GE 6757 TOTAL QUALITY MANAGEMENT

LECTURE NOTES

UNIT 3

Five phases of achieving six sigma state, also
as DMAIC Process are :

① Define, ② Measure, ③ Analyze, ④ Improve, ⑤

The Six sigma organisation consists of :

1. Quality council / apex council
2. Sponsor
3. Champions
4. Master black belts
5. Black belts
6. Green belts
7. Team members

BENCHMARKING

Bench marking is defined as the process of ident
understanding, and adapting outstanding practies
processes from organisation any where in the w
an organisation to improve its performance

CLASSIFICATION OF BENCHMARKING

I. Based on the object to be benchmarked

Product benchmarking

SEVEN QC TOOLS

1. Flow chart
2. Check sheet
3. Histogram
4. Pareto diagram
5. Cause and effect diagram
6. Scatter diagram
7. Control chart

New Seven management tools and their purpose

Affinity (KJ) diagram

Relationship diagram

Tree diagram

Matrix diagram

Matrix data analysis

Decision tree (PDPC)

Arrow diagram (PERT)

SIX SIGMA

... is defined by GE as a vision of quality

3.1 Concept of Statistical Process Control

Definition of Statistical Process Control (SPC) :

A method of monitoring, controlling and, ideally, improving a process through statistical analysis. Its four basic steps include measuring the process, eliminating variances in the process to make it consistent, monitoring the process, and improving the process to its best target value.

Measure of Central Tendency and Dispersion

Step 1: Do you want to measure the disperison with in the data? Yes: Calculate the range (Highest value - Lowest Value)

Step 2: Do you want to know more about other observations in the data sets by avoiding the extreme values? Yes: Calculate the interquartile range (Q3-Q1)

Step 3: Do you want a better measure of the dispersion that takes every observation in to account: Yes: Calculate the variance of the population (to calculate Population variance each item in the population by the total number of items in the population. By squaring each distance we are converting the -ve values to the positive values and at the same time assigning more weightage to to the large deviations).

Step 4: Do you want to a measure of dispersion with more convenient units? Yes: Calculate the standard deviations where the standard deviation of the population is the square root of population variance.

Step 5: Do you want to know how many standard deviation a particular observation lies below or above the mean: Yes: Calculate the standard score of the population

Step 6: Do you want to know a relative measure of magnitude of the standard deviation as compared to the magnitude of the mean for use in comparing two distributions? Yes: Calculate the coefficient of variation

The arithmetic mean is found by adding the numbers and dividing the sum by the number of numbers in the list. This is what is most often meant by an average. The median is the exact middle number. Place them in order from least to greatest and see which number is in the middle. The mode is the most frequently occurring value on the list.

Measure of Dispersion Range = highest observation in a series – lowest observation in that series

Standard deviation It measures the spreading tendency of the data The smaller the deviation better the quality Formula for SD S = sample SD X = observed value X = average N = number of observed value

Population and Sample A population is any entire collection of people, animals, plants or things from which we may collect data. It is the entire group we are interested in, which we wish to describe or draw conclusions about. In order to make any generalisations about a population, a sample, that is meant to be representative of the population, is often studied. For each population there are many possible samples. A sample statistic gives information about a corresponding population parameter. For example, the sample mean for a set of data would give information about the overall population mean. It is important that the investigator carefully and completely defines the population before collecting the sample, including a description of the members to be included.

A sample is a group of units selected from a larger group (the population). By studying the sample it is hoped to draw valid conclusions about the larger group. A sample is generally selected for study because the population is too large to study in its entirety. The sample should be representative of the general population. This is often best achieved by random sampling. Also, before collecting the sample, it is important that the researcher carefully and completely defines the population, including a description of the members to be included.

3.2 Control Charts

Control charts, also known as Shewhart charts or process-behaviour charts, in statistical process control are tools used to determine whether or not a manufacturing or business process is in a state of statistical control.

A control chart is a statistical tool used to distinguish between variation in a process resulting from common causes and variation resulting from special causes. It presents a graphic display of process stability or instability over time.

Every process has variation. Some variation may be the result of causes which are not normally present in the process. This could be special cause variation. Some variation is simply the result of numerous, ever-present differences in the process. This is common cause variation.

