig. 18.9 Operating characteristic curve.

In the above figure, percent defective is shown on x-axis. The probability of accepting the lot for a given per cent defective is shown on y-axis. The value for percent defective indicates the quality level of the lot inspected. AQL means acceptable quality level. LTPD means lot tolerance percent defectives. These represent quality levels of the lot submitted for inspection. If the quality level of the lot inspected is at AQL or less than AQL, then the customers are satisfied with the quality of the lot. The corresponding probability of acceptance is called 1 — a. On the other hand, if the quality level is more than or equal to LTPD, the quality of the lot is considered to be inferior from consumer's

3.1 Risks in Acceptance sampling

1. Producer's risk-: Sometimes inspite of good quality, the sample taken may show defective units as such the lot will be rejected, such type of risk is known as producer's risk.
2. Consumer's Risk-: Sometimes the quality of the lot is not good but the sample results show good quality units as such the consumer has to accept a defective lot, such a risk is known as consumer's risk.

3.2 ACCEPTANCE SAMPLING PLANS

A **sampling plan** is a plan for acceptance sampling that precisely specifies the parameters of the sampling process and the acceptance/rejection criteria. The variables to be specified include the size of the lot (*N*), the size of the sample inspected from the lot (*n*), the number of defects above which a lot is rejected (*c*), and the number of samples that will be taken.There are different types of sampling plans.

- Single Sampling (Inference made on the basis of only one sample)
- Double Sampling (Inference made on the basis of one or two samples)
- Sequential Sampling (Additional samples are drawn until an inference can be made) etc.

3.2.1 Single Sampling Plan

In a single sampling plan, the decision regarding acceptance or rejection is made after drawing a sample from a bigger lot. An inspection is carried out and if the defectives exceed a certain number the lot is rejected. Otherwise, the lot is accepted when the number of defectives is less than the acceptance number.

3.2.2 Double Sampling Plan

In this, a small sample is first drawn. If the number of defects is less than or equal to the acceptance number (C1) the lot is accepted. If the number of defectives is more than another acceptance number (C2) which is higher, then C1 then the lot is rejected. If in case, the number in the inspection lies between C2 and C1, then a second sample is drawn. The entire lot is accepted or rejected on the basis of outcome of second inspection.

3.2.3 Sequential Sampling Plan

Sequential sampling plan is used when three or more samples of stated size are permitted and when the decision on acceptance or rejection must be reached after a stated number of samples. A first sample of n1 is drawn, the lot is accepted if there are no more than c1 defectives, the lot is rejected if there are more than r1 defectives. Otherwise, a second sample of n2 is drawn. The lot is accepted if there are no more than c2 defectives in the combined sample of n1 + n2. The lot is rejected if there are more than r2 defectives in the combined sample of n1 + n2. The procedure is continued in accordance with the table below.

Sample	*Sample Size*	*Size*	*Acceptance Number*	*Rejection Number*
First	n_1	n_1	c_1	r_1
Second	n_2	$n_1 + n_2$	c_2	r_2
Third	n_3	$n_1 + n_2 + n_3$	c_3	r_3
Fourth	n_4	$n_1 + n_2 + n_3 + n_4$	c_4	r_4
Fifth	n_5	$n_1 + n_2 + n_3 + n_4 + n_5$	c_5	$c_5 + 1$

If by the end of fourth sample, the lot is neither accepted nor rejected, a sample n5 is drawn. The lot is accepted if the number of defectives in the combined sample of n1 + n2 + n3 + n4 + n5 does not exceed c5. Otherwise the lot is rejected. A sequential sampling plan involves higher administrative costs and use of experienced inspectors

Chapter 3: Total Quality Management (TQM)

Contents
Evolution of quality improvement techniques, ISO standards, TQM approach,

3 WHAT IS QUALITY?

Quality indicates the capability of all components of an entity to satisfy the stated and implied needs, that a quality item will perform satisfactorily in service, and is suitable for its intended purpose. Quality is referred to as "fitness for use," "fitness for purpose," "customer satisfaction," "conformance to the requirements," or has a pragmatic interpretation as the non-inferiority or superiority of something. In any case, to achieve satisfactory quality, we must be concerned with all three stages of the product or service cycle which include:

● The definition of needs

● The product design and conformance

● The product support throughout its lifetime

4 QUALITY DEFINITIONS

There have been several definitions of quality as given by various quality organizations, as well as quality gurus. Nevertheless, all these definitions focus on the efforts put in by organizations to fulfill customer requirements as stated above.

1. Quality is the fitness for the purpose or use. (Fitness as defined by the customer.)–Dr. J.M. Juran in 1988.
2. Quality means getting everyone to do what he has agreed to do and do it right the first time. Quality is conformance to specifications. –Philip Crosby.
3. Quality is the degree to which a set of inherent characteristics fulfills requirements. –ISO 9000
4. TQM is a way of managing to improve the effectiveness, flexibility, and competitiveness of a business. –Prof. John Oakland

5 THE PARADIGM OF TQM

In their definition of TQM, the International Organization for Standardization (ISO) has specified the three paradigms of TQM to be composed of:

Total: Organization wide

Quality: With its usual definitions and all its complexities

Management: The system of managing with steps like Plan, Organize, Control, Lead, Staff, Provisioning, etc. We can elaborate ISO's above definition indicating that the following are involved in TQM:

Total		
All functions	***All levels***	***All persons having a stake***
● Design	● Chairman and Managing Director	● Factory personnel
● Production	● General Manager	● Corporate office
● Marketing	● Supervisor	● Shareholders
● Purchase	● Operator	● Suppliers
● Maintenance		
● Quality Control		
● HR		

Quality	**Management**	**Customer satisfaction**
1. Customer satisfaction	**1.** Effective direction, monitoring, and control	**1.** Customer driven
2. Customer driven	**2.** Continuous improvement	2. Functional requirement of the product
3. Functional requirement of the product	**3.** Effective utilization of resourses	3. Product specifications
4. Product specifications	**4.** Executive commitment	4. Process parameters
5. Process parameters	**5.** Well-planned and effective decision-making	
	6. Employee empowerment	

6 THE HISTORICAL DEVELOPMENT OF TQM

Although Total Quality Management (TQM) techniques were adopted prior to World War II by a number of organizations, the creation of the TQM philosophy is generally attributed to Dr. W. Edwards Deming. Before the Industrial Revolution, every operator generally produced the whole product himself and hence, was inspecting his own work after completing all the needed operations. However, the Industrial Revolution introduced the concept of specialization of labor, by which a worker made only a portion, or a single operation, and not the entire product. Since most products of this early period were not complicated, quality was not greatly affected. However, this necessitated inspection after each and every operation before the component moved on to the next operator. This initiated further controls as detailed below.

I. Operative Quality Control
II. Foreman Quality Control
III. Inspection Quality Control
IV. Statistical Quality Control
V. Total Quality Control

6.1 Operative Quality Control

● Prevalent during the medieval era, but became prominent after the Industrial Revolution.

● Number of products was less and individually made.

● Quality is judged by the workmanship and aesthetic appearance.

● Dimensional accuracy not given importance as there are hardly any mating or interchangeable components and Workers were trained in craftsmanship to achieve higher quality viz. Workmanship.

6.2 Foreman Quality Control

Until the 17th century as business increased, the foreman supervised the quality function more as a person controlling the work of several operatives. Quality conformance became one of his responsibilities. The concept of quality remained more or less the same as before. Here again, the dimensional accuracy is less critical than the functional quality, the workmanship, or the aesthetic appearance.

6.3 Inspection Quality Control

During the Industrial Revolution, which saw the emergence of mass production, manufacturing operations were being broken down to produce small components and then assembling them. Hence, a need arose to maintain dimensional accuracy leading to product inspection procedures, basically for dimensional accuracy. Initially this inspection was done by the operator himself or the supervisor on line inspection. This led to deployment of highly skilled, trained operators as inspectors for better quality standards, initially as a decentralized function of production.

Around this period, F.W. Taylor, who is called the *Father of Scientific Management*, put forward the principles of functional specialization for effective performance. This gave birth to the centralized inspection departments, who generally were performing 100% inspections at least for high value items.

6.4 Statistical Quality Control

In view of the small size of the component and the high volume of production by each operator, this inspection for each and every component and its operation became very expensive, more than the cost of manufacture. These facts led to developing the concept of SQC. The inspectors were, in any case, required to maintain records and data to justify the rejections they made. A study of these records revealed the statistical conformance of these values.

