

KV INSTITUTE OF MANAGEMENT AND INFORMATION STUDIES
BA 5107 - TOTAL QUALITY MANAGEMENT

UNIT III - STATISTICAL PROCESS CONTROL

Meaning and significance of statistical process control (SPC) – construction of control charts for variables and attributed. Process capability – meaning, significance and measurement – Six sigma - concepts of process capability. Reliability concepts – definitions, reliability in series and parallel, product life characteristics curve. Total productive maintenance (TMP), Terotechnology. Business process Improvement (BPI) – principles, applications, reengineering process, benefits and limitations.

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INTRODUCTION

Statistical process control (SPC) is a method of quality **control** which uses **statistical** methods. SPC is applied in order to monitor and **control** a **process**. Monitoring and controlling the **process** ensures that it operates at its full potential.

Meaning of SPC

Statistical process control (SPC) may be defined as the application of statistical methods to the measurement and analysis of variation in any process. SPC is the application of appropriate statistical tools to processes for continuous improvement in quality of products and services, and productivity in the workforce.

Statistical process control (SPC) is the application of statistical techniques to determine whether the output of a process conforms to the product or service design. In SPC, control charts are used primarily to detect production of defective products or services or to indicate that the production process has changed and that products or services will deviate from their design specifications unless something is done to correct the situation.

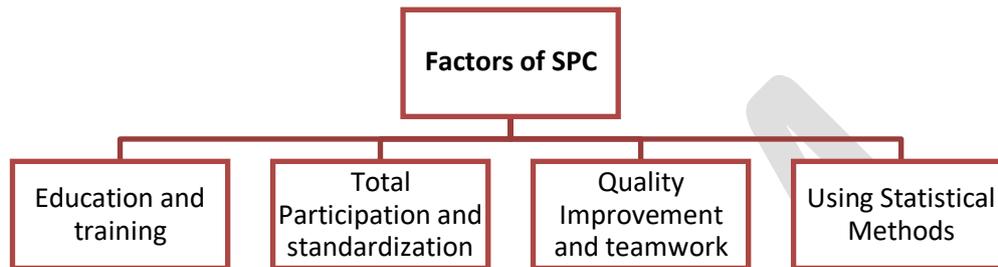
1 SPC system

SPC is for prevention of out-of-specification product, and it is not for detection or inspection. It is much more effective to avoid waste by not producing unusable output in the first place. In the past, the whole manufacturing process mainly depended on production to make the product, on quality control to inspect the final product, and screen-out items not meeting specifications, which is wasteful and costly. SPC is a feedback system for prevention

- 1) S(Statistical): By the help of statistical data and statistical analyzing methods
 - 2) P(Process): Understanding the present process capability and quality specifications
 - 3) C(Control): Control the quality to meet the specifications with minimum variations
-
- SPC is a methodology using control charts for assisting managers, supervisors and engineers to monitor the output from a process to identify and to eliminate various causes of variation
 - SPC is a proven technique for reducing scrap and rework, and hence increases productivity

- It provides the basis for determining process capability and predicting the yield from the process
- It helps to determine when to take action to adjust a process that is out control and when to leave the process alone.

The four major factors of SPC are as follows:



1) Education and training:

Education of statistical thinking, Quality control (QC) tools, SPC methods, and other scientific management methods such as Total Productive Maintenance (TPM), Just-In-Time, etc.,

2) Total participation and standardization:

Hundred per cent participation of all employees, self motivation atmosphere, suggestion system and full participation in making and observing standards

3) Quality improvement teamwork:

Small group activities such as quality circle, quality improvement team, taskforce-team and cross-functional team

4) Using statistical methods:

Proper use of statistical tools such as control charts, process capability index, reliability, correlation and regression methods, design of experiments, etc.

3 Elements of SPC system:



a) Process:

The whole combination of suppliers, design quality, input materials, manufacturing methods, manpower, measurement system, machines, environment that work together to produce output.

b) Information about process performance:

Information about the actual performance of the process can be learned by studying the process output. Quality measurement, evaluation and comparison of the produced output are necessary.

c) Diagnosis:

Diagnosis on the quality problems, and statistical analysis to find-out the causes of quality variations. The causes are divided into common and special causes.

d) Action on the process:

Actions based on the diagnostic results are required. For common causes, systematic action would be necessary by managers, and for special causes, action By people close to the process can be taken. Some adjustments may be necessary for design quality.