Control Charts differentiate between these two types of variation.

One goal of using a Control Chart is to achieve and maintain **process stability**. Process stability is defined as a state in which a process has displayed a certain degree of consistency in the past and is expected to continue to do so in the future. .

There are two main categories of Control Charts, those that display ***attribute data***, and those that display ***variables data.***

Attribute Data: This category of Control Chart displays data that result from counting the number of occurrences or items in a single category of similar items or occurrences. These ―count‖ data may be expressed as pass/fail, yes/no, or presence/absence of a defect.

Variables Data: This category of Control Chart displays values resulting from the measurement of a continuous variable. Examples of variables data are elapsed time, temperature, and radiation dose.

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

Control Charts When the quality controls have to focus on a quality characteristic hard or expensive to measure on a numerical scale, the control chart for attributes are a useful alternative. Attributes concern quality characteristics which are able to be classified in two types, conform and not conform to specifications. What is called nonconforming means that the unit controlled is not conformed to standard on one or more of examined quality characteristics. The goal of control charts for variable is still to control mean and variability of a process but here, we focus of number of nonconforming units or nonconformities in a population. Three types of charts exist. Their use depends on the production (which quality characteristic to control, how many to examine), the characteristic of controls (constant or variable sample size):

The p-chart: it is a control chart for fraction nonconforming
The c-chart: it is a control chart for number of defects or nonconformities
The u-chart: it is a control chart for number of nonconformities per unit
The np-chart: Control chart for fraction nonconforming

The focus of the chart is the ratio of the number of nonconforming units in a population over the total number of units in this population.

Pi= Di/Ni

This fraction is called "p"
where : fraction of nonconforming
D : number of nonconforming units in the ith sample n : sample size of the ith sample p

The p-chart: Control chart for fraction nonconforming

The focus of the chart is the ratio of the number of nonconforming units in a population over the total number of units in this population. This fraction is called "p".

$$\hat{p}_i = \frac{D_i}{n_i}$$

where $\hat{p}$: fraction of nonconforming

D : number of nonconforming units in the ith sample

In general, m samples of n units are tested but the sample size can be either constant or variable. In the following, we study both cases.

1. For a constant sample size

Mathematical notions

If the sample size is constant, the formula for the value plotted on the p-chart is:

$$\hat{p}_i = \frac{D_i}{n}$$

The central line and control limits are computed as shown bellow:

To construct the p-chart, we plot the fraction nonconforming for each sample.

Central line

$$\bar{p} = \frac{\sum_{i=1}^{m} \hat{p}_i}{n}$$

Limits

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

The c-chart: Control chart for number of nonconformities observed

The focus of the chart is the number of nonconformities in a population. This number is called "c" and is directly plotted on a c-chart. In this case again, m samples of n units are controlled and the sample size can be constant or not.

For a constant sample size

Mathematical notions

The central line and control limits are computed as shown bellow:

Central line

$$\bar{c} = \frac{\sum_{i=1}^{m} c}{m}$$

Limits

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

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

The u-chart: Control chart for number of nonconformities per unit

The u- chart is often used for controls where the sample size is variable. It consists plotting the number of nonconformities per unit tested.

$$u_i = \frac{x_i}{n_i}$$

where u : average nonconformities per unit

x : number of total nonconformities in a sample

Mathematical notions

Here are formulas for control chart characteristics:

Central line

$$\bar{u} = \frac{\sum_{i=1}^{m} x_i}{\sum_{i=1}^{i=m} n_i}$$

Limits

$$UCL = \bar{u} + 3\sqrt{\frac{\bar{u}}{n_i}}$$

$$LCL = \bar{u} - 3\sqrt{\frac{\bar{u}}{n_i}}$$

The scheme for building a u-chart is the same than the one for other charts.

3.3 Process Capability

Process capability can be defined as the ability of a process to produce more uniform products with little variations. Process capability compares the output of an *in-control* process to the specification limits by using *capability indices*. The comparison is made by forming the ratio of the spread between the process specifications (the specification "width") to the spread of the process values, as measured by 6 process standard deviation units (the process "width").

3.4 Six Sigma

The Concept Six Sigma has evolved over the last two decades and so has its definition. Six Sigma has literal, conceptual, and practical definitions.