During World War II, due to very high demand of higher outputs in shorter duration, the managers started applying statistical principles in developing random inspection procedures based on the theory of probability to save

inspection time and to enhance the productivity. This also helped in determining the trend of the rejections leading to the development of control charts, etc. Walter A. Shewart of Bell Telephones is credited for this in 1924, when in his book *Economic Control of Manufactured Product* showed that productivity improves when variation is reduced. These charts enabled the correction of the process before the rejections occurred.

6.5 Total Quality Control

After the US bombing of Japan, the latter wanted to teach the Americans a lesson, not by driving them out, but by capturing American markets as explained in the next paragraph. The quality consciousness was developed as a national spirit among the Japanese workforce to achieve the above goal. Deming, an American quality expert was invited to Japan to study their production systems. He developed several principles, mostly adapted from traditional management principles and explained them in simple language, and terms that were easily understood and remembered by the Japanese workforce, helping to convert their quality consciousness to quality commitment as a national fervor.

7 QUALITY MANAGEMENT IN THE JAPANESE SCENARIO

Before World War II, Japan was not a highly industrialized nation. Most of the electrical and electronic goods were imported from the United States and Europe. So, Japan was playing second fiddle to the United States in commerce

and trade.

- Japan's decision to side with Hitler alienated them against the United States and Japan's raid on Pearl Harbor infuriated the United States, resulting in the dropping of atom bombs on Hiroshima and Nagasaki, one of the most inhumane acts ever committed in the history of mankind.

- Consequently, the Japanese wanted to pay back the Americans in their own coin.

- They knew it couldn't be in a war and hence, decided to beat the Americans in world trade, by producing more quality goods and capturing the international market currently rules by Americans. The Japanese being highly

patriotic by nature, this desire percolated into the minds of every national, specifically into all categories of personnel in Japanese industry.

- Higher productivity became the initial buzz word. Because it was realized higher productivity without quality products would take the nation nowhere, the subsequent buzz word was high quality production. Quality in all aspects

of manufacture was given high priority. As a first step, Japan sent a delegation of productivity personnel on a study

tour of the United States and then invited Deming as a consultant in quality improvement and training in Japan.

- While Deming's chief task was to lecture on quality control methods, he talked more on the theory of systems and cooperation and professed team spirit and more operative-level participation in shop floor decisions. This, in fact, being the very spirit of the Japanese, they paid more attention to his teachings, and it gave them a different approach to problem-solving than what they were following.

- Deming also professed that quality is more a management responsibility than the inspector's responsibility, and developed the systematic approach, the PDCA (Plan–Do–Check–Act).
- The whole quality revolution in Japan during the post-war era can be accredited to the above principle, as well as other practices, such as quality circles.

8 TQM Principles

Principle 1—Customer Focus

The first and prime principle of total quality management (TQM) is to focus on the customers who are buying the products and services as well as potential customers. Customers are the people who justify the quality of the products and services. So, the company needs to ensure that the customers will feel that they have spent their money on a quality product if it can last long to fulfil demands. You can exceed customer satisfaction only when you know their needs. So, successful companies align their objectives with the client's needs.

Principle 2—Leadership

Leadership is essential in maintaining unity among employees to achieve interdependent goals. Although there are mainly three types of leadership in the industry, the democratic leadership style is the best to perform well. Leaders can form a convenient environment to work effectively inside the organization, in which all employees work to achieve the organization's goal. So, leadership seems to be a significant principle of total quality management.

Principle 3—Involvement Of People

People from every level give their all-out efforts and dedication to the organization's profits. The total employee commitment enables the industry to develop products and raise sales growth. So, all the employees in the organization have to be well-trained, committed, and dedicated to achieving an interdependent goal on time. Additionally, the industry needs to create a responsive environment where every employee will be motivated to complete the task correctly. The employees' activeness, motivation, and retention can yield customer gratifications. The involvement of people can produce effective teamwork. Three types of cooperation are vertical, horizontal, and inter-organization.

Principle 4—Process Approach

The company needs to improve the process consistently to yield sound output. A good result from the processes approach can bring customer satisfaction. Hence, TQM focuses on the process approach to assure the quality of the product or service.

Principle 5—System Approach To Management

The total quality (TQM) highlights executing the strategy systematically. The industry makes a proper implementation plan, and they collect data while applying those processes. The International Organization for Standardization (ISO) describes this principle: "Identifying, understanding, and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives."

Principle 6—Continual Improvement

Continual improvement of the process is an essential step for every industry to make their customer satisfied. Therefore, TQM assists the company in keeping watching the constant improvement of the system to improve the service and product of the industry. Above all, continual improvement assists the company in achieving competitive advantages, and it is the most critical principle among the eight principles of TQM.

Principle 7—Factual Approach To Decision Making

A factual approach to decision-making is another crucial principle of TQM. It eases making decisions based on the information collected from data. Making a decision based on facts is an effective way to achieve customer satisfaction. This principle uses the actual method to collect and analyze data in order to make decisions for the company's progress.

Principle 8—Mutually Beneficial Supplier Relationships

Mutual beneficial supplier relationship is another important principle of total quality management for building rapport with suppliers. It is also called reciprocity. Usually, a business is conducted by multiple combined departments, and each of the departments is assigned individual tasks, although the function of these departments is interconnected. The total quality management process helps all sections work combined to achieve an interdependent objective. The company uses visual aids and flowcharts to understand how employees perform perfectly. Executing total quality management (TQM) is not easy; TQM represents a significant cultural shift, so the company needs to implement it slowly and accurately.

9 TEAM APPROACH

TQM stresses that quality is an organizational effort. To facilitate the solving of quality problems, it places great emphasis on teamwork. The use of teams is based on the old adage that “two heads are better than one. Using techniques such as brainstorming, discussion, and quality control tools, teams work regularly to correct problems. The contributions of teams are considered vital to the success of the company. For this reason, companies set aside time in the workday for team meetings.

Teams vary in their degree of structure and formality, and different types of teams solve different types of problems. One of the most common types of teams is the **quality circle,** a team of volunteer production employees and their supervisors whose purpose is to solve quality problems. The circle is usually composed of eight to ten members, and decisions are made through group consensus. The teams usually meet weekly during work hours in a place designated for this purpose. They follow a preset process for analyzing and solving quality problems. Open discussion is promoted, and criticism is not allowed. Although the functioning of quality circles is friendly and casual, it is serious business. Quality circles are not mere “gab sessions.” Rather, they do important work for the company and have been very successful in many firms.

10 THE SEVEN TOOLS OF QUALITY CONTROL

1. Cause and effect analysis
2. Flowcharts
3. Checklists
4. Control techniques including Statistical quality control and control charts.
5. Scatter diagram
6. Pareto analysis which means identification of vital few from many at a glance. This is used for fixing the priorities in tackling a problem.

7. Histograms.

10.1 Cause-and-Effect Diagrams

Cause-and-effect diagrams are charts that identify potential causes for particular quality problems. They are often called fishbone diagrams because they look like the bones of a fish. A general cause-and-effect diagram is shown in Figure 5-8. The “head” of the fish is the quality problem, such as damaged zippers on a garment or broken valves on a tire. The diagram is drawn so that the “spine” of the fish connects the “head” to the possible cause of the problem. These causes could be related to the machines, workers, measurement, suppliers, materials, and many other aspects of the production process. Each of these possible causes can then have smaller “bones” that address specific issues that relate to each cause. For example, a problem with machines could be due to a need for adjustment, old equipment, or tooling problems. Similarly, a problem with workers could be related to lack of training, poor supervision, or fatigue.

Cause-and-effect diagrams are problem-solving tools commonly used by quality control teams. Specific causes of problems can be explored through brainstorming.

The development of a cause-and-effect diagram requires the team to think through all the possible causes of poor quality.

10.2 Flowcharts

A flowchart is a schematic diagram of the sequence of steps involved in an operation or process. It provides a visual tool that is easy to use and understand. By seeing the steps involved in an operation or process, everyone develops a clear picture of how the operation works and where problems could arise.

10.3 Checklists

A checklist is a list of common defects and the number of observed occurrences of these defects. It is a simple yet effective fact-finding tool that allows the worker to collect specific information regarding the defects observed. The checklist in Figure 5-7 shows four defects and the number of times they have been observed.

It is clear that the biggest problem is ripped material. This means that the plant needs to focus on this specific problem—for example, by going to the source of supply or seeing whether the material rips during a particular production process. A checklist can also be used to focus on other dimensions, such as location or time.