The objective of a SPC system is to provide a statistical signal when assignable causes of variation are present. Such signals can facilitate quick and appropriate action to eliminate assignable causes. SPC is a proven technique for improving quality and productivity. Many customers require their suppliers to provide evidence of statistical process control. Thus SPC provides a means by which a firm may demonstrate its quality capability, an activity necessary for survival in today's highly competitive markets. Because SPC requires process to show measurable variation within 3 sigma, it is ineffective for quality levels approaching six sigma. However, SPC is quite effective for companies in the early stages of quality efforts.

a) The inspection process

Many firms use quality inspection merely trying, often unsuccessfully to weed out the defectives before they reach the customers. This approach is doomed to failure because of internal and external failure costs. In contrast, world class companies combine early inspection with SPC to monitor quality and detect and correct abnormalities. Important decisions in implementing such a program include how to measure quality characteristics, what size of sample to collect and at which stage in the process to conduct inspection.

b) Quality measurements:

To detect abnormal variations in output, inspectors must be able to measure quality characteristics. Quality can be evaluated in two ways- to measure variables that is product or service characteristic such as weight, length, volume, area etc that can be measured. The advantage of measuring a quality characteristic is that if a product or service misses its

quality specifications, the inspector knows by how much. But such measurements involve special equipments, employee skills, exacting procedures and time and effort.

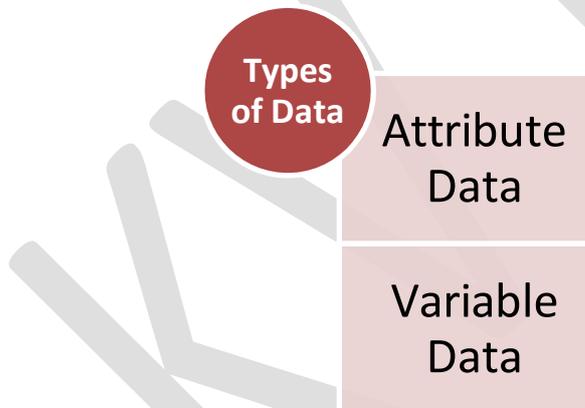
c) Statistical fundamental

The fundamentals of statistics are necessary to describe and to completely understand the SPC tools.

- Types of data
- Measures of central tendency
- Measures of dispersion
- Population
- Sample and sampling
- Normal curve

1) Types of data

In statistics, data can be categorised into two types:



- The data obtained by counting are discrete (or attribute) data while data obtained by actual measurement are continuous (or variable data).
- In other words, all qualitative characteristics are known as attributes and those characteristics that can be quantified and measurable are known as variables

Examples of attribute (or discrete) data:

- The number of defective pieces found in a sample
- Weekly number of accidents in a factory

Examples of variables (or continuous) data:

- (i) A dimension of a part measured
- (ii) Diameter of metal cylinders

2) Measures of central tendency

A measure of central tendency of a distribution is a numerical value that describes the central position of the data.

The three measures of central tendency generally used are:

1. Mean
2. Median
3. Mode

3) Measures of dispersion

The measures of central tendency locate the centre of the distribution. But they do not tell how the individual observations are spread on either side of the centre.

The three measures of dispersion generally used are:

1. Range
2. Mean deviation
3. Standard deviation

4. Population

- The word „population“ or „universe“ in statistics is used to refer to any collection of individuals or of their attributes or of results of operations.
- A population or universe can be defined as an unknown pattern of variation from which known sample has been drawn

5) Sample and sampling

- A part or small section selected from the population is called a sample and the process of such selection is called sampling
- The sample selected should resemble or represent the entire population

6) Normal curve

- The normal curve is the most important frequency curve. Normal curve is also known as Gaussian curve and Probability curve
- A normal curve is a symmetrical, unimodal, bell-shaped distribution with the mean, median and mode having the same value

- The normal distribution is fully defined by the population mean and population standard deviation

Significance of SPC

- 1) Provides surveillance and feedback for keeping processes in control
- 2) Signals when a problem with the process has occurred
- 3) Detects assignable causes of variation
- 4) Accomplishes process characterization
- 5) Reduces need for inspection
- 6) Monitors process quality
- 7) Provides mechanism to make process changes and track effects of those changes
- 8) Once a process is stable (assignable causes of variation have been eliminated), provides process capability analysis with comparison to the product tolerance

Uses of SPC

Statistical process control (SPC) is a methodology to monitor and benchmark a process to improve its variability, stability and capability. The control chart is the main tool in this methodology. Statistical process control can be used to:

- 1) Monitor and reduce process variability
- 2) Monitor and maintain the process on target
- 3) Determine when a process needs adjusting and when it does not
- 4) Establish process stability and detect process changes so that corrective action can be taken
- 5) Determine the capability of a manufacturing process to make product that conforms to specifications and monitor it online
- 6) Improve quality and productivity by improving the process, which reduces product inspection, scrap and re-work at the end of the line

Construction of control charts for variables and attributed

Control charts

- A control chart is a statistical technique for controlling the quality of a product being manufactured. It was first devised by Dr. Walter A. Shewart after whose name these charts are also called shewart charts. The main advantage of a control chart is that it can predict the rejects when they are likely to occur, which enables corrective action to be taken before a defective product is actually produced. It is based upon the fact that variability does exist in all the repetitive processes
- A control chart is a graphical representation of the collected information. The information may pertain to measured quality characteristics or judged quality characteristics of samples. It detects the variation in processing and warns if there is any departure from the specified tolerance limits.

