Chapter II

Theoretical Consideration

At present, the manufacturing industry has higher rate of competition because of the globalization. To make the better decision for customers, quality, cost and time or delivery should be closely considered. Moreover, all of them are developed from the customer requirement and margin of the company. In this thesis, the categories in quality improvement section will be investigated.

The quality improvement is a part of the quality management. And the quality management can be leveled into four levels which are inspection, quality control, quality assurance and total quality management. Each level is differentiated by its scope of work and systematic of management as shown in fig. 2.1

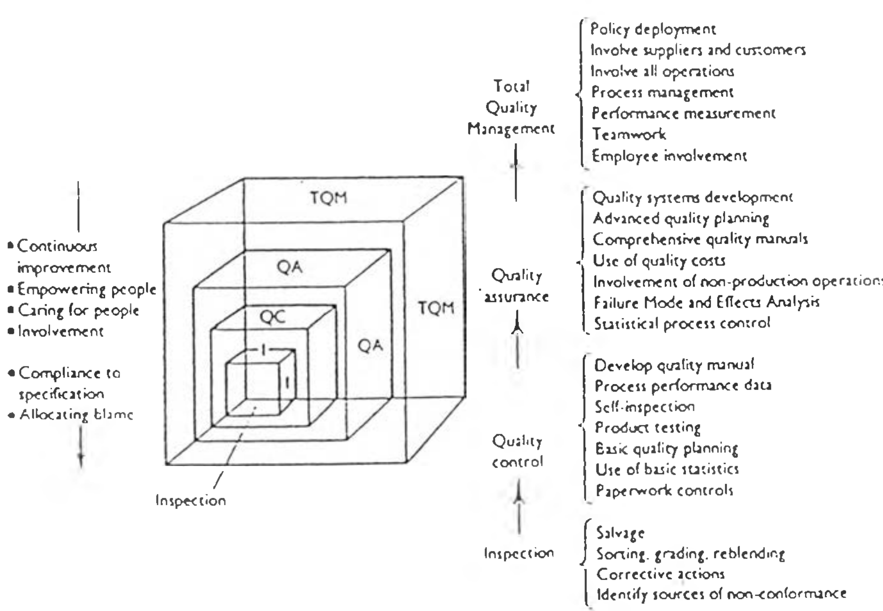

Fig. 2.1 The levels of quality management

Source: Barrie G. Dale, Managing Quality, Prentice Hall International Limited, 2nd edition, 1994, p.5

"Inspection: Activities such as measuring, examining, testing, gauging one or more characteristic of a product or service and comparing these with specified requirements to determine conformity" (BS.4778: Part1, 1987; ISO 8402, 1986)

The inspection is the base of quality management but it can only monitor the status of products by classification. For example: conformity product/ non-conformity product, OK/ NG. Another application of inspection graded the product to do corrective action such as rework, repair, regrade and reject.

"Quality control: 'the operational techniques and activities that are used to fulfil requirements for quality'." (BS.4778: Part1, 1987; ISO 8402, 1986)

Quality control is broader than inspection because it can monitor the situation of product and process. In term of systematic, the quality control has the basic of quality system to control and prevent the failure of product in process.

"Quality assurance: all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality." (BS.4778: Part1, 1987; ISO 8402, 1986)

The system of quality assurance emphasis on preventive action to detect and ensure that the non-conformity product must not be sent to customer by using specific tools and techniques. For example:

- Seven quality control tools
- Statistical Process Control (SPC)
- Failure Modes and Effects Analysis
- Mistake proofing, and etc.

"Total Quality Management: a management philosophy embracing all activities through which the needs and expectations of customer and the community, and the objectives of the organization are satisfied in the most efficient and cost effective way by maximizing the potential of all employees in a continuing drive for improvement."

(BS.4778: Part 2, 1991)

The total quality management system is the largest scope of quality management because it includes all levels together regarding expansion the system to everyone, which is suppliers and customers. The key elements of total quality management include these following topics

- Commitment and leadership of chief executive officer or top management
- Planning, strategies and organization
- Using tools and techniques
- Education and training
- Involvement
- Team working
- Measurement and feedback
- Culture change

QC 7 tools and techniques

The seven basic quality control tools is one technique that broadly used in manufacturing process because it is the powerful, practical and implemented tools. The 7 QC tools compose of these tools which are flow chart, check sheet, histogram, Pareto diagram, cause and effect diagrams, scatter diagram and control chart as shown briefly in table 2.1.

