CHAPTER 2

THEORY AND LITERATURE SURVEYS

There has been a continuous improvement for quality control. The important of applying quality tools lies in bringing tangible results which will reduce a defection rate, a cost reduction while improve quality as well as financial incomes thus increasing the market share. It is as well as intangible results namely pride and satisfaction. Therefore, this chapter studies related theories and literature surveys for quality improvement tools.

In this research, quality improvement tools are suggested to reduce defective product. Three causes are used to describe the defects.

1. Design Defect - A design defect is a defect that affects an entire line of products. It may be a result of cost-benefit analysis, and/or customer's requirements. A design defect occurs when a product does not adequately protect against risks of injury, fails to perform intended functions safely, does not protect efficiently against the danger to which it is supposed to guard, creating unreasonably dangerous side effects, or fails to minimize avoidable consequences in the event of an accident.

2. Manufacturing Defect - A manufacturing defect occurs when the product does not meet the manufacturers own specifications. This can be due to several reasons such as:

- The raw materials or components used in making the product may contain unacceptable flaws.
- These are assembly mistakes.

3. Service Defect - A service defect occurs when the service does not meet the defined criteria of the design and/or the customer.

2.1 Causes and effect diagrams

The causes and effect diagrams is a useful tool. It uses to identify and breakdown the main causes of a given problem. All of the possible causes are related to a problem under study and are hierarchical by their nature. This diagram is also called a fish bone diagram because of its shape, or an Ishikawa diagram in honor of Kaoru Ishikawa, who developed this technique in 1943. The diagram is illustrated in a clear manner the possible relationships between some identified effect and the causes of problem and in generating improvement ideas. According to Barrie G. Dale, there are three diagrams.

1. 5M Cause and effect diagram. The main bone structure is typically comprised of machinery, manpower, method, material, and maintenance. Often teams omit maintenance and hence use a 4M diagram, while others may add a sixth M (Mother Nature) and so use a 6M diagram. The 4M or 5M

or 6M diagram is useful for those with little experience of constructing cause and effect diagrams, and is a good starting point in the event of any uncertainty. As with any type of cause and effect diagram, the exact format is not so important as the process of bringing about appropriate countermeasures for the identified and agreed major causes for the problem.

2. Process cause and effect diagram. The team members should be familiar with the process under consideration; therefore, mapping it out using a flowchart and seeking to identify potential causes for the problem at each stage of the process. The process flow is so large as to be unmanageable, the sub-processes or process steps should be separately identified. Each stage is then brainstormed and ideas developed using, for example a 4M, 5M or 6M format. The key causes are identified for further analysis.

3. Dispersion analysis cause and effect diagram. This diagram is usually used after 4M/5M/6M diagram have been completed. The major causes identified by the group are then treated as separate branches and expanded upon by the team.

According to David Straker, 1995, the causes and effect diagrams are used when:

- Investigating a problem, to identify and select key problem causes to investigate or address.
- The primary effect of a problem is known, but possible causes are not all clear.
- Working in a group, to gain a common understanding of problem causes and their relationship.
- Find other casual relationships, such as potential risks or causes of desired effects.

To draw the causes and effect diagrams, first find all possible causes of an effect and then classify them into about four to eight categories and into subcategories where appropriate. Draw a horizontal arrow pointing to a box at the right end, which is labeled with the effect under consideration. For each major classification, draw a line slanting into the horizontal arrow so that the resulting pattern resembles the skeleton of a fish; label each slanting line with the name of a major subcategory. Then draw horizontal arrows into each slanting line to represent causes within the labeled category. If there are subcategories, there horizontal lines will be represented with slanted lines into them to represent their members. Similar to a graph, the causes and effect diagrams is a very effective communication tool. The following figure shows a sample of causes and effect diagrams.