- In other words, control chart is a device which specifies the state of statistical control, second a device for attaining statistical control, and third, a device to judge whether statistical control has been attained. The control limits on the chart are so placed as to disclose the presence or absence of the assignable causes of quality variation. This makes possible the diagnosis and correction of many production troubles and often brings substantial improvements in product quality and reduction of spoilage and rework.
- Moreover, by identifying certain of the quality variations as inevitable chance variations, the control chart tells when to leave the process alone and thus prevents unnecessarily frequent adjustments that tend to increase the variability of the process rather than to decrease it.
- With the help of a control chart it is possible to find out the natural capability of a production process, which permits better decisions on engineering tolerances and better comparisons between alternative designs and also between alternative production methods.

Characteristics of control charts

A control chart is a time-ordered diagram to monitor a quality characteristic, consisting of:

1. A nominal value, or centre line, the average of several past samples
2. Two control limits used to judge whether action is required, an upper control limit (UCL) and a lower control limit (LCL)

Objectives of control charts:

Control charts are used to analyze a process with a view to one or more of the following objectives:

- To secure information to be used in establishing or changing specifications or in determining whether a given process can meet specifications
- To secure information to be used in establishing or changing production procedures. Such changes may be either elimination of causes of variation or fundamental changes in production methods that may be called for whenever the control chart makes it clear that specifications cannot be met with present methods.
- They are used to provide a basis for current decisions during production as to when to hunt for causes of variation and take action intended to correct them, and when to leave a process alone. This is nearly always one of the purposes of any control charts for variables.

Benefits of control charts:

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Statistical process control plays a very important role during the effort for process improvement. Some of the important benefits that come from using control charts include:

- 1) Control charts are simple and effective tools to achieve statistical control. They can be maintained at the job station by the operator, and give the operator reliable information on when action should/should not be taken.
- 2) When a process is in statistical control, its performance to specification will be predictable. In this way, both the producer and the customer can rely on consistent quality levels and stable costs of achieving that quality level.
- 3) After a process is in statistical control, its performance can be further improved to reduce variation. The expected effort of proposed improvements in the system can be anticipated, and the actual effect of even relatively subtle changes can be identified through the control chart data. Such process, improvements will:
 - (i) Increase the percentage of output that meet customer expectations
 - (ii) Decrease the percentage of scrap or re-work
 - (iii) Increase the total yield of acceptable output through the process

Types of control charts

- **Control charts for variables**
- **Control charts for attributes**

Control charts for variables:-

- The quality characteristics which can be measured and expressed in specific units of measurement are called variables
- Control charts based upon measurements of quality characteristics are called as control charts for variables

Types of variable control charts : The most commonly used variable control charts are

- X bar or average charts
- R or range charts, and
- Standard deviation chart

Control charts for attributes:-

- Where the nature of product is such that the quality characteristic cannot be measured quantitatively, the items are classified only defectives and non-defectives at the time of final inspection. There can be a number of factors responsible for defining any item to be defective and the separate record for each cause may be out of question.

Types of attributes control charts used are:

- P chart
- Np chart

- C chart
- U chart

Process capability-meaning, significance and measurement.

The aim is to have a process where the product variability is sufficiently small so that all the products produced are within tolerance. Since variation can never be eliminated, the control of variation is the key to product quality and capability studies gives one tool to achieve this

Control limits Vs specification limits

- Control limits are determined using the averages. In other words, control limits are for averages
- Specifications are the permissible variation in the size of the part. In other words, specifications are for individual values. The specification (or tolerance) limits are provided by design engineers to meet a particular function.

Why do we need process capability analysis?

- The individual item may not be within the specified limits. So it necessary to see whether the process is capable of producing the items within the specified items. This can be achieved by carrying out the process capability.

Definition and purpose of process capability

Definition:

Process capability may be defined as the “minimum spread of a specific measurement variation which will include 99.7% of the measurements from the given process”.

In other words, Process capability = 6 standard deviation. Since 99.7% area is the normal curve is between -3 standard deviation to + 3 standard deviation, therefore process capability is equal to 6 standard deviation.

Process capability = 6 standard deviation is also called as natural tolerance.

The purpose of process capability analysis is:

- (i) To find out whether the process is inherently capable of meeting the specified tolerance limits.
- (ii) To indentify why a process „capable“ is failing to meet specifications

Method of doing process capability analysis

The procedure to do process capability analysis is as follows:

1. Calculate the average X bar and Range R of each sample
2. Calculate the grand average X Double bar. This measures the centring of the process.
3. Calculate the control limits and plot X bar and R charts. These control charts measure the stability of the process.

The term process capability refers to the inherent variability of process output relative to the variation allowed by the design specifications.

Process capability means ability of the process to meet technological or other requirements, to fulfil demands put on it. Process capability is a measure of variability of a process only due to „common causes“. It is measure of minimum variability that has to be tolerated in a process at a given period. Process capability can be improved by reducing the magnitude of variability in „common causes“ through various measures as already enumerated.

Process capability concepts

A capability study is a statistical tool which measures the variations within a manufacturing process. Samples of the product are taken, measured and the variation is compared with a tolerance. This comparison is used to establish how capable the process is in producing the product. Process capability is attributable to a combination of the variability in all of the inputs.