Table 2.1 The applications of 7 QC tools

Tool	Problem solving step	Description	Purpose	Method
Flow chart	Understanding the situation	Show steps in process by symbols	Show sequence of process	Use standard symbols show step by step of process
Check sheet	Finding facts	Form for collect data by groups of categories	Collect data	Design clarify topics and ease form for collect data
Histogram	Identifying problem	The chart shows data in divided classes in equal width of class or same unit	Show pattern in dispersion of sample data	Establish length of data and set divided class of equal width or same unit to show whole interest data
Pareto diagram	Identifying problems	Bar chart descends order from left with cumulative percent line	Identify significant of category	Frequency or amount on left and cumulative percent on right
Cause and effect analysis	Generating idea	Shows cause and effect relationship	Aids in identifying root cause and relate cause	Show the problem in right end and branches show the groups of causes
Scatter diagram	Developing solutions	Show variation and spread of sample data by dots from pattern	Show trend or relationship of sample data	Suspected cause on X-axis and effect on Y-axis
Control chart	Implementation	Show the moving of data in the control limit	Monitor the output of process	Separate types of charts for continuos and discrete data

1. Flow chart

The flow chart shows mapping or modeling of process by using a set of symbols that show all steps or stages in a process. Each symbol represents the activity in each process and shows the sequence of event and describes a process as an aid to examination and improvement.

Traditionally, the conventional symbols define activities in process such as operation, inspection, storage, transportation, decision and etc. as shown in fig 2.2

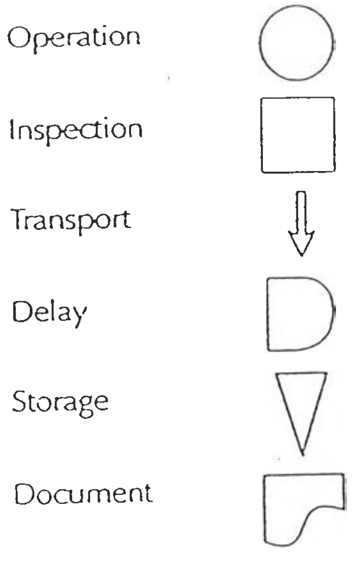

Fig.2.2 The conventional symbols and meaning by activities

The format of symbols may have some difference depends on the setting of each company. However, the importance of process flow is not the format of symbols. Basically, the flow chart is used to map out with key input, value-adding steps and key output to understand directly involve and responsible for initiation improvement. Another advantage of flow chart is easier to understand and analyze the irregular and potential problem points.

2. Check sheet

The check sheet is a form to record the raw data such as types of defects and amount of defect, category of problem and number of problem. The good form of check sheet should be simple and easy to determine the occurrence of event. To make the check sheet much more understandable and helpful to answer the key question, the application is to transform data into information data. In traditional, the main purposes of check sheet are the problem solving method and process improvement. For example: defective item checks, defect location checks, defect cause checks and etc.

3. Histogram

The histogram is the most broadly used tools because it is easy to present and understand for management. The applications of histogram are as same as the check sheet but there are some differences in the kind of data. In practical, the histogram is used with the variable data to show the pattern of variation displayed by dividing the range of data into the equal size of class.

The result of histogram can show the distribution of the data and pattern of variation. In fig. 2.3 show the sample of the shape of histogram.