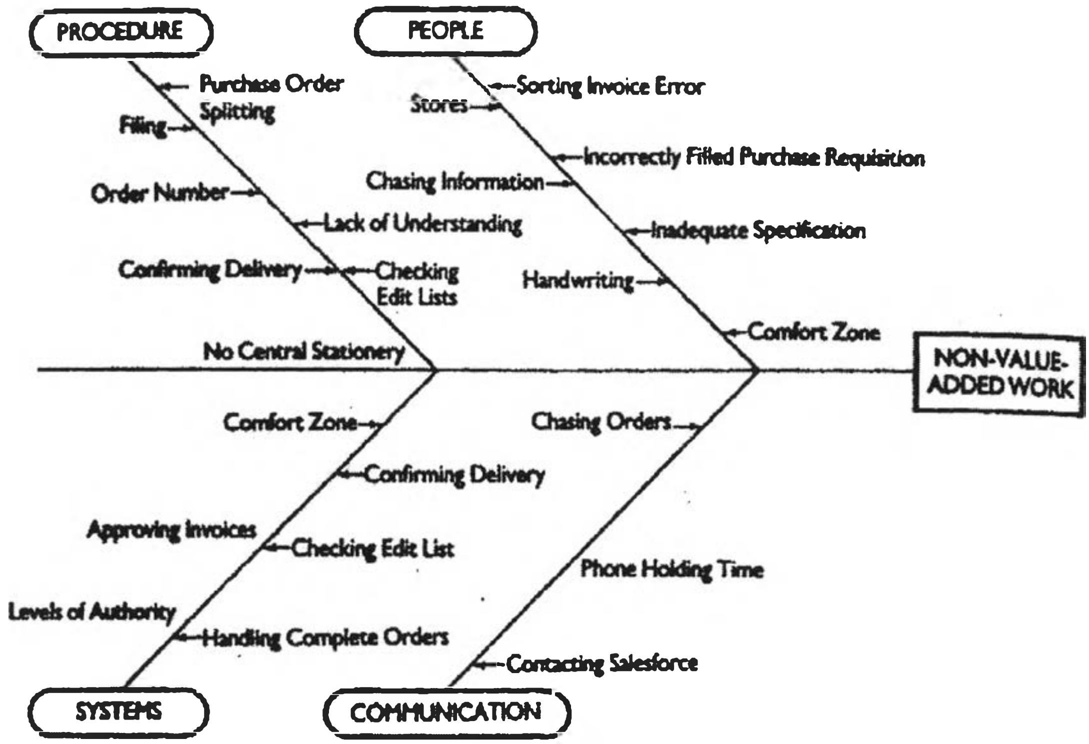

Figure 2.1: Causes and effect diagram

2.2 Relation diagrams

According to Burrill Ledolter, 1998, relation diagrams discussed by Futami is shown in figure 2.2. The relation diagrams are also called relationship diagraph or linkage diagram. The most common use of the relation diagrams is to show the relationship between one or more problems and their causes. However, it can also be used to show any complex relationship between problem elements.

There are obvious similarities among the relation diagram, the interrelationship diagraph, and the causes and effect diagrams. The causes and effect diagrams is used to identify, in increasing detail, all the possible causes that are related to a problem or condition. The interrelationship diagraph is a tool to study the causes and effect relationships among critical issues, and it is useful for uncovering the root causes of problems. The relation diagram is a way to list the interrelations among factors that are pertinent to a certain problem.

The major steps in constructing the relation diagrams are:

- The central problem or issue to be discussed is described clearly and accepted by those concerned.

- Issues, causes and related problems, which are believed to be affecting the central problem, are identified. These are written, in summary form on cards, one issue, cause or problem per card.
- The cards are then placed around the central problem/issue in a cause and effect relationship. This is done by placing the card believed to have the strongest relationship closest to the central problem/issue and the other cards are ranked respectively.
- The cause and effect cards are enclosed within rectangles or ovals, and arrows are used to highlight which causes and effects are related, they are indicated by arrows pointing from cause to effect.