There are five occasions when capability studies should be carried-out, these are:

- 1) Before the machine / process is bought
 - 2) When it is installed
 - 3) At regular intervals to check that the process is given the performance required
 - 4) If the operating conditions change
 - 5) As part of a process capability improvement
4. Calculate the process capability. This process capability measures the piece to piece variability of the process

Six sigma concepts of process capability

- Six sigma stands for six standard deviation from mean (sigma is the Greek letter used to represent standard deviation in statistics)
- Six sigma, similar to zero defects (ZD), is a philosophical benchmark or standard of excellence proposed by Philip Crosby.

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- Six sigma methodology provides the techniques and tools to improve the capability and reduce the defects in any process
- It was started by Motorola in 1987, in its manufacturing division.
- Six sigma strives for perfection
- Six sigma improves the process performance, decreases variation and maintains consistent quality of the process output. This leads to defect reduction and improvements in profits, product quality and customer satisfaction.

Objectives of six sigma

- Six sigma quality levels are close to zero defects.
- Total customer satisfaction can be achieved with reliable products / services
- Reduction of cost is possible
- It gives higher yield
- Improved reliability
- The goal of six sigma quality programme is to improve customer satisfaction through reducing and eliminating defects and to continuously improve processes thereby improving quality and productivity.

Steps involved in the application of six sigma

The methodology of six sigma consists of DMAIC and DMADV cycle. Brief explanations of the same are as follows.

DMAIC cycle

- D-Define / Identify
- M-Measure
- A-Analysis
- I-Improvement
- C-control

Define / identify

The primary aim is to identify, within each sub-process, the possibilities for defects or quality problems which can be arrived at through the use of different statistical tools, such as regression analysis, design of experiments and chi-square testing. The quality problem which requires breakthrough solution has to be defined clearly in measurable terms. The

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problem selected should consider the requirements of the customer and should have relevance to the company's business. In other words, its solution should ensure great customer satisfaction as well as monetary gains / saving to the company. If the company has developed its business strategies, the problem should fall under any one of them. Defining a problem in manufacturing area is easier when compared to service areas.

Measure

The second most important step is the establishment of the metrics that will be improved using six sigma. It is also necessary to identify and rank the improvement opportunities. First the CTQ (Critical to Quality) characteristics of the process have to be identified in order to focus six sigma on areas that will have the greatest impact on customer satisfaction. For instance, design might turn out to contain the crucial CTQ in a manufacturing process while speed might be more relevant in the case of proceeding an order.

- The output of the process, measured as multiples of its sigma under each CTQ (existing quality level), has to be recorded so that defect per unit (DPU). These will be used as the starting points for setting new targets, and proceeding with the subsequent steps.

Analysis

- This is the stage at which new goals are set, and the route-maps created for the gap between current and target performance levels. It begins with benchmarking key product performance against the best-in-class so that the sigma levels attained by comparable processes can be ascertained as the basis for new targets.
- Then, a GAP analysis is conducted to identify the factors that distinguish best-in-class processes from those being analyzed so that the areas of change can be identified.

Improvement

- The objective of this phase is to confirm the key process variables and quantify their effects on the CTQ.
- Identify the maximum acceptable ranges of the specification; and then tackle the capability of the process
- If the existing quality level is 3 standard deviation, efforts must be directed to improve the processes so as to achieve at least 3 standard deviation.

Control

- The final stage of six sigma implementation is to hold the gains that have been obtained from the improve stage. Unless there is a good control we are likely to go back to the original state. Hence, in this stage the new process-conditions are documented, and frozen into systems so that the gains are permanent. The process is

assessed once more after the setting-in-period in order to check whether the improvements are being sustained or not.

- If a quality programmes have to achieve meaningful results, the changes have to be put into a formal structure. Workers may go back to the earlier processes.

DMADV cycle

- **D-Define**
- **M-Measure**
- **A-Analyze**
- **D-Design**
- **V-Verify**

Define:-

In the first step, you must define the design goals that are both consistent with your customer's demands and your own company's goals.

Measure:-

In this step, four things should be measured. They include, CTQ's which stand for Critical to qualities, production process capability, risk assessments and product capabilities.

Analyze:-

It is important to use the process of analysis to develop and design better alternatives that can reduce defects. These designs must be evaluated for their inherent capabilities to determine whether the design is the best available or if an alternative can be created which may be better.

Design details:-

In this step a design must be optimized to function at its peak. In addition, in order to optimize a design, a design must usually be verified. While verification is the last process, during the design details step, a design plan should be readied for the next step

Verification:-

Once a design has been analyzed and tested, it should be verified. Verification usually occurs through pilot runs. As a design is verified through the pilot run, it can be readied for full production.

Advantages of six sigma

A) Rapid and almost radical improvements:

Several of the quality initiatives of the earlier days such as quality circles, Kaizen and Quality Function Deployment are very necessary for an organization at all the times. However, by their very nature, these measures produce incremental improvements. In addition to these kinds of improvements, an organization in today's fast-changing business world needs improvements to be brought in very rapidly in order to match the pace of changing technologies and changing customer requirements. Six sigma is such an instrument of change, which can bring about radical changes in the way an organization functions.