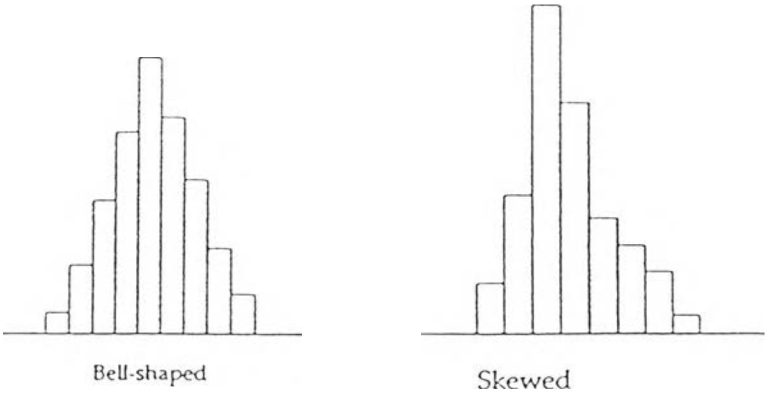

Fig. 2.3 The samples shape of the histogram

Each shape of the histogram explains the specific variation of process and data and indicates a problem in data collection method. But the correct conclusion of histogram needs sufficient sample sizes and appropriate method to collect datum, neither biased nor out of date.

4. Pareto diagram

This technique employs the priority of any type of problems such as quality, production, stock control and etc. The Pareto diagram ranks from the highest to the lowest significant of problems. It indicates what the first problem that should be corrected or solved and points the direction of solving coping the area of problem. In Pareto diagram, it represents the data by focusing on the major contributions to specific problem.

Pareto diagram shows the significant in primary Y-axis by amount or frequency, the accumulate line of percentage in secondary Y-axis and the causes or defects in X-axis as shown in fig. 2.4.

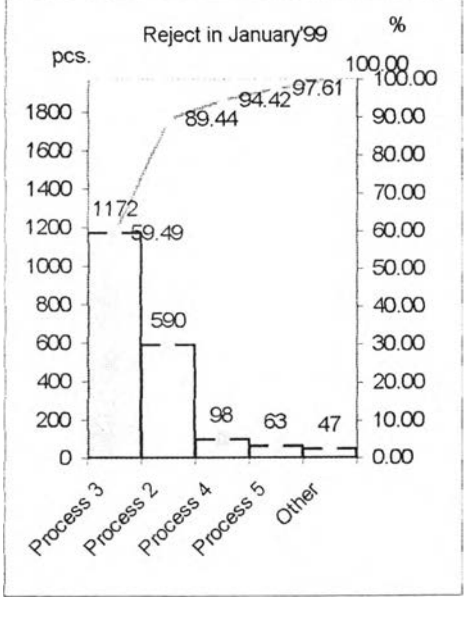

Fig. 2.4 The sample of Pareto diagram

5. Scatter diagram

The scatter diagrams are used to examine the relationship between two variables, characteristics or factors, causes and effects. These relationship may be difficult to show the exact patterns or standard patterns because the variation of data and the method of the data collection. In practical, the analytical data has much more than two relationship or multi-relations that make the conflict in analysis, so the scatter diagram should be used to compare between two relationships and distinction effects.

6. Cause and effect diagrams

Cause and effect diagrams were developed by Kaoru Ishikawa so they were often called Ishikawa diagrams. But the skeleton appearance looks like fishbone so sometimes it is known as fishbone diagrams. The cause and effect diagrams are used to determine and break down the main causes of problem by illustrating the possible relationship between some identified effect and causes. They can also identify the deep causes of a problem and generate generous idea.

The cause and effect diagrams can be divided into three types as

1. Five M (5M) cause and effect diagram

The main branches of diagram composed of 5 M, Machinery, Manpower, Method, Material and Measurement. But sometimes the teams cut one measurement off and used 4M diagram, while sometimes may add environment and so call 5M1E diagrams.

In case of in non-manufacturing area, they can use 4Ps (Policy, Procedure, People and Plant). But any types of cause and effect diagrams must be brought out the appropriate counter measure for identified and agreed major cause of problems.

2. Process cause and effect diagram

After mapping the flow chart, the process of cause and effect diagrams are used to seek and identify the potential causes and effects of the problem in each process or stage by using 4M, 5M and 5M1E format.

3. Dispersion analysis cause and effect diagram

This diagram is usually used after 4M, 5M and 5M1E diagrams to treat as separate branches and expand upon by the team.

7. Control chart

The control chart is used to display the output and the trends of processes during the period of time. In order to design the effective control chart, we should apply the statistic in it because there is specific characteristics in each point or process. So the control chart is usually applied with the statistical process control (SPC) to monitor and improve the process.