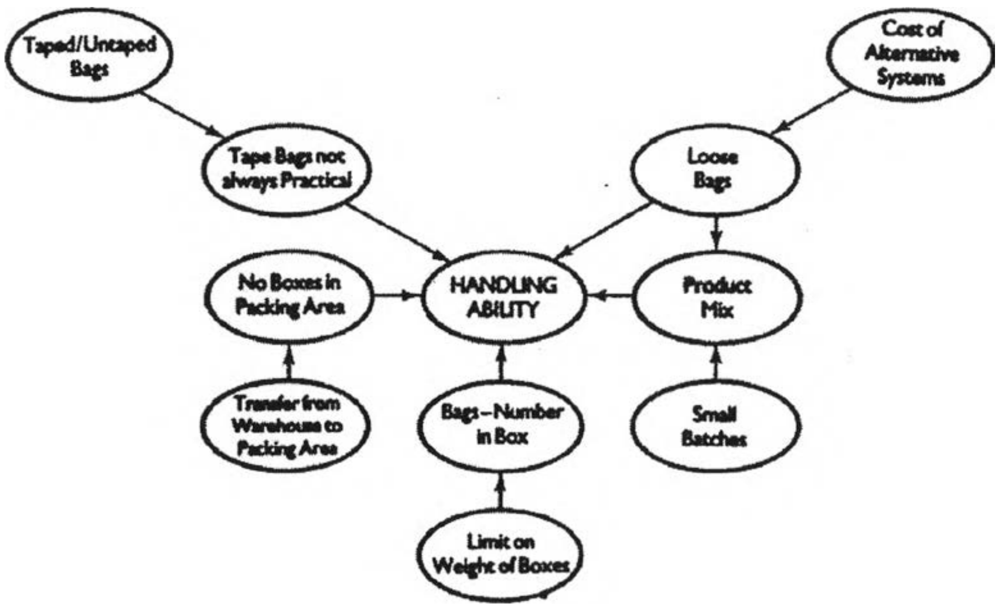

Figure 2.2: Relation diagrams

2.3 Check sheet

A check sheet is a sheet or form used to record data. The data from the check sheet provides the factual basis for subsequent analysis and corrective action. There are three main uses of check sheets. First, it can be used to count items, such as defects, or to show the distribution of a set of measurements. Second, it many be used to show the physical location of something such as defects on a manufactured item. This is useful for finding significant bunching of measurements, which may help to find problems. Finally, it may be used to help prompt for an action and consequently be ticked to certify that a particular action has been carried out.

The following are the main steps in constructing the check sheet.

- Determine the type of check sheet to use.
- Decide the type of data to be illustrated. The data can be related to: number of defectives, percentage of total defectives, cost of

defectives, type of defective, process equipment, shift, business unit and operator.
- Decide which features/characteristics and items are to be checked.
- Design the sheet; ideally it should be flexible enough to allow the data to be arranged in a variety of ways. Data should always be organised in the most meaningful way to make best use of it.
- Decide the period over which data are to be collected.
- Specify the format, instructions and sampling method for recording the data, including the use of appropriated symbols.

There are many different kinds of check sheet. Figure 2.3 is an example of a check sheet, which has been used for counting defects of door paint.

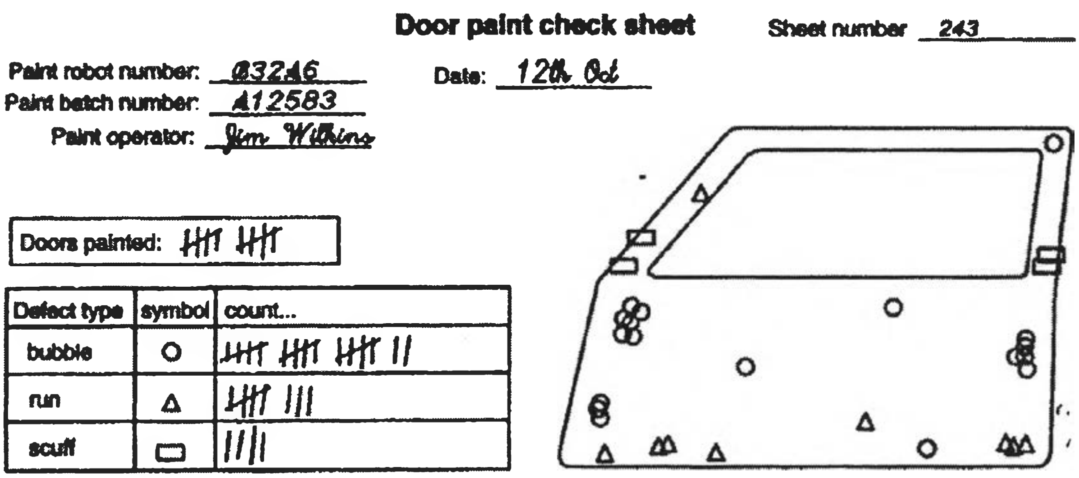

Figure 2.3: Check sheet

2.4 Failure Mode and Effect Analysis

The technique of Failure Mode and Effect Analysis (FMEA) was developed in the aerospace and defence industries. FMEA is a systematic and analytical quality planning tool for identifying. At the product, service and process design stages could potentially go wrong either with a product during its manufacturing or end-using by customers or with the provision of a service. The use of FMEA is a powerful aid to advance quality planning of new products and services. There are advantages of the FMEA method, such as:

- FMEA is a visibility tool; that is, FMEA tabulations are visible.
- FMEA is a systematic procedure.
- FMEA can easily be understood.
- FMEA identifies weaknesses in the system design.