B) Transforms the entire organization:

When six sigma is implemented, the entire organization in all its constituent parts is geared for absorbing rapid and radical changes. One cannot possibly bring in large changes in the past of the organization, without adequate measures in the other part. Six sigma initiatives make the management to take a closer look at the various functions and departments and the inter-relationships between them.

C) Provides a consistent metric:

- By its very nature, six sigma provides measures and targets that are quantifiable. Specific defects – deviations from the customer requirements – are identified and measured. Improvement performance is also measured. A consistently uniform measurability is one of its important distinguishing characteristics.
- Organizational changes are brought about by the implementation of six sigma. These transformations are general in nature. But, the improvements they generate can be and should be measurable against a yardstick. Six sigma uses „customer requirements“ as its yardstick.

D) Customer is always in focus:

The benefit of constant measurements is that the customer is always in focus with her requirements being the standard against which the measurements are done. Due to the presence of six sigma, an organization is always aware of the changes in the market.

E) Continuous improvement process:

Since six sigma is a measurement-based initiative, the organization that implements this initiative would have to constantly keep itself appraised of the customer's requirements. In short, a six sigma initiative never stops. It is forever. It is true that six sigma signifies radical improvement. But, a radical improvement system does not have to negate continuous improvement.

Disadvantage of six sigma

□ □ **Six sigma is ‘Exacting’ but not necessarily ‘Exciting’:**

For one, in this intensely competitive business world, quality-even six sigma or even literally zero defects quality-forms just the basic minimum. When a firm implements six sigma it is only trying to reach the level of customer’s expectations. This means, the firm is only trying to catch up with the competition. A customer is satisfied after the six sigma efforts; but, she may not be „delighted“ or „excited“, six sigma is good, but it does not „surprise“ the customer. While quality is about prevention of non-conformance, it is more so about delightfully surprising the customer.

□ □ **Detraction from ‘creativity’:**

Because six sigma believes in metrics-and-measures that detect / account for the minutes one in a million error, it is feared that, it may get caught in its own numbers trap.

There are organizations that innovate. There are organizations that do a perfect job as regards quality. Today’s business environment calls for an organization that is excellent in both these aspects. Though it seems like a tall order that is the need for a society that is ever evolving and is on a path to progress.

Reliability Concepts

Reliability concerns with the prediction of failures that may occur during the life of a product or service. Improving reliability has become an important part of the larger overall goal of improving product quality. It is agreed that an unreliable product is not a high-quality product. It is also emphasized that “reliability is quality over time”.

Definition:

Product reliability is defined as the ability of a product to perform a required function under stated conditions for a stated period of time

From the above definition, four significant element of product reliability can be identified.

They are:

- □ Probability
- Performance

- Time

- Conditions

Objectives of reliability engineering:

The important objectives of reliability engineering are:

- (i) To prevent failure;

- (ii) To provide economic benefits
- (iii) To assist with the optimization of operating availability
- (iv) To lower the maintenance and its costs to the customer; and
- (v) To minimize overdesign

Key terms relevant to the reliability concepts

1. Failure: a failure is „an inherent state of a system component in which an item is unable to perform its standard function“

2. Failure rate is the number of failures per unit time

3. Common cause failure: A common cause failure is one in which several failures can occur as a consequences of a common cause, e.g., loss of power supply

4. Availability: Availability is the probability that the system is ready to perform its stated task as and when required

5. Maintainability: Maintainability is the probability that a failed unit can be put back to satisfactory working condition within a given downtime

6. Redundancy: Redundancy is the existence of two or more means of carrying out a stated function in a given system.

- (i) **Active redundancy:** It applies when redundant units are functioning simultaneously rather than being switched on only at the moment of need
- (ii) **Standby redundancy:** A standby redundancy is when an alternative means of carrying out the function is switched on when the primary means of performing the function fails.

7. Mean Time To Repair (MTTR):

This is the average time to failure of a large sample of identical components or subsystems.

8. Mean Time Between Failures (MTBF):

This is the average time between successive failures of a system or a repairable component

9. Hazard

The hazard is expressed as the ratio of the number of failures in a given time interval to the number of “good” components remaining at the end of the interval.

Reliability in series and parallel

Reliability in series:

- The simplest and perhaps most common structure in reliability analysis is the series configuration. In the series case the functional operation of the system depends on the proper operation of all system components. A series string of christmas tree lights is an obvious example.

Reliability in parallel:

- In many systems several signal paths perform the same operation. If the system configuration is such that failure of one or more paths still allows the remaining path or paths to perform properly, the system can be represented by a parallel model.

Product life characteristics curve

In almost all cases the failure rate of a product changes with time. A product's failure rate is represented by the product life characteristic curve. Because of its shape, the product life characteristic curve is also known as a „bathtub curve“.