Features that set Six Sigma apart from previous quality improvement initiatives include

1. A clear focus on achieving measurable and quantifiable financial returns from any project.
2. An increased emphasis on strong and passionate management leadership and support.
3. A special infrastructure of "Champions," "Master Black Belts," "Black Belts," etc. to lead and implement the Six Sigma approach.
4. A clear commitment to making decisions on the basis of verifiable data, rather than assumptions and guesswork.

At Motorola University, we think about Six Sigma at three different levels:

1. As a metric
2. As a methodology
3. As a management system

DMAIC is commonly used by Six Sigma project teams and is an acronym for:

DMAIC - The basic methodology consists of the following five steps:

- **D***efine* process improvement goals that are consistent with customer demands and the enterprise strategy.
- **M***easure* key aspects of the current process and collect relevant data.
- **A***nalyze* the data to verify cause-and-effect relationships. Determine what the relationships are, and attempt to ensure that all factors have been considered.
- **I***mprove* or optimize the process based upon data analysis using techniques like Design of Experiments.
- **C***ontrol* to ensure that any deviations from target are corrected before they result in defects. Set up pilot runs to establish process capability, move on to production, set up control mechanisms and continuously monitor the process.

DMADV

The basic methodology consists of the following five steps:

- **D***efine* design goals that are consistent with customer demands and the enterprise strategy.
- **M***easure* and identify CTQs (characteristics that are **C**ritical **T**o **Q**uality), product capabilities, production process capability, and risks.
- **A***nalyze* to develop and design alternatives, create a high-level design and evaluate design capability to select the best design.
- **D***esign* details, optimize the design, and plan for design verification. This phase may require simulations.
- **V**erify the design, set up pilot runs, implement the production process and hand it over to the process owners.

Implementation roles - One of the key innovations of Six Sigma is the professionalizing of quality management functions. Prior to Six Sigma, quality management in practice was largely relegated to the production floor and to statisticians in a separate quality department.

Six Sigma identifies several key roles for its successful implementation.

- *Executive Leadership* includes the CEO and other members of top management. They are responsible for setting up a vision for Six Sigma implementation. They also empower the other role holders with the freedom and resources to explore new ideas for breakthrough improvements.
- *Champions* are responsible for Six Sigma implementation across the organization in an integrated manner. The Executive Leadership draws them from upper management. Champions also act as mentors to Black Belts.
- *Master Black Belts*, identified by champions, act as in-house coaches on Six Sigma. They devote 100% of their time to Six Sigma. They assist champions and guide Black Belts and Green Belts. Apart from statistical tasks, their time is spent on ensuring consistent application of Six Sigma across various functions and departments.
- *Black Belts* operate under Master Black Belts to apply Six Sigma methodology to specific projects. They devote 100% of their time to Six Sigma. They primarily focus on Six Sigma project execution, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma.
- *Green Belts* are the employees who take up Six Sigma implementation along with their other job responsibilities. They operate under the guidance of Black Belts.

3.6 Total Productive Maintenance

Total = Overall features for production
Productive = production of goods and services that meet expectation
Maintenance = Keeping the equipments and plant as good as new and working condition Goals of TPM Maintaining and Improving equipment capacity

Maintaining equipment for longer life Using support from all areas of operation Encouraging input from all employees Continuous improvement Improve
ment needs Machines expected to fail at one point or another – minimise that risk Employees who use and work that machine give the first hand information

Six major loss areas in terms of time Downtime loss

1. Planned – i) start ups ii) Shift change iii) tea / lunch breaks iv) planned maintenance
2. Unplanned – i) Equipment breakdown ii) changeovers iii)lack of materials
3. Idling and minor stoppages
4. Slow downs
5. Process change
6. Scraps Calculating Equipment Effectiveness

Downtime loss measured by equipment availability

A = (T/P) X 100 A – availability,
T – operating time (P – D),
P – Planned operation time
D- Downtime Performance efficiency
E = (CXN/T) X 100
E – Performance efficiency,
C – Theoretical cycle time,
N – Processed amount (qty) Rate of quality products
R = (N-Q/N)X 100 R – Rate of quality products,
N = Processed amount Q – nonconformities