The result of control chart can illustrate about the cause of problems, common or special, from the run in the chart. The example of the run in chart shows the irregular of process as shown in fig. 2.5.

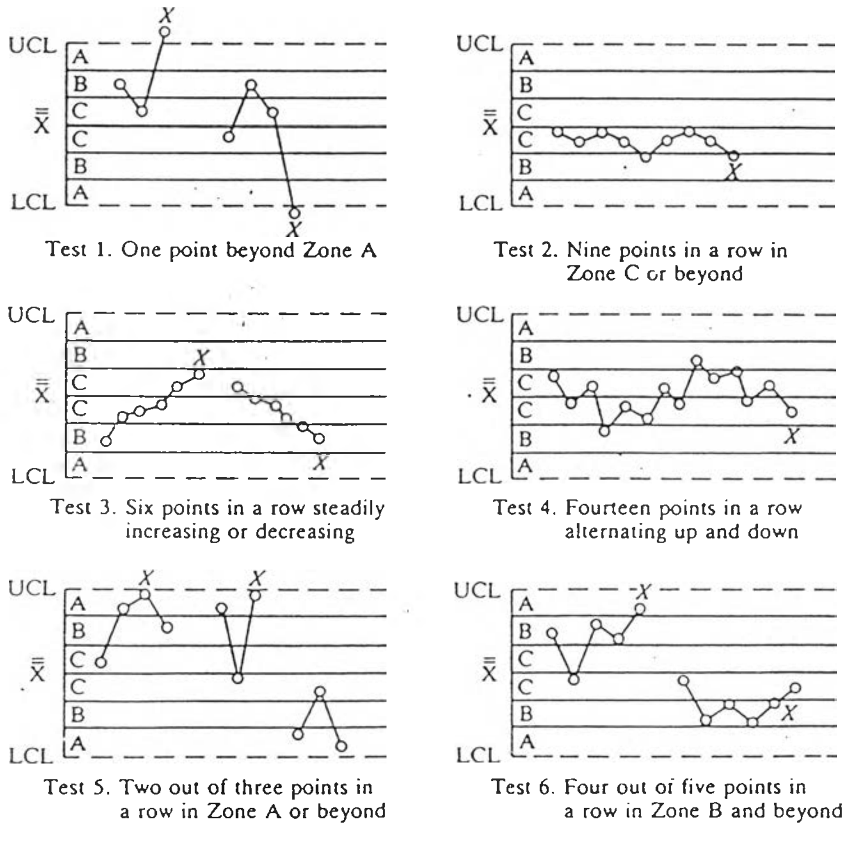

Fig. 2.5 The samples of special cause applied in control chart (from Nelson, 1984)

Statistical Process Control (SPC)

SPC, Statistical Process Control, is the application of statistical method to measurement, monitor, and analysis of the variation in any process. SPC can measure the variation of tools, machines, and people in manufacturing in term of the input and output in products and service.

For example

- Percentage of output that meet the customer requirement
- Number of nonconforming products
- Percentage of downtime in manufacturing process
- Period of calibration
- Capability of process, etc

The SPC is the powerful technique and is applied in broadly application. In each applications, some use different, it relied on the specific characteristic. So before implementation SPC in the system we should prepare 5 major steps which are

1) Establishing the environment that suitable for action (e.g. habits of people in organization teach the basic acknowledge and advantage to user, etc.)
2) Understanding and define process and relationship for measurement
3) Determining the characteristic to be controllable such as customer requirements, current potential problem, and correlative characteristic that effect the cause of problem.
4) Defining measurement system, the reliable in measurement tools and methods are necessary if we need accurate and precise data
5) Reducing the external correlative influences that affect to the scope of study

At first, the SPC was used to make the distinction between controlled and uncontrolled variation that were called as commons causes and special causes.

Common causes: a source of variation that affects individual value of process output as random process variation

Special causes: a source of variation that is often unpredictable or unstable as run or non-random pattern process

The SPC technique can be used with other technique to make it more effective in implementation. They are statistical tool (e.g. the histogram, box plots), probability distribution, normal distribution and other quality control technique (e.g. QC 7 tools, QCC, QA). It can reduce the economic lost of Type I and Type II error of sampling in manufacturing process.