Generally, it is accepted that there are four types of FMEA. They are:

1. System FMEA - Used to analyze systems and subsystems in the early concept and design stage. A system FMEA focuses on potential modes between the functions of the system caused by system deficiencies. It includes the interactions between systems and its elements.

The benefits of system FMEA are that it:

- Helps select the optimum system design alternative
- Helps determining redundancy
- Helps defining the basis for system level diagnostic procedures
- Increases the likelihood that potential problems will be considered
- Identifies potential system failures and their interaction with other systems or subsystems

2. Design FMEA - Used to analyze products before they are released to production, for major change process, and manufacturing. A design FMEA focuses on failure modes of product caused by design deficiencies.

The benefits of design FMEA are that it:

- Establishes a priority for design improvement actions
- Documents the rationale for changes
- Provides information to help through product design verification and testing
- Helps identify the critical or significant characteristics
- Assists in the evaluation of design requirements and alternatives
- Helps identify and eliminate potential safety concerns
- Helps identify product failure early in the product development phase

3. Process FMEA - Used to analyze manufacturing and assembly processes. A process FMEA focuses on failure modes caused by process deficiencies.

The benefits of process FMEA are that it:

- Identifies process deficiencies and offers a corrective action plan
- Identifies the critical and/or significant characteristics and helps developing control plans
- Establishes a priority of corrective actions
- Assists in the analysis of the manufacturing or process
- Documents the rationale for changes

4. Service FMEA - Used to analyze services before they reach the customer. A service FMEA focuses on failure modes (tasks, errors, and mistakes) caused by system or process deficiencies.

The benefits of service FMEA are that it:

- Assists in the analysis of job flow
- Assists in the analysis of the system and/or process

- Identifies task deficiencies
- Identifies critical or significant tasks and helps in the development of control plans
- Establishes a priority for improvement actions
- Documents the rationale for changes

The FMEA is revised following the standard procedure [6]. The procedure for conducting an FMEA follows:

Step 1 Select a review team and team leader.

A FMEA should include a team of four to six participants with representatives from cross-functional areas such as manufacturing, engineering, and maintenance. If a manufacturing process is involved at least one of the manufacturing operators, the team leader does not have to be the person most familiar with the process.

Step 2 Define the process boundaries.

A FMEA on an entire process would be extremely complex and identify the overall approach to be used. The FMEA may be a part of a larger set of failure analyses. In this case, the way that items are selected needs to be determined. Typical strategies include [David Straker, 1995]:

- Top-down analysis, where the system being analyzed is broken into pieces and FMEA done on the larger items first.
- Bottom-up analysis, where the analyses of the smallest pieces are done first, followed by the higher level assemblies from which these are made. This is the reverse of top-down analysis.
- Component analysis, where the FMEA is done on the physical parts of the system. This will typically use component specifications to determine failure levels.
- Functional analysis, where the analysis is the intended functions and operation of the system. This is to look at failure from the product user's standpoint, rather than the engineering's, and will typically use product specifications to determine failure modes.

Step 3 Brainstorm potential failure modes.

The brainstorm should focus on the process under study and on the potential process failure modes that will affect the product. Remember that the product from this process will usually be the incoming material for another process. The approach could be brainstorming on all potential failure modes or it could be a series of directed brainstorming on each specific area: equipment and components, methods, materials, people and the measurement system.

The brainstorming results should be organized and transferred onto the FMEA data collection form. Use a cause and effect diagram to aid in grouping related failure modes.

Step 4 List all potential effects of each failure.

Next to each of the potential failure modes on the FMEA form, list the potential effects for each failure; describing the result if failure occurs. The failure could impact other components in the system, leading to a domino effect. It could impact the whole process. It could obviously affect the customer, whether it is an internal customer (the next system or manufacturing process) or an external (paying) customer. The description of the potential effects should be as specific as possible.

Step 5 List the potential causes of each failure.

The potential causes will also be listed next to the potential failure modes on the FMEA form. These are the possible reasons why the failure could occur. This information is important later in the FMEA process to help direct the improvement efforts.

Step 6 List the current control.

For each of the potential causes of failure, list the controls that are in place to prevent each cause from occurring, to detect the cause of failure, or to detect the failure mode.

Step 7 Estimate the frequency or probability of occurrence.