Product life characteristic curve

- Infant mortality period
- Useful-life period
- Wear-out period

Infant mortality period

- Infant mortality region, also known as burn-in region, the break-in region or the debugging region.
- The first stage of the curve shows a high failure rate, which rapidly decreases as a function of time. The initial high failure rate, known as infant mortality or the debugging stage.
- In this period, the failures are mainly due to weakness in the materials used, poor manufacturing methods or incorrect installation and start up.

Useful-life period

- This part of the curve is usually the longest and of the greatest interest in reliability studies.
- The failure rate over this region is reasonably constant and of low value
- The failures over this period occur randomly and are unpredictable e.g., failures due to safety factors, human error and natural failures.

Wear-out period

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- The final phase of the lifecycle curve is the wear-out phase of the equipment life. The failure rate rapidly increases as a function of time during this stage. By this point most equipment is probably fully depreciated, and now becomes a candidate for retirement, for use as back-up or may be cannibalized for spare parts. As long as it can be economically justified, the equipment's useful life can be extended and a proper and a proactive preventive and predictive maintenance program can delay the wear-out phase.

Total Productive Maintenance

Maintenance defined:

- Maintenance is defined as the management, control, execution, and quality assurance of activities which ensure the achievement of optimum availability and performance of a plant in order to meet business objectives.
- Maintenance is the activity to ensure the physical assets to continue to do what their users wanted to do

Total productive maintenance

- Total Productive Maintenance (TPM) is the systematic execution of maintenance by all employees through small group activities.
- TPM is a manufacturing led initiative that emphasizes the importance of people, a „can do“ and „continuous improvement“ philosophy. It also emphasizes the importance of production and maintenance staff working together.
- The dual goals of TPM are zero breakdowns and zero defects
- TPM improves equipment efficiency rates and reduces cost. It also minimizes inventory costs associated with spare parts.
- The implementation of TPM can generate considerable cost savings through increased productivity of the machinery.
- Thus the TPM is concerned with the fundamental rethink of business processes to achieve improvements in cost, quality, speed etc.
-

Goals of TPM

- 1) Improve equipment effectiveness:
- 2) Achieve autonomous maintenance:

Allow the people who operate equipment to take responsibility for at least some of the maintenance tasks. This can be at:

- (i) Repair level
- (ii) Prevention level
- (iii) Improvement level

3) Plan maintenance:

Have a systematic approach to all maintenance activities. This involves the identification of the nature and level of preventive maintenance required for each piece of equipment, the creation of standards for condition based maintenance, and the setting of respective responsibilities for operating and maintenance staff. The respective roles of operating and maintenance staff are seen as being distinct. Maintenance staff are seen as developing preventive actions and general breakdown services, whereas operating staff take on the ownership of the facilities and their general care.

4) Train all staff in relevant maintenance skills:

The defined responsibilities of operating and maintenance staff require that each has all the necessary skills to carry out these roles. TPM places a heavy emphasis on appropriate and continuous training

5) Achieve early equipment maintenance:

The aim is to move towards zero maintenance through maintenance prevention. Maintenance prevention involves considering failure causes and the maintainability of equipment during its design stage, its manufacture, its installation, and its commissioning.

Types of maintenance

The maintenance policies may be broadly classified into four categories.

Types of maintenance

1. Corrective or breakdown maintenance: It implies that repairs are made after the failure of machine or equipment. It says wait until a failure occurs and then remedy the situation as quickly as possible

2. Scheduled or routine maintenance: It is a stitch-in-time procedure aimed at avoiding breakdowns

3. Preventive maintenance: It is carried out before the failure arises or prior to the equipment actually breaks down

4. Predictive maintenance: In this technique, on the prediction of any fault, maintenance is being done.

Objectives of TPM

The five goals of TPM are:

1. To improve equipment effectiveness:- TPM examines the effectiveness of facilities by identifying and examining all losses, like down time losses, speed losses and defect losses

2. To achieve autonomous maintenance:

TPM allows the people who operated equipment to take responsibility of the maintenance tasks.

3. To plan maintenance:

TPM has a systematic approach to all maintenance activities. This involves the identification of the nature and level of preventive maintenance required for each piece of equipment, the creation of standards for condition-based maintenance, and the setting of respective responsibilities for operating and maintenance staff.

4. To train all staff in relevant maintenance skills:

TPM places a heavy emphasis on appropriate and continuous training to all operating and maintenance staffs.

5. To achieve early equipment management:

TPM aims to move towards zero maintenance through „Maintenance prevention (MP). TPM attempts to track all potential maintenance problems back to their root cause so that they can be eliminated at the earliest point in the overall design, manufacture and deployment process.

What are the 6 big losses?

- | | | |
|------------------|---------------------------|-------------------------------|
| 1. Break downs | 2. set up and change over | 3. Idling and minor stoppages |
| 4. Reduced speed | 5. Defects and rework | 6. start up losses |

Steps in TPM

Stage A: preparatory stage

Announcement by management to all about TPM introduction in the organization

- Initial education and propaganda for TPM
- Setting-up TPM and Departmental committees:
- Establishing the TPM working system and target:

Now each area is benchmarked and fix-up a target for achievement

Stage B: Introduction stage

This is a ceremony and one should invite all. Suppliers should know that we want quality supply from them. Some may learn from us and some can help us and customers will get the communication from us that we care for quality output.