Type I error (α): Rejecting an assumption that is true, over control

Type II error (β): Failing to reject an assumption that is false, under control

After the SPC is used continuously, it is developed into a simple and powerful chart that is used for three major phases as following;

1. Collection: Selecting the specific characteristic for study then gather and convert them into the form, plotted on the control chart. The chart can be used with both variable and attribute data
2. Control: The SPC technique is used in manufacturing process in form of the control chart to control the variation of process and measure the process capability.
3. Analysis and Improvement: After all specific characteristics are addressed and the process can run within the statistical control, the control chart is not only the monitor of the current process but it can also show the trend and variation of data in the control limit. The run in control chart can tell us about the cause of problem in term of common causes and special causes this is easier for corrective action and reduce time to investigate cause of problem.

In manufacturing process, the SPC is used in form of the control chart and the process capability. The control chart is used for variable data while the SPC is used for calculating the control limit. In control chart, it composes of 5 lines, upper specification limit (USL), lower specification limit (LSL), upper control limit (UCL), lower control limit (LCL), and central line. The control limit is the specific values for controlling the variation of process by statistical calculation. The value of the control limit comes from the data of sample group that run continuously in manufacturing process, both variable and attribute data. In each control chart, there are several methods to calculate the control limit but all of them use the formula base on the standard deviation. The calculation of control limit value has two method which are calculated by using 3 standard deviation (3σ) and using formula with the constant value but the result of them are nearly same.

The control chart can be divided into two types by the kinds of data which are the control chart for variable data and the control chart for attribute data.

1. Control chart for variable data

There are four types of the control chart for variable that broadly used in manufacturing process which are as following,

1.1 X and R chart (Average and Range charts)

- Using for process with some calculation
- Broadly use in manufacturing process
- Usually use for calculation process capability index (Cp. and Cpk)

1.2 X and S chart (Average and Standard deviation charts)

- Suitable for recorded by computer real time basis
- Routine run basis has available computer
- More efficient in large subgroup sample size

1.3 X and R chart (Median charts)

- Suitable for shop floor with non-calculation
- Each group show variation by itself

1.4 X and MR chart (Chart for individual and Moving Range)

- Can use with individual and subgroup
- Suitable for distribution not symmetry.
- Small sample size for high cost of inspection, destructive test and expensive experiment

2. Control chart for attribute data

There are four types of control chart for attribute that broadly used in manufacturing process is

2.1 p – chart (Proportion of units nonconforming)

- Show proportion or percentage of nonconforming
- Can interpret for process capability

2.2 np – chart (Number of units nonconforming)

- Show actual number of nonconforming that ease to understand
- Can interpret for process capability

2.3 c – chart (Number of nonconformity)

- Nonconforming are scatter through a continuous flow of product in specific condition (e.g. amount of defect in inch^2)
- Collect several kind of defect in a unit

2.4 u – chart (Number of nonconformity per unit)

- Show number of defects per unit basis
- Sample size can vary from period of time
- Show number of defect in proportion per unit

Process Capability Index (Cp.. Cpk.)

Process capability is the ability of process that is quantified prediction of process adequacy in term of the total range or widespread of a stable processes' inherent variation.

Variables data case: 1. Normally used 6σ, $\pm 3\sigma$ for control the process variation compare with specification or control limit

2. Measuring the indices by considering process centering as spread (e.g. Cpk) with some assumptions

Attribute data case: Usually uses the average proportion or defection rate with specification or target

The formula for calculation the process capability (Cp.) and capability index (Cpk.) is:

$$Cp. = \text{Capability ratio} = \frac{\text{Specification range}}{\text{Process capability}} = \frac{USL - LSL}{6\sigma}$$

$$Cpk. = \text{Capability index} = \min. \left[\frac{\text{Mean} - LSL}{3\sigma}, \frac{USL - \text{Mean}}{3\sigma}\right]$$

Where USL = Upper specification limit

LSL = Lower specification limit

Mean = Average value of sample group

σ = Standard deviation of sample group

The value of Cp. is used to tell about the capability of process compared with the tolerance of specification. But Cpk. is used to show the capability of process by using the average of data group compared with the center of the tolerance of specification so the value of Cp. is bigger than Cpk.