The frequency or probability of occurrence for each cause of failure is rated from 1 to 10. Each factory or team should develop their own rankings. The ranking system used must remain constant throughout the FMEA.

In estimating the occurrence probability, consideration must be given to those controls designed to prevent the cause of failure from occurring.

Step 8 Estimate the severity.

Each of the effects of failure, rank the seriousness of the failure from 1 to 10. Again, each factory should establish their standardized ranking scale and criteria, especially for quality problem that affect their final customers. Teams working on internal processes could establish their ranking of the severity of quality problem on their internal customers.

Step 9 Estimate the detection ranking.

The detection ranking is the probability of detect a defect or quality problem before it is sent to the customer. This, again, should be customized for each factory.

Step 10 Calculate the Risk Priority Number (RPN).

This is not a statistical risk calculation. It is a relative ranking method used to prioritize the items with the greatest risk to focus improvement efforts. The calculation for the RPN is:

RPN = (Occurrence)(Severity)(Detection)

Where the highest possible risk is 1000 and the lowest is 1.

Step 11 Determine recommended actions.

The FMEA team should use the Pareto principle to identify those causes of failure with the highest risk. These will be the first items targeted for corrective actions, although the team should also consider improving those causes of failure with very high occurrence rankings. A cut off point may be set where all items with a risk greater than a preset "danger" level must be corrected before the process is put into operation.

To reduce the risk, the improvement effort can focus on:

- Reducing the probability or frequency of occurrence.
- Reducing the severity of failure occurring.
- Improving the detection methods.

The improvement efforts may focus on only one of these areas or the efforts may strive for some improvement in all three to reduce the overall risk. The team should establish responsible individuals and set a due data for each of the items slated for corrective measures or improvement.

Step 12 Follow-up on actions.

The team should review the actions taken and then revise the occurrence, severity and detection rankings. The new RPN can be calculated from the new rankings to determine if the actions were effective in reducing the risk to an acceptable level. When all the ratings are below the danger level, the team may elect to disband. Of course, they may also elect to continue the improvement process by working down their Pareto of risks that are unsatisfactory. It is recommended that each FMEA teams review their progress with management before they disband.

After the FMEA procedures have been developed, it becomes a living document and is never really completed. It is a truly dynamic tool for improvement because regardless of the beginning phase, it will use information to improve the system, design, product, process or service. It is continually updated as often as necessary.

The concise twelve steps of FMEA implementation is easy to read, understand and follow in each step of which are as shown below.

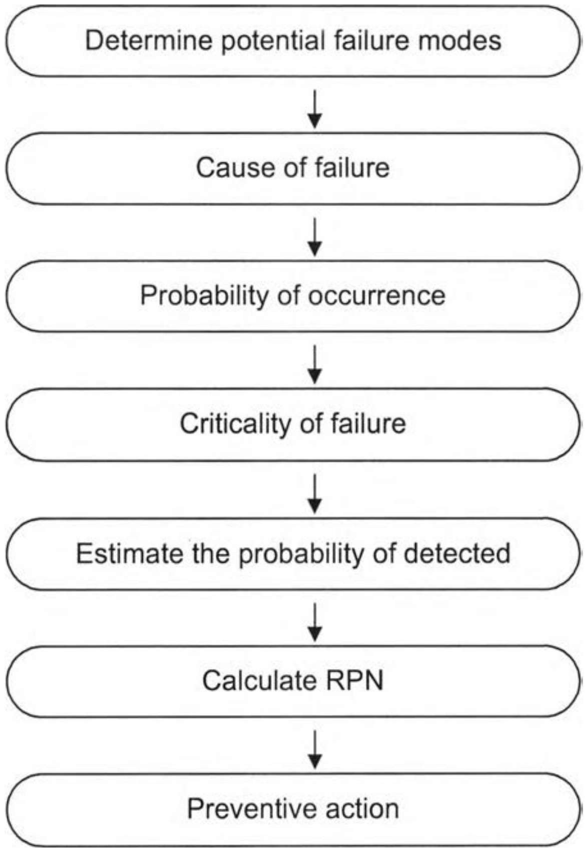

Figure 2.4: Step of FMEA implementation

2.5 Pareto diagrams

Pareto diagram is a technique employed for prioritizing problems of nay type; for example, quality, production, stock control, accident occurrences and resource allocation. The diagram highlights the fact that most problems come from a few of the causes and also it is an extremely useful tool for condensing a large volume of data into a manageable form and in helping to determine which problems to solve and in what order. Therefore, the Pareto diagram is simply a bar chart in which the bars sorted into size order.