Stage C: Implementation

In this stage eight activities are carried which are called eight pillars in the development of TQM activity. Of these, four activities are for establishing the system for

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production efficiency, one for initial control system of new products and equipment, one for improving the efficiency of administration and are for control of safety, sanitation as working environment.

Stage D: Institutionalizing stage

By these entire activities one would have reached maturity stage.

Benefits of TPM

Productivity

Productivity implies development of an attitude of mind and a constant urge to find better, cheaper, easier and safer means of doing a job, manufacturing a product and providing a service.

Quality

Quality is the measure of an organization to provide better acceptable products / services to the customer.

Cost:

A cost reduction programme means maximization of profits by reducing costs through economics and savings in the cost of manufacture, administration, selling, distribution and use.

Delivery performance:

Delivery performance is the ability of the supplier to provide the required type and the number of items according to schedule.

Safety:

Safety and hygiene constitutes the foundation stone of the preventive approach in achieving the goals of industrial health, as it deals with identification, assessment and control of environmental factors harmful to the health of employees.

Morale:

Morale is used to describe the overall group satisfaction. Small group activities in the factory should be based on participative management.

Work environment:

Quality of work life programme yields benefits such as improved inter communication better employer-employee relationships, better career development, reduced stress, high confidence and self management.

Competitive advantage:

Firms competitive advantage is defined not by cost alone but by the total time required to produce a product or service, dependable deliveries, rapid design changes, after sales services, rapid volume changes, consistent quality, loyalty and sustainable commitments towards customer's promises.

Tero technology

- A word derived from the Greek word "tero" or "I care", which is now used with the term "technology" to refer to the study of the costs associated with an asset throughout its life cycle-from acquisition to disposal

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- Tero technology is concerned with the application of managerial, financial, engineering and other skills to extend the operational life and increase the efficiency of equipment and machinery
- It is concerned with the reliability and maintainability of physical assets and also takes into account the processes of installation, commissioning, operation, maintenance, modification and replacement
- Tero technology is an integrated approach to cost control and encompasses all the cost elements starting from design and development of part or product upto its final disposal. It is concerned with plant design, manufacture of the plant and equipment, installation and commissioning of the same and subsequent maintenance and repairs and after sale, service with a view to achieve results at most economical levels.

Objectives of use of tero technology in TPM

The objectives of the use of principles of tero-technology are,

1. To minimize total lifecycle costs
2. Extend the useful life of the plant and equipment
3. Assure optimum availability of the installed equipment and
4. To ensure operational readiness at all times

Activities of terotechnology

These may thus consist of:

- (i) Decision regarding design, production and cost targets
- (ii) Decision as regards requirement of physical resources, plant, and equipment
- (iii) Considering requirements of plant and equipment from the point-of-view of production capability, reliability, environment control, safety of operations, decrease toxicity of materials and processes, and human aspects.
- (iv) Deciding on the specifications of the equipment to be procured from outside
- (v) Acquiring, installing and commissioning the plant and equipment and handing it over to the production department after carefully carried-out tests and inspection.

Benefits of terotechnology

- Better maintenance and higher reliability of plant and equipment
- Lower costs of maintenance and repairs
- Better control on spare part management
- Less breakdowns, lower breakdown costs and smooth, uninterrupted production

- Higher quality, better efficiency of operations, and high quality of work life
- Better image of the company amongst its customers
- Better communication between suppliers, producers and customers
- Higher prices can be fixed and greater profitability is possible

BUSINESS PROCESS REENGINEERING

“BPR is defined as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed.” The keywords in the preceding definition are the italicized ones.

BPR advocates that enterprises go back to the basics and reexamine their very roots. It doesn't believe in small improvements. Rather it aims at total reinvention. As for results: BPR is clearly not for companies who want a 10% improvement. It is for the ones that need a ten-fold increase.

BPR methodology

BPR employs a structured methodology that reduces work processes to their essential composite activities, and provides cost performance metrics to facilitate a business case for dramatic improvements. Both functional and cross-functional processes are evaluated through workflow analysis and activity based costing. In many cases, the application of new technology and industry best practices will enable quantum improvement in an organization's cost and performance.

Principles of business process reengineering

Reengineering is about achieving a significant improvement in process so that contemporary customer requirements of quality, speed, innovations, customization and service are met. This entails seven new rules of doing work proposed by hammer, relating to who does the work, where and when it is done and information gathering and integration. These seven rules are:

- Rule 1: Organize around outcomes, not tasks
- Rule 2: Have those who use the output of the process perform the process
- Rule 3: Merge information processing work into the real work that produces the information
- Rule 4: Treat geographically dispersed resources as through they work centralized
- Rule 5: Link parallel activities instead of integrating their results

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- Rule 6: Put the decision point where the work is performed and build control into the process
- Rule 7: Capture information once-at the source

Rule 1: organise around outcomes, not tasks

Several specialized tasks previously performed by different people should be combined into a single job. The new job created should involve all the steps in a process that creates a well-defined outcome. Organizing around outcomes eliminates the need for hand-off resulting in greater speed, productivity and customer responsiveness.