For example, if a defect is being observed frequently, a checklist can be developed that measures the number of occurrences per shift, per machine, or per operator. In this fashion we can isolate the location of the particular defect and then focus on correcting the problem.

10.4 Control Charts

Control charts are a very important quality control tool. We will study the use of control charts at great length in the next chapter. These charts are used to evaluate whether a process is operating within expectations relative to some measured value such as weight, width, or volume. For example, we could measure the weight of a sack of flour, the width of a tire, or the volume of a bottle of soft drink. When the production process is operating within expectations, we say that it is "in control."

To evaluate whether or not a process is in control, we regularly measure the variable of interest and plot it on a control chart. The chart has a line down the center representing the average value of the variable we are measuring. Above and below the center line are two lines, called the upper control limit (UCL) and the lower control limit (LCL). As long as the observed values fall within the upper and lower control limits, the process is in control and there is no problem with quality. When a measured observation falls outside of these limits, there is a problem.

10.5 Scatter Diagrams

Scatter diagrams are graphs that show how two variables are related to one another. They are particularly useful in detecting the amount of correlation, or the degree of linear relationship, between two variables. For example, increased production speed and number of defects could be correlated positively; as production speed increases, so does the number of defects. Two variables could also be correlated negatively, so that an increase in one of the variables is associated with a decrease in the other. For example, increased worker training might be associated with a decrease in the number of defects observed.

The greater the degree of correlation, the more linear are the observations in the scatter diagram. On the other hand, the more scattered the observations in the diagram, the less correlation exists between the variables. Of course, other types of relationships can also be observed on a scatter diagram, such as an inverted. This may be the case when one is observing the relationship between two variables such as oven temperature and number of defects, since temperatures below and above the ideal could lead to defects.

10.6 Pareto Analysis

Pareto analysis is a technique used to identify quality problems based on their degree of importance. The logic behind Pareto analysis is that only a few quality problems are important, whereas many others are not critical. The technique was named after Vilfredo Pareto, a nineteenth-century Italian economist who determined that only a small percentage of people controlled most of the wealth. This concept has often been called the 80–20 rule and has been extended too many areas. In quality management the logic behind Pareto's principle is that most quality problems are a result of only a few causes. The trick is to identify these causes.

One way to use Pareto analysis is to develop a chart that ranks the causes of poor quality in decreasing order based on the percentage of defects each has caused. For example, a tally can be made of the number of defects that result from different causes, such as operator error, defective parts, or inaccurate machine calibrations.

10.7 Histograms

A **histogram** is a chart that shows the frequency distribution of observed values of a variable. We can see from the plot what type of distribution a particular variable displays, such as whether it has a normal distribution and whether the distribution is symmetrical.

In the food service industry the use of quality control tools is important in identifying quality problems. Grocery store chains, such as Kroger and Meijer, must record and monitor the quality of incoming produce, such as tomatoes and lettuce. Quality tools can be used to evaluate the acceptability of product quality and to monitor product quality from individual suppliers. They can also be used to evaluate causes of quality problems, such as long transit time or poor refrigeration.

Similarly, restaurants use quality control tools to evaluate and monitor the quality of delivered goods, such as meats, produce, or baked goods.

11 ISO Standards

The International Organization for Standardization (ISO), its central office located in Geneva, is the world's largest developer and publisher of international standards. It forms a platform for several countries to establish quality systems. It has a network of National Standards Institutes in 163 participating countries, including the Bureau of Indian Standards (BIS) of India. ISO standards are constantly advancing to meet the needs of growing sectors within the industry. The vast majority of the ISO international standards are highly specific to product, material, and process, ensuring regulation from start to finish.

11.1 NEED FOR QUALITY MANAGEMENT SYSTEMS

Quality management has become a way of life in the manufacturing sector, in fact, in every sector, whether service, logistic, road building, or any other sector, and its importance is widely understood. This calls for a quality management system for unified standards for evaluating the processes. Without a system in place to establish procedure, monitor progress, and evaluate performance, it is nearly impossible to consistently deliver a quality product to your customer.

11.2 ISO 9000 SERIES OF QUALITY STANDARDS

The ISO 9000 family addresses various aspects of quality management and contains some of ISO's best known standards. The standards provide guidance and tools for companies and organizations who want to ensure that their products and services meet customers' requirements, and that quality is consistently improved.

ISO 9000 was originally issued as a series of six internationally agreed-upon standards to guide and audit a company's quality management Practices. Named as ISO 9000, IS0 9001, ISO 9002, ISO 9003. ISO 9004and ISO 8402, each standard contains specific guidelines pertaining to a certain segment of quality-related activities.

These standards are the minimum acceptable level of standards that a supplier's quality management practices should meet, in or to receive the "ISO 9000 accreditation or certification".

11.3 ISO 9000 and TQM

ISO 9000 is not TQM but is a subcomponent of TQM and a good start of TQM path. ISO 9000 is only the minimum required quality standard that supplier must demonstrate to receive the ISO

9000 accreditation. TQM by contrast is much more comprehensive. TQM links quality customer satisfaction by requiring action on four essentials:

i. A strong customer orientation (internal and external in all activities in the organization).
ii. Top management's direct involvement in the delivery of quality.
iii. Total company-wide participation in the delivery of quality; and
iv. The systematic analysis of quality problems focused on continuous improvement of quality performance and the prevention of quality problems.

11.4 OBJECTIVES OF ISO 9000

Following are the five objectives of ISO 9000:

i. To achieve, maintain and seek to continuously improve product quality (including service in relationship to requirements).
ii. Improve the quality of operations to continually meet customers' and stakeholders' stated and implied needs.
iii. Provide confidence to internal management and other employees that quality requirements are being fulfilled and that improvement is taking place.
iv. Provide confidence to customers and other stakeholders that quality requirements are being achieved in the delivered product.
v. Provide confidence that quality system requirements are fulfilled.

11.5 ISO 9000 SERIES

ISO 8402: Terminology standard, provides definitions of all terms, is a comprehensive glossary:

ISO 9000: Helps companies determine which standard of ISO 9001, 9002 and 9003 applies.

ISO 9001: Outlines guidelines for companies that engage in design, development, production installation, and servicing of products or services.

ISO 9002: Similar to ISO9001, but excludes companies engaged in design and development.

ISO 9003: Covers companies engaged in inspection and testing.

ISO 9004: Ihe guidelines for applying the elements of the Quality Management System.

11.6 BENEFITS OF ISO 9000 CERTIFICATION

An organization must consider submitting to the compliance audit if customers demand certification as a condition of making any purchases. Many firms now demand this certification of suppliers, making it an important order qualifier. "International competition and customer demands. More specifically, three forces are boosting the impetus for ISO 9000 certification:" Market realities and perceptions.

11.7 ISO 14001

This standard provides organizations with the elements for an environmental management system (EMS), which can be integrated into other management systems to help achieve environmental and economic goals.

The basic approach to EMS is shown in Figure 1. It begins with the environmental policy, which is followed by planning, implementation and operation, checking and corrective action, and management review. There is a logical sequence of events to achieve continual improvement.

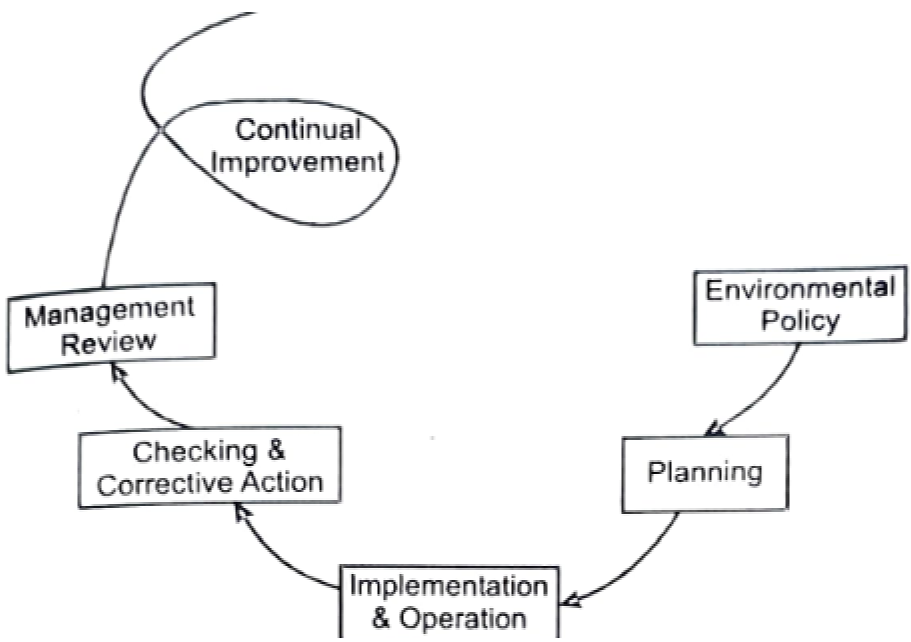


Figure 1: EMS Model

Chapter 4: Sales Management and Forecasting

Contents:
Introduction, types of forecasting, importance of demand planning, methods of sales forecasting, Qualitative and Quantitative methods of demand planning

4 INTRODUCTION

A forecast is an estimate of an event which will happen in future. The event may be demand of a product, rainfall at a particular place, population of a country, or growth of a technology.

The forecast value is not a deterministic quantity. Since, it is only an estimate based on the past data related to a particular event, proper care must be given in estimating it.

In any industrial enterprise, forecasting is the first level decision activity. That is the demand of a particular product must be available before taking up any other decision problems like, materials planning, scheduling, type of production system (Mass or batch production) to be implemented, etc.

So, forecasting provides a basis for coordination of plans for activities in various parts of a company. All the functional managers in any organization will base their decisions on the forecast value. So, it is a vital information for the organization. Due to these reasons, proper care should be exercised while estimating forecast values.

In business, forecasts may be classified into technology forecasts, economic forecasts and demand forecasts.

4.1 TYPES OF FORECASTS

i. **Technology Forecast:**

Technology is a combination of hardware and software. Hardware is any physical product while software is the know-how, technique or procedure. Technology forecast deals with certain characteristics such as level of technical performance, rate of technological advances. Technological forecast is a prediction of the future characteristics of useful machines, products, process, procedures or techniques. Based on the importance of this activity, Government of India has established a "Technology Information Forecasting and Assessment Council (TIFAC)", under the Ministry of Science and Technology to promote action oriented studies and forecasting in selected areas.

ii. **Economic Forecasts:**

Government agencies and other organizations involve in collecting data and prediction of estimate on the general business environment. These will be useful to government agencies in predicting future tax revenues, level of business growth, level of employment, level of inflation, etc. Also, these will be useful to business circles to plan their future activities based on the level of business growth.

iii. **Demand Forecast:**

The demand forecast gives the expected level of demand for goods or services. This is the basic input for business planning and control. Hence, the decisions for all the functions of any corporate house are influenced by the demand forecast.

5 IMPORTANCE OF DEMAND PLANNING

Demand planning is the process of predicting future customer demand. Effective demand planning can help in improving business productivity and profitability.

The advantages of Demand Planning are as follows:

i. **Improvement Forecast Accuracy:** Creating an accurate demand forecast can be extremely challenging. However, this is an essential component of demand planning and is a process that can be improved over time. When manufacturing organizations create demand forecasts and review them against actual demand, the accuracy of the generated forecasts will improve over time.

ii. **Manage Inventory Levels:** Demand planning can help manage the inventory levels to align with increases and decreases in demand. Incorporating demand forecasting strategies to actual demand signals will allow manufacturers to have the right number of items in stock. This ensures that you have enough materials and products when the demand for those items increases and prevents holding too many unnecessary items in stock when the demand decreases.

iii. **Improved Production Scheduling:** By predicting when sales are likely to happen, manufacturing organizations can better plan production scheduling, warehousing, and shipping. Being able to plan production in advance can help save costs. For example, the capacity plan can be used to identify the best time to conduct mandatory maintenance work on machines by avoiding periods where there are many orders scheduled. This will help save money as the production schedule can be optimized around the planned downtime and will help prevent unexpected machine breakdowns.

iv. **Optimize Labor Scheduling:** The labor costs represent one of the highest in manufacturing, it is important to know how many workers are required to complete orders on time. When there are too few workers during a period of high demand, your business will experience a decrease in fulfillment time and will have a reduced daily order completion rate. While having too many workers can be costly, it is important to be able to deliver on promises to maintain your customers' satisfaction levels high. As inventory management, forecasting, and production scheduling become more accurate, will lead to know how many workers will be required to complete the production orders in a timely manner.

6 METHODS OF SALES FORECASTING

The forecasting techniques can be classified into qualitative techniques and quantitative techniques.

i. Qualitative techniques use subjective approaches. These are useful where no data is available and are useful for new products.

ii. Quantitative techniques are based on historical data. These are more accurate, and computers can be used to speed up the process.

6.1 QUANTITATIVE FORECASTING TECHNIQUES

- Simple moving average
- Single exponential smoothing
- Double moving average
- Double exponential smoothing

- Simple regression
- Semi-average method
- Multiple regression
- Box Jenkins

6.2 QUALITATIVE FORECASTING TECHNIQUES

- Delphi type method
- Market surveys

6.3 MEASURES OF FORECAST ACCURACY

Demand forecast influences most of the decisions in all the functions. Hence, it must be estimated with the highest level of precision. Some common measures are inevitable to measure the accuracy of a forecasting technique. This measure may be an aggregate error (deviation) of the forecast values from the actual demands. The different types of errors which are generally computed are as presented below.

1. Mean Absolute Deviation (MAD)
2. Mean Square Error (MSE)
3. Mean Forecast Error (MFE)
4. Mean Absolute Percent Error (MAPE)

The formula for error is given below.

$$E_t = D_t - F_t$$

where D_t = Demand for the period t.

F_t = Forecast demand for the period t, and

e_t = Forecast error for the period t

6.3.1 MEAN ABSOLUTE DEVIATION (MAD)

It is the mean of absolute deviations of forecast demands from actual demand values. The MAD is sometimes called as the mean absolute error (MAE).

$$\text{MAD} = \frac{\sum_{t=1}^{n} |D_t - F_t|}{n}$$

where

D_t = Actual demand for the period t

F_t = Forecast demand for the period t

n = Number of time period used.

6.3.2 MEAN SQUARE ERROR (MSE)

Mean square error is the mean of the squares of the deviations of the forecast demands from the actual demand values. Usually the effects on operations of small errors are not serious. These errors may be smoothed out by inventory or overtime work. It will be difficult to have smoothed values for forecast even if there are few large errors. Consequently, a method of measuring errors that penalizes large errors more than small errors is sometime desired. The mean square error (MSE) provides this type of measure of forecast error.

$$\text{MSE} = \frac{\sum_{t=1}^{n} (D_t - F_t)^2}{n}$$

where

D_t = Actual demand for the period t

F_t = Forecast demand for the period t

n = Total number of errors used.

6.3.3 MEAN FORECAST ERROR (MFE)

Mean forecast error (MFE) is the mean of the deviations of the forecast demands from the actual demands.

$$\text{MFE} = \frac{\sum_{t=1}^{n} (D_t - F_t)}{n}$$

where

D_t = Actual demand for the period t

F_t = Forecast demand for the period t

n = Number of years (time period) used.

6.3.4 MEAN ABSOLUTE PERCENTAGE ERROR (MAPE)

Mean absolute percentage error (MAPE) is the mean of the percent deviations of the forecast demands from the actual demands.

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{|D_t - F_t|}{D_t} \times 100$$

6.3.5 SIMPLE MOVING AVERAGE

A simple moving average is a method of computing the average of a specified number of the most recent data values in a series. The formula for computing the simple moving average (SMA) is as follows.

$$M_t = \frac{1}{n}\{D_{t-(n-1)} + D_{t-(n-2)} + \cdots + D_{t-2} + D_{t-1} + D_t\}$$

where

M_t = Simple moving average at the end of period t (It is to be used as a forecast for period $t + 1$).

D_t = Actual demand in period t.

n = Number of periods included in each average.

Table 4.2 Three Months Moving Averages

Time (Month) (t)	Demand for Month (t)	Moving Average $M(t)$	Forecast F_t	Error e_t
1	95			
2	100			
3	87	94.00		
4	123	103.33	94.00	29.00
5	90	100.00	103.00	–13.00
6	96	103.00	100.00	– 4.00
7	75	87.00	103.00	–28.00
8	78	83.00	87.00	– 9.00
9	106	86.33	83.00	23.00
10	104	96.00	86.33	17.67
11	89	99.67	96.00	–7.00
12	83	92.00	99.67	–16.67

Mean Forecast Error (MFE) = –0.889

Mean Absolute Deviation (MAD) = 16.37

The values printed under column $M(t)$ are obtained as:

$$\text{Moving Average Period } (n) = 3$$

$$M\ (3) = (95 + 100 + 87)/3 = 94$$

$$M\ (4) = (100 + 87 + 123)/3 = 103.33$$

The forecast for period 13 would be:

$$F_{13} = M_{12} = 92$$

6.3.6 DOUBLE MOVING AVERAGE

Model:

Let the moving average period = n

First single moving average = $M_1(n)$

$$= \frac{(D_1 + D_2 + \cdots + D_n)}{n}$$

Subsequent single moving average for any period = $M_1(t)$

$$= M_1(t - 1) + \frac{[D(t) - D(t - n)])}{n}$$

First double moving average= $M_2(2n - 1)$

$$= \frac{M_1(1) + M_1(2) + \cdots + M_1(2n - 1)}{n}$$

Subsequent double moving average = $M_2(t)$

$$= M_2(t - 1) + \frac{M_1(t) - M_1(t - n)}{n}$$

Forecast for any future period Z from period $t(F_{t+Z}) = 2M_1(t) - M_2(t) + (2Z/(n - 1))\ [M_1(t) - M_2(t)]$

Table 4.4 Double Moving Averages

Time (Month)(t)	Demand $D(t)$	$M_1(t)$	$M_2(t)$	$F(t)$	Error
1	60				
2	70				
3	85	71.66			
4	60	71.66			
5	88	77.66	73.66		
6	68	72.00	73.77	85.66	–17.66
7	106	87.33	79.00	68.44	37.56
8	75	83.00	80.77	104.00	–29.00
9	86	89.00	86.44	87.44	– 1.44
10	124	95.00	89.00	94.11	29.89
11	122	110.66	98.22	107.00	15.00
12	87	111.00	105.55	135.55	–48.55

Explanation of solution.

$$n = 3$$

$$M_1(3) = (60 + 70 + 85)/3$$

$$= 71.66$$

$$M_1(4) = M_1(3) + (D(4) - D(1))/3$$

$$= 71.66 + (60 - 60)/3$$

$$= 71.66$$

Other single (simple) moving averages are calculated, in the similar way.

First double moving average = $M_2(2n - 1) = M_2(5)$

$$M_2(5) = (71.66 + 71.66 + 77.66)/3 = 73.66$$

$$M_2(6) = M_2(5) + [M_1(6) - M_1(3)]/3$$

$$= 73.66 + (72 - 71.66)/3 = 73.77$$

New forecast for period say 10, made as of period 9 is

$$F(9 + 1) = 2 * M_1(9) - M_2(9) + \{2 * 1/(3 - 1) * [M_1(9) - M_2(9)]\}$$

$$= 2 \times 89 - 86.44 + (1 * 2/(3 - 1))\ (89 - 86.44)$$

$$= 178 - 86.44 + 2.56$$

$$F(10) = 94.12$$

6.4 QUALITATIVE FORECASTING METHODS

6.4.1 DELPHI METHOD

Delphi method is a forecasting technique applied to subjective nature of demand values. In view of globalization in India, Indian companies will have difficulty in estimating the demand of their products mainly because of possible mixed reactions of customers towards various attributes of a specific product which is manufactured by multinational firms and indigenous firms. Under such a situation, one has to resort to subjective estimates. Technology forecasting is another example where there is no quantitative data based on which the future technology can be predicted.

In Delphi method of forecasting, several knowledgeable persons are asked to provide subjective estimates of demands or forecasts of possible advances of technology. The experts may provide several opinions. Based on the opinions of the experts, a consensus will be arrived at the demand of product/advances of technology. The essential precautions to be followed in this method are as follows:

• Panel members must be unknown to each other.

• The initial questionnaire should be unambiguous, and it should explain every matter about which opinion is sought.

After getting the opinions from the panel members, they are to be compared for similarity. If the variation among the opinions is too much, the summary of opinions is to be circulated again among the members without mentioning the names of persons who provided the opinions. Generally, 50 per cent of the estimate is treated as the basis for comparison. The panel members whose opinions differ significantly from the middle 50 per cent of the estimate will be asked to reconsider their opinions. Still, if they want to stick to their original opinions, they will be asked to provide rationale for the same.

So, the Delphi method is an iterative process until the panel converges on a specific value or a range of values as defined by the required accuracy or arrives at a consensus on the matter under consideration.

Chapter 5: Materials Handling and management

Contents:
Principles of material handling, material handling equipments, material requirement planning, objectives of materials management, purchasing, vendor selection, JIT in purchasing, supply chain management.

5 INTRODUCTION

Materials handling systems are responsible for moving materials from one stage of production to another and thus is very important concept of product management. Materials handling includes moving, packaging and storing all the materials used by a firm. The materials handling system is judged by how well it serves the production process and how economical it is.

With the development of technology, a variety of materials handling equipments have been developed to economize costs, lessen the monotony and effort of the workers, improve the safety for men and materials and improve the overall productivity. Such equipments range from hand trolleys to automatic devices for handling a variety of products and materials. The design of the plant layout and the materials handling system are clearly interlinked and the design of one affects the other.

5.1 Unit Load Concept

The materials are shipped from a given source to a given destination in batches consisting of certain number of pieces or certain quantity in each trip. Again, for the purpose of handling within a given work area, loading to a material handling equipment and unloading from a material handling equipment, ***there must be a limit on the number of pieces in the case of discrete items or a limit on the quantity (weight) of materials in the case of continuous materials to be picked and placed simultaneously while loading and unloading the materials.***

In this process, ***the batch of materials which are placed at particular destination should retain its original shape and size before picking. The optimal shape and size of the bulk of material which will retain its original shape and size even after unloading is called as unit load.***

5.2 Principles of Materials Handling

Some of the important principles of materials handling are listed below.

1. All materials to be handled mechanically from the inbound raw materials stage to the outgoing finished goods stage.

2. Heavy loads must be handled mechanically.

3. Avoid mixing materials which require future sorting.

4. Transfer of materials from one container to another should be done mechanically.

5. Hot and hazardous materials must be handled mechanically.

6. Unit load concept must be followed. The larger the size of the unit load, the greater the economy.

7. Use of overhead space for conveyers and for stocking materials to be stored must be encouraged.

8. Materials are to be moved in a straight line to the extent possible. Minimum number of changes in the direction while moving materials is preferable.

9. Avoiding floor contact of materials is preferable. Pallets can be used for this purpose.

10. Gravity feed must be taken into advantage wherever feasible.

11. Pick and place of materials within operations and in transit should be infrequent.

5.3 Materials Handling Equipments

The materials handling equipments can be classified into the following categories.

• Fixed path equipments

• Variable path equipments

• Auxiliary equipments

5.3.1 Fixed path equipments.

The fixed path equipments are as listed below.

(a) Conveyers • Belt conveyer • Roller conveyer • Screw conveyer • Bucket conveyer • Pneumatic conveyer • Gravity conveyer

(b) Cranes and Hoists • Overhead travelling crane • Gantry crane • Jib crane • Hoist • Stacker crane • Monorail

5.3.2 Varied path equipments.

The equipments that can be included in this category are listed below.

• Lift truck • Platform truck • Hand stacks • Tractors • Hand trolleys

5.3.3 Auxiliary equipments.

These can be classified into the following categories. • Pallets, skids • Containers • Lift truck attachments • Loaders and unloaders • Ramps

Sample Questions

30. The optimal shape and size of the bulk of material which will retain its original shape and size even after unloading is called as ____________.
    (a) Cubical load (b) Rectangular load
    (c) Unit load (d) None of the above
31. Pallets are used to avoid ____________ contact.
    (a) Floor (b) Wall
    (c) Machine (d) None of the above
32. ____________ is a fixed path equipment.
    (a) Lift truck (b) Ramps
    (c) Hand trolleys (d) None of the above
33. ____________ is a varied path equipment.
    (a) Platform truck (b) Belt conveyor
    (c) Jib crane (d) None of the above
34. Ramp is an ____________ equipment.
    (a) Fixed path (b) Varied path
    (c) Auxiliary (d) None of the above
35. Overhead travelling crane is a ____________ equipment.
    (a) Fixed path (b) Varied path
    (c) Auxiliary (d) None of the above

6 MATERIAL REQUIREMENT PLANNING (MRP)

MRP is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy master schedule requirements.

In reality, many times we encounter products with sub-assemblies and components. The concept of inventory control and its categories that are applied to independent items. The conventional concept of inventory control cannot be applied to this type of dependent products as such without modifications.

6.1 Inputs to MRP

The basic inputs for MRP are as listed below.

• Product structure or Bill of Materials (BOM)

• Master Production Schedule for the final assembly

• Economic Order Quantity or [Carrying cost and setup cost details]

• Beginning inventory

6.1.1 Bill of Materials (BoM)

The parts/components requirements of the final product which is to be manufactured is usually presented in the form of a Product Structure/Bill of Materials. It is a listing of all components (sub-assemblies and materials) that go into an assembled item. It frequently includes the part numbers and quantity required per assembly.

6.1.2 Master Production Schedule for the final assembly

The master production schedule gives particulars about demands of the final assembly for the periods in the planning horizon. These are known as projected requirements of the final assembly.

A master production schedule (MPS) is a product-wise plan for manufacturing products.

It specifies

(1) the sizing and timing of production orders for specific items,

(2) the sequencing of individual jobs and

(3) the short-term allocation of resources to individual activities and operation.

6.1.3 Economic Order Quantity or [Carrying cost and setup cost details]

The order size at which the total cost is minimum is called Economic Order Quantity (EOQ). The Economic Order Quantity (EOQ) is calculated based on the set-up cost and carrying cost.

7 OBJECTIVES OF MATERIALS MANAGEMENT

i. **Low Prices:** If materials department succeeds in reducing the price of items it buys, it contributes in not only reducing the operating cost but also in enhancing the profits.

ii. **Lower Inventories:** By keeping inventories low in relation to sales, it ensures that less capital is tied up in inventories. This increases the efficiency with which the capital of the company is utilized resulting in higher return on investment. Storage and carrying costs are also lower.

iii. **Reduction in Real Cost:** Efficient and economical handling of materials and storage lowers the acquisition and possession cost resulting in the reduction in the real cost.

iv. **Regular Supply:** Continuity of supply of materials is essential for eliminating the disruption in the production process. In the absence of regular supply of materials, production costs go up.

v. **Procurement of Quality Materials:** Materials department is responsible for ensuring quality of materials from outside suppliers. Therefore, quality becomes the single most objective in procurement of materials.

vi. **Efficient handling of Materials:** The effective material control techniques help the efficient handling of materials resulting in the lowering of production cost.

vii. **Enhancement of firm's goodwill:** Good relations with the suppliers of materials enhance the company's standing in society as well as in the business community.

viii. **Locating and developing future Executives:** Materials manager must devote special effort to locate men at lower position who can take up the executive posts in future. It helps in developing talented personnel who are ready to undertake future responsibilities of the business relating to materials management.

Secondary Objectives:

The following are the important secondary objectives of materials management.

1. Reciprocity:

The purchase of raw materials from the organization's/customer's by the concern and in turn, sale of finished products to the above customers is known as reciprocity. It serves the twin purpose of increasing purchasing as well as sales.

2. New Developments:

The staff of the materials department deals regularly with the suppliers responsible for new developments in material handling. These developments can be successfully applied in material handling and management.

3. Make or Buy Decisions:

The material manager with regular reviews of cost and availability of materials can safely conclude that whether the material is to be purchased or developed in the organization itself.

4. Standardization:

Standardization of materials is greatly helpful in controlling the material management process. With regular stock-taking, the non-standardized items can be rejected and standard components may be brought into product designs to reduce the cost of production. It is further helpful in promoting the standardization with suppliers.

5. Assistance to Production department:

By supplying the standardized materials or components to the production department, quality products can be assured. It is helpful in imparting the economic knowledge in bringing about the desired improvement in the product.

6. Co-operation with other departments:

Successful management of materials department contributes to the success of every other department in the organization. At the same time the success of materials department depends on how successful it is in getting the co-operation of the staff of the other departments.

7. Conception of future outlook:

The materials manager must have some conception of future outlook for prices, cost and general business activity. Forecasting can be made about the future trends in materials. The materials manager should be able to foresee the prices and costs of the raw materials and general business conditions through their daily contracts with the suppliers.

The different functions of materials management are materials planning, purchasing, receiving, stores, inventory control, scrap and surplus disposal.

8 PURCHASING

The objective of the purchasing function is to ensure continuity of supply of raw materials, subcontracted items and spare parts and at the same time reduce the ultimate cost of the finished goods. The different parameters of purchasing are as listed below:

• Purchasing items with right price.

• Purchasing items with right quality.

• Purchasing items at right time so that the items are available when needed.

• Purchasing items from right source. Here, the dependability of the vendors are estimated using vendor rating. The location of vendors, nature of items, mode of transportation, vendor's commitments to due dates, etc. should be taken into account.

• Purchasing items of right quantity. Generally, there is a trade-off between cost of ordering and cost of carrying inventory. Hence, orders should be placed with optimal quantity

9 VENDOR SELECTION

Vendor selection is an important task while sourcing either materials or procuring machineries in industries. The first step is to identify potential vendors who can supply the items. Let us consider the procurement of costly equipment. The objective of the procurement process is to buy the best equipment.

10 JIT IN PURCHASING

The primary goal of JIT is to achieve zero inventory within an organization as well as throughout the entire supply chain. This is achieved by questioning each and every aspect of stock at raw materials stores, in-process buffers, etc. This is primarily to find out important causes for unnecessary stock at various points. A detailed analysis of these causes would further breakdown the major causes into a wide range of reasons for holding excessive stock.

10.1 Basic Principles

In JIT, the key theme is to work without buffer stock/with minimal buffer stock. To achieve this objective, identify every point in the organization where buffer stocks normally occur. Then critically examine the reasons for such stock, if any.

A set of possible reasons for maintaining high stock is listed below:

- Unreliable or unpredictable deliveries
- Poor quality from suppliers
- Increased variety of materials
- Machine breakdown
- Labour absenteeism
- Frequent machine setting
- Variation in operators' capabilities
- Schedule changes
- Changing product priorities
- Product modifications

11 SUPPLY CHAIN MANAGEMENT.

The global competitiveness means that customer is supreme. The customer can source his goods and services from anywhere in the world. This objective can be met through proper supply chain management. The evolution of moving materials/products is from the conventional distribution to logistics management and then to the present-day supply chain management. Alternatively, one can call the supply chain management as the integrated logistics system.

A supply chain management encompasses all the facilities, functions and activities in producing and delivering of a product/service from suppliers to customers. In view of global competition, the objectives of supply chain are to:

- fulfil right product with right quality at right place and right time at the least cost.
- manage inventory efficiently

• support customer service and

• reduce cycle time.

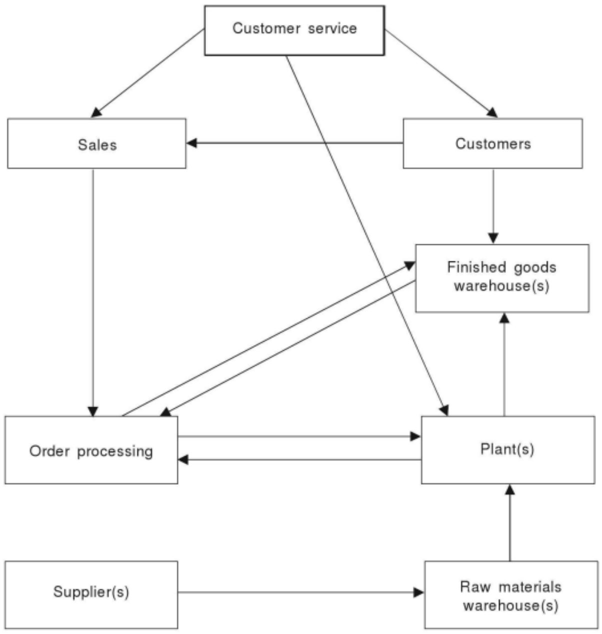


Figure 1: Supply Chain Network

A supply chain has two distinct functions namely, physical function and market function (Fischer, 1997). The physical function of a supply chain consists of converting raw materials into parts, components and finished goods, and transporting all of them from one point in the supply chain to the next point in it. The market mediated function ensures that the variety of products reaching the market place matches with the requirements of customers.

The physical function of the supply chain in turn has the following:

• Forecasting of product or service demand

• Selection of suppliers

• Procurement of materials

• Inventory control

The market mediation function of supply chain consists of the following (Russel, 1998).

- Scheduling production, shipping and delivery
- Great customer care service

Chapter 6: Business Organization and Forms of Ownership

Contents:
Introduction, Organization structure, good organization design, types of organizations, sole proprietorship, partnership.

1 INTRODUCTION

An organization is a group of individuals who work together to accomplish common goals and targets. It could be a private or public entity, such as a company, school, charity, government agency, etc., with a specific mission. Organizations register as businesses and pay taxes according to the rules and laws of the state or country.

2 CHARACTERISTICS OF GOOD ORGANIZATION

Following the characteristics of an organization

Clear Purpose and Goals: Organizations pursue a very specific mission or objective which serves as a guide to their entire existence.

Structure and Hierarchy: Organizational structure is used to define the roles of employees, the work that they do, and the chain of command in the organization. It sets out the reporting lines and communication channels that are to be used for coordinating and decision-making.

Division of Labor: Work is divided into tasks and distributed among the staff according to the level of their competence and specialty. Specialization facilitates the division of labor and leads to the development of more expertise but only to the extent coordination exists which ensures cooperation and integration.

Formalized Processes and Procedures: Companies create formalized procedures and processes to provide a standardized way of working and to ensure consistency. These include the ways of working, standards, and procedures for different tasks, for example, decision-making, project management, and quality assurance.

Culture and Values: The organizational culture is the sum of the values, beliefs, norms, and actions, which create identity and the way, in which employees act in the organization. It is how decisions are made, how people interact with each other, and how work is done, which is all influenced by technology.

Communication Channels: The way in which the communication paths operate is one of the most important factors for the transfer of information within the elements. These channels can be either formal (for instance, official memos, and meetings) or informal (for example, hallway conversations, and social events) and help in knowledge sharing, activity coordination, and relationship building.

Adaptability and Innovation: Organizations must be able to adjust to internal and external environment factors, for example, the trends in the market, technological advancements, and regulatory requirements. Stimulating innovation and ingenuity provides organizations with the ability to solve problems, take advantage of opportunities, and remain relevant.

Resource Management: Organizations can allocate a variety of resources, such as financial, human, physical, and technical ones, to reach their goals. Resource management, including allocation, use, and optimization, all play a critical role in the success of an organization.

Accountability and Responsibility: The existence of clear lines of authority and roles that define accountability and responsibility means that people are held accountable for their actions and decisions. This will certainly enhance transparency, trust, and ownership among employees.

Continuous Improvement: Organizations seek to improve continuously through regular assessment of their performance, searching for the areas to be enhanced and applying corrective measures. Through this process which is usually called "kaizen" (continuous improvement), the organizations evolve in the long run for the betterment of efficiency, quality, and effectiveness.

These characteristics collectively contribute to the identity, functioning, and success of organizations across various sectors and industries.

3 TYPES OF ORGANIZATIONS

On the basis of administrative procedures, there are three basic types of organization:

I. Line organizations
II. Line and Staff organizations
III. Functional organizations

3.1 LINE ORGANIZATIONS

It is the simplest form of organization. In this organization, the authority flows from top to bottom, i.e. the line of command is carried out from top to bottom. For this reason it is also known as scalar organization, this means scalar chain of command is a part and parcel of this type of organization.

The following are the characteristics of line organization:

1. It is the simplest form of organization.
2. Line of authority flows from top to bottom.
3. Specialized and supportive services do not take place in this organization.
4. Unified control by the line officers can be maintained since they can independently take
5. decisions in their areas and spheres.
6. This line of the organization always helps in bringing efficiency in communication and
7. bringing stability to a concern.

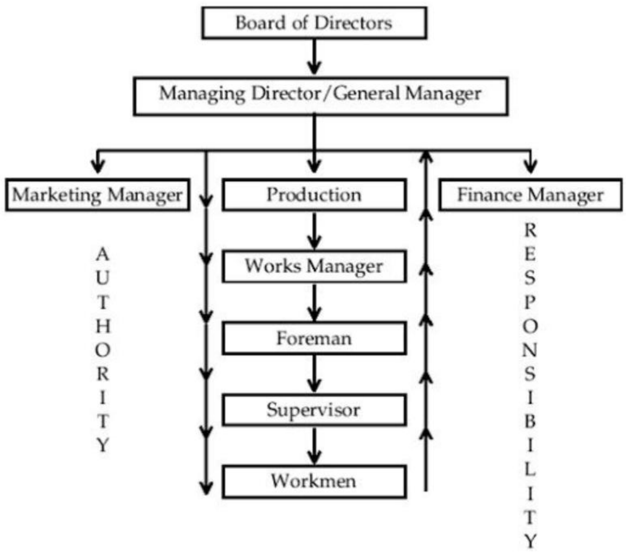


Figure 1: Line organization

3.1.1 Merits of Line Organization

1. **Simplest:** It is the simplest and oldest method of administration.
2. **Unity of Command:** In these organizations, superior-subordinate relationship is maintained and scalar chain of command flows from top to bottom.

3. **Strong discipline**: The control is unified and concentrates on one person and therefore, he can independently make decisions of his own. Unified control ensures better discipline.
4. **Fixed responsibility:** In this type of organization, every line executive has got fixed authority, power and fixed responsibility attached to every authority.
5. **Flexibility:** There is a co-ordination between the top most authority and bottom line authority. Since the authority relationships are clear, line officials are independent and can flexibly take the decision. This flexibility gives satisfaction of line executives.
6. **Quick decision**: Due to the factors of fixed responsibility and unity of command, the officials can make prompt decisions.

3.1.2 Demerits of Line Organization

1. **Over-reliance:** The line executive's decisions are implemented to the bottom. This results in over-relying on the line officials.
2. **Lack of specialization:** A line organization flows in a scalar chain from top to bottom and there is no scope for specialized functions. For example, expert advice, whatever decisions are taken by line managers, is implemented in the same way.
3. **Inadequate communication:** The policies and strategies which are framed by the top authority are carried out in the same way. This leaves no scope for communication from the other end. The complaints and suggestions of lower authority are not communicated back to the top authority. So, there is one way of communication.
4. **Lack of co-ordination:** Whatever decisions are taken by the line officials, in certain situations wrong decisions are carried down and implemented in the same way. Therefore, the degree of effective co-ordination is less.
5. **Authority leadership:** The line officials have a tendency to misuse their authority positions. This leads to autocratic leadership and monopoly in the concern.

3.1.3 Line and Staff organization

Line and staff organization is an extended form of line organization, and it is more complex than line organization. According to this administrative organization, specialized and supportive activities are attached to the line of command by appointing staff supervisors and staff specialists who are attached to the line authority. The power of command always remains with the line executives, and staff supervisors guide, advice and counsel the line executives.

The Personal Secretary to the Managing Director is a staff official. There are the following characteristics of line and staff organization:

1. There are two types of staff: (a) Staff Assistants- P.A. to Managing Director, Secretary to Marketing Manager. (b) Staff Supervisor-Operation Control Manager, Quality Controller, Public Relation Officer (PRO).
2. Line and staff organization is more complex than the line concern.
3. Division of work and specialization takes place in line and staff organization.
4. The whole organization is divided into different functional areas to which staff specialists are attached.
5. Efficiency can be achieved through the features of specialization.
6. There are two lines of authority which flow at one time in a concern: line authority and staff authority.
7. Power of command remains with the line executives and staff serves only as counsellors.

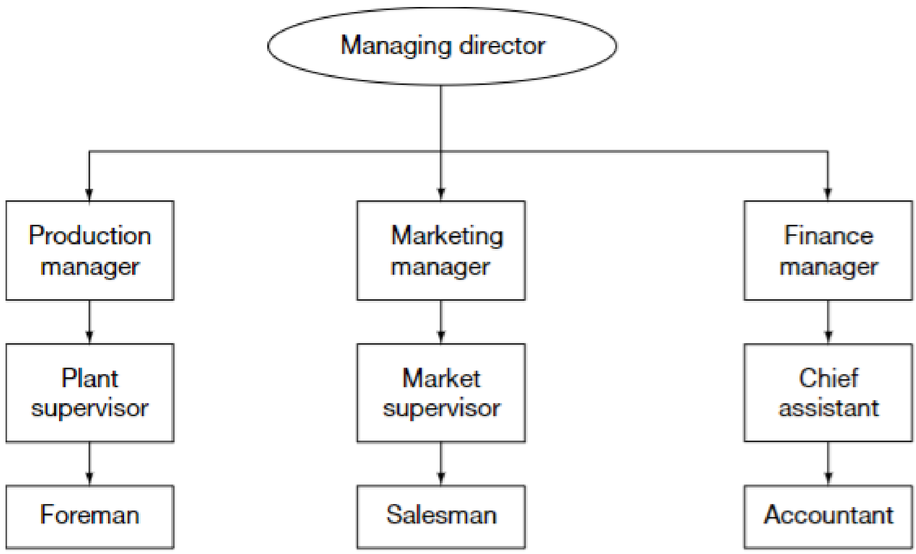


Figure 2: Line and Staff organization

3.1.3.1 Merits of Line and Staff Organization

There are the following merits of line and staff organization:

1. **Relief to line of executives:** In a line and staff organization, the advice and counselling which is provided to the line executives divides the work between the two. The line executive can concentrate on the execution of plans and they get relieved of dividing their attention to many areas.

2. **Expert advice:** The line and staff organization facilitate expert advice to the line executive at the time of need. The planning and investigation, which is related to different matters, can be done by the staff specialist and line officers can concentrate on execution of plans.
3. **Benefit of specialization:** Line and staff through division of the whole concern into two types of authority divides the enterprise into parts and functional areas. This way every officer or official can concentrate in its own area.
4. **Better co-ordination:** Line and staff organization through specialization is able to provide better decision-making and concentration remains in few hands. This feature helps in bringing co-ordination in work as every official is concentrating in their own area.
5. **Benefits of research and development:** Through the advice of specialized staff, the line executives get time to execute plans by taking productive decisions which are helpful for a concern. This gives a wide scope to the line executive to bring innovations and go for research work in those areas. This is possible due to the presence of staff specialists.
6. **Training:** Due to the presence of staff specialists and their expert advice serves as ground for training to line officials. Line executives can give due concentration to their decision-making. This in itself is a training ground for them.
7. **Balanced decisions:** The factor of specialization which is achieved by line staff helps in bringing co-ordination. This relationship automatically ends up the line official to take a better and balanced decision.
8. **Unity of action:** Unity of action is a result of unified control. Control and its effects take place when co-ordination is present in the concern. In the line and staff authority all the officials have got independence to make decisions. This serves as effective control in the whole enterprise.

3.1.3.2 Demerits of Line and Staff Organization

1. **Lack of understanding:** In a line and staff organization, there are two authorities flowing at one time. This results in the confusion between the two. As a result, the workers are not able to understand as to who their commanding authority is. Hence the problem of understanding can be a hurdle in effective running.

2. **Lack of sound advice:** The line official gets used to the expertise advice of the staff. At times the staff specialist also provides wrong decisions which the line executive has to consider. This can affect the efficient running of the enterprise.
3. **Line and staff conflicts:** Line and staff are two authorities which are flowing at the same time. The factors of designations, status, influence sentiments which relate to their relation, can pose a distress on the minds of the employees. This leads to disturbing the co-ordination which hampers a concern's working.
4. **Costly:** In line and staff concern, the concerns have to maintain the high remuneration of staff specialist. This proves to be costly for a concern with limited finance.
5. **Assumption of authority:** The power of concern is with the line official, but the staff dislikes it as they are the one more in mental work.

3.1.4 Functional organization

In this organization, the entire organization is divided into different functional departments such as marketing, finance, production, personnel departments, etc. The functional authority remains confined to functional guidance to their departments. This helps in maintaining the quality and uniformity of performance of different functions throughout the enterprise.

Following are the characteristics of functional organization:

1. The entire organizational activities are divided into specific functions such as operations, finance, marketing and personal relations.
2. A complex form of administrative organization compared to the other two.
3. Three authorities exist-Line, staff and function.
4. Each functional area is put under the charge of functional specialists and he has got the authority to give all decisions regarding the function whenever the function is performed throughout the enterprise.
5. The principle of unity of command does not apply to such organization as it is present in the line organization.

3.1.4.1 Merits of Functional Organization

1. **Specialization:** Better division of labour takes place, which results in specialization of function and its consequent benefit.

2. **Effective control:** Management control is simplified as the mental functions are separated from manual functions. Checks and balances keep the authority within certain limits. Specialists may be asked to judge the performance of various sections.
3. **Efficiency:** Greater efficiency is achieved because of every function performing a limited number of functions.
4. **Economy:** Specialization compiled with standardization facilitates, maximum production and economical costs.
5. **Expansion:** Expert knowledge of functional manager facilitates better control and supervision.

3.1.4.2 Demerits of Functional Organization

1. **Poor coordination:** The functional system is quite complicated to put into operation, especially when it is carried out at low levels. Therefore, co-ordination becomes difficult.
2. **Lack of command:** Disciplinary control becomes weak as a worker is commanded not by one person but a large number of people. Thus, there is no unity of command.
3. **Difficulty in fixing responsibility:** Because of multiple authorities, it is difficult to fix responsibility.
4. **Conflicts:** There may be conflicts among the supervisory staff of equal ranks. They may not agree on certain issues.
5. **Costly:** Maintenance of specialist's staff of the highest order is expensive for a concern.

4 FIRM'S OWNERSHIP

A firm is a group of people located in any premises or area, who do work and transform raw materials into goods and services with the help of tools and sell them. The firm may be industrial, commercial or financial. Firm's size and characteristics depend on the type of ownership. Some major types of firm's ownership are sole partnership, general partnership, limited partnership, limited liability partnership, corporation, joint stock company (private and public company), cooperative society, etc. The following type of ownerships will be discussed in detail.

- Sole Proprietorship
- Partnership

4.1 SOLE PROPRIETORSHIP/PARTNERSHIP

A sole proprietorship is the simplest form of business ownership. It is owned by a single person. The owner enjoys alone with the business's profits and losses. There is no liability protection for the owner. The owner is liable to pay all the debts. If the individual is sued and loses, the business and personal property may be seized to pay obligations.

The characteristics of sole partnership are enumerated as follows:

1. Sole proprietorships do not have perpetuity.
2. The proprietor may sell or quit the business.
3. The business does not need to be registered with the state.
4. The trademarks can be registered with the Secretary of State's office if desired.
5. A federal employer's identification number is not required as long as there are no employees.
6. The business income is taxed at the sole proprietor's individual tax rate.

The following are advantages and disadvantages of sole partnership:

4.1.1 Advantages

1. It is easy to start the business.
2. No documents are required to file with the state.
3. There is only one level of taxation.
4. Decision-making is easy.
5. One can discontinue his/her business at his/her will.

4.1.2 Disadvantages

1. No tax breaks are provided for company benefits.
2. The owner is liable for all debts incurred, i.e. unlimited liability.
3. The amount of capital investment one can raise is limited.

4.2 PARTNERSHIP

A partnership can be general partnership, limited partnership and limited liability partnership.

4.2.1 General Partnership

A general partnership is formed by two or more persons. Similar to a sole proprietorship, the partners are not separate from the business. Unless agreements/provisions have been established, each individual is responsible for all of the partnership's debt. Also, each partner can incur debton behalf of the business unless other provisions have been made. Each partner shares in the losses and profits of the business. Partnerships do not have perpetuity. When a partner leaves or dies, the business ends. As with a sole proprietorship, the general partnership does not need to be registered with the Secretary of State's office. The partnership does need a Federal Employer's Identification Number even if there are no employees. Characteristics of a general partnership are very similar to sole partnership.

4.2.1.1 Advantages of General Partnership

1. It is relatively easy to create.
2. Only one level of taxation is subjected.

4.2.1.2 Disadvantages of General Partnership

1. There are no tax breaks for company benefits similar to sole partnership.
2. Each partner is liable for debts incurred.
3. In case of death or quit, business may end.

4.2.2 Limited Partnership

One main difference between the general partnership and a limited partnership is that the limited partners' risk is reduced to the amount contributed to the partnership. The general partnership does not need any special registration, but a limited partnership certificate needs to be filed with the Secretary of State's office. Tax reporting and payment is carried out the same way as a general partnership. There are certain advantages and disadvantages of limited partnership as discussed below:

4.2.3 Advantages of Limited Partnership

1. There is limited risk to some partners.
2. It is relatively easier to create.
3. One level of taxation is possible.

4.2.4 Disadvantages of Limited Partnership

1. There is liability for debts incurred by partners.
2. The business owners are taxed as corporations under certain circumstances.
3. There are no tax breaks for company benefits.
4. There is no perpetuity of business.

4.2.5 Limited Liability Partnership

Limited liability partnerships are similar to other partnerships except that the partners have limited personal liability due to negligence, malpractice and conduct of partners not under immediate and direct control of a partner. The partnership is not free from liability due to debts or acts of partners under direct control of a partner. A limited liability partnership is designed to help the professionals who operate as a partnership and desire the limited liability protection afforded.

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