There are two types of Pareto diagrams as following.

1. Pareto diagrams by phenomena

This is a diagram concerning the following undesirable results, and is used to find out what the major problem is.

- Quality: defects, faults, failures, complaints, returned items, repairs.
- Cost: amount of loss, expenses.

- Delivery: stock shortages, defaults in payments, delays in delivery.
- Safety: accidents, mistakes, breakdowns.

2. Pareto diagrams by causes

This is a diagram concerning causes in the process, and is used to find out what the major cause of the problem is.

- Operator: shift, group, age, experience, skill, individual person.
- Machine: machines, equipments, tools, organisations, models, instruments.
- Raw material: manufacturer, plant, lot, kind.
- Method: conditions, orders, arrangements, methods.

The following are the basic steps in constructing a Pareto diagram.

- Decide the problem, which is to be analysed.
- Decide the period over, which data are to be collected.
- Identify the main causes or categories of the problem.
- Collect the data, using, for example, a check sheet.
- Tabulate the frequency of each category and list in descending order of frequency. (If there are too many categories it is permissible to group some into a miscellaneous category, for the purpose of analysis and presentation.)
- Arrange the data as in a bar chat.
- Construct the Pareto diagram with the columns arranged in order of descending frequency.
- Determine cumulative totals, which can cumulative percentages and construct the cumulative percentage curve.

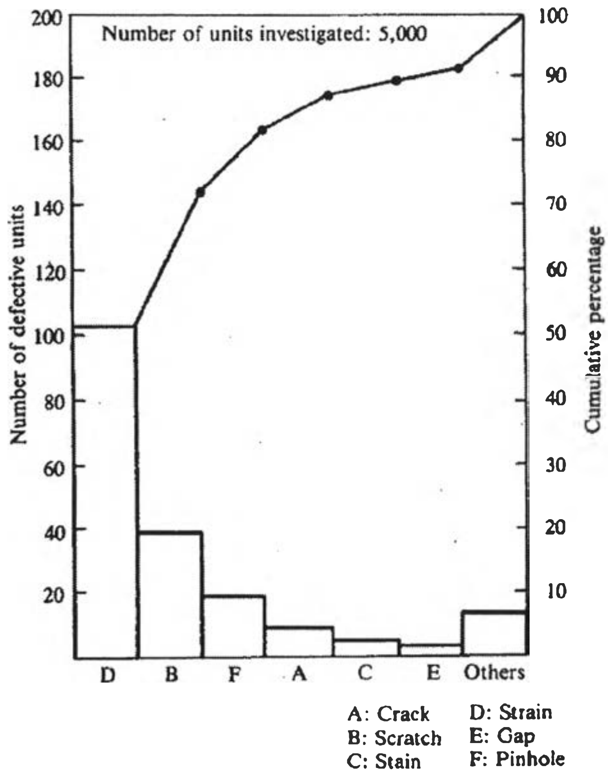

Figure 2.5: Pareto diagram

2.6 Decision tree diagrams

Decision tree diagrams are chains of decisions that determine the best decision at each point. Making decision can be difficult when future events are uncertain and can give widely results. For example, where there are several possible improvements to a product, each of which has a different cost and has several possible failure modes. The decision then becomes an important thing, where the aim is to identify those actions, which will give the best results.

A key part of using the decision tree is in selecting the strategy for the real present value of the potential payoffs. It can deal with more than just one set of actions and subsequent events, as the occurrence of an event may trigger another decision point. For example, a project failure might require an appropriated contingency action to be selected. Thus decision trees can become quite deeply rooted as chains of possible events and decision are considered. Therefore, decision trees are constrained in the same way as other data-driven tools in that their value is very much affected by the accuracy of the data being used.

2.7 Why-Why analysis

Why-Why analysis is an analyzing technique leading to the factor or root causes that review problems systematically step by step. Nowadays, quality tool is widely used to search for the cause/ find out, for example Cause and Effect Diagram and Relation Diagram. The Cause and Effect Diagram is used to find out the major cause in order to roughly solve the problem. The Relation Diagram is a technique to bridge a relationship in related factors. However, it cannot be employed to analyse the source of the problems in order to find a measure preventing the same mistakes. On the other hand, Why-why analysis can analyse the source deeply to the very root, then find the solution for it.

The simply steps for doing the why-why analysis are following