Rule2: Have those who use the output of the process perform the process

In other words, “work should be carried out where it is”, makes the most sense to do it. This results in people closest to the process actually performing the work, which shifts work across traditional intra and inter-organizational boundaries. For instance, employees can make some of their purchases without going through the purchasing department. Customers can perform simple repairs themselves and suppliers can be asked to manage parts in inventory.

Rule 3: Merge information processing work into the real work that produces the information

This means that people who collect information should also be responsible for processing it which greatly reduces errors by cutting the numbers of external contact points for a process

Rule 4: Treat geographically dispersed resources as though they work centralized

Centralized databases and telecommunication networks allow companies to link separate units or individual field personnel, providing them with economies of scale while maintaining their individual flexibility and responsiveness to customers.

Rule 5: Link parallel activities instead of integrating their results

The concept only integrating the outcome of parallel activities that must eventually come together is the primary cause of rework, high costs and delays in the outcome of the overall process. Such parallel activities should be linked continuously and coordinated during the process.

Rule 6: Put the decision point where the work is performed and build control into the process

Decision-making should be made part of the work performed. This is possible today with a more educated and knowledgeable workforce plus decision-aiding technology. Controls are now made part of the process

Rule 7: Capture information once-at the source

- Information should be collected and captured in the company's on-line system only once at the source where it is created. This approach avoids data entries and costly re-entries

Steps for BPR

Phase 1: Begin organizational change

- Assess the current state of the organization
- Explain the need for change
- Illustrate the desired state
- Create a communication campaign for change

Phase 2: Build the reengineered organization

The major activities of the second phase are given below:

- 1) Establish a BPR organizational structure
- 2) Establish the roles for performing BPR
- 3) Choose the personnel who will reengineer

Phase 3: Identify BPR opportunities

This phase consists of the following activities:

- 1) Identify the core / high – level processes
- 2) Recognize potential change – enablers
- 3) Gather performance metrics within the industry
- 4) Gather performance metrics outside the industry
- 5) Select processes that should be reengineered
- 6) Prioritize selected processes
- 7) Evaluate pre-existing business strategies
- 8) Consult with customers to know their desires
- 9) Determine customer's actual needs
- 10) Formulate new process performance objectives
- 11) Establish key process characteristics
- 12) Identify potential barriers to implementation

Phase 4: Understand the existing process

The main activities of the fourth phase are:

- Understand why the current steps are being performed
- Model the current process
- Understand how technology is currently used
- Understand how information is currently used
- Understand the current organizational structure
- Compare current process with the new objectives

Phase 5: reengineer the process

The major activities are:

- Ensure the diversity of the reengineering team
- Question current operating assumptions
- Brainstorm using change levels
- Brainstorm using BPR principles
- Evaluate the impact of new technologies
- Consider the perspectives of stakeholders
- Use customer value as the focal point

Phase 6: Blueprint the new business system

The activities of phase 6 are the following:

- Define the new flow of work
- Model the new process steps
- Model the new information requirements
- Document the new organizational structure
- Describe the new technology specifications
- Record the new personnel management systems
- Describe the new values and culture required

Phase 7: Perform the transformation

The activities of this last phase are:

- Develop a migration strategy
- Create a migration action plan
- Develop metrics for measuring performance during implementation
- Involve the impacted staff
- Implement in an iterative fashion
- Establish the new organizational structures
- Assess current skills and capabilities of workforce
- Map new tasks and skill requirements to staff
- Re-allocate workforce
- Develop a training curriculum
- Educate the staff about the new process

Applications of reengineering

- 1) Reengineering is applied to any business process
- 2) Hammer states that business process may be defined as a set of logically related tasks to achieve a defined business outcome. A set of processes forms a business system-the way in which a business unit or a collection of units carries out its business
- 3) Assuming that a company has decided that its processes are ineffective and inefficient, the following are the major steps the company should embark on to redesign its process according to hammer.

Develop business vision and process objectives: this step involves prioritizing objectives and setting targets for the future. A BPR vision statement describes the ideal state of a process

- 5) Identify processes to be redesigned; This involves identifying critical processes and envisioning the steps to avert shortcomings in them

Benefits of BPR

- Satisfaction:
- Growth of knowledge
- Solidarity to the company □
- Demanding jobs
- Authority

Limitations of BPR

70% of the BPR projects fail. Biggest obstacles that reengineering faces are:

- Lack of sustained management commitment and leadership
- Unrealistic scope and expectations
- Resistance to change
- Improper knowledge of reengineering
- Reengineering too many processes at initial stages.
- Lack of training for process owners and team members.
- Improper monitoring of a reengineered process.
- Wastage of time due to detailed process analysis.
- Fear of failure.
- Unfavorable organizational environment.
- Delay in achieving results.
- Unsatisfactory appraisal system.
- Inability to quantify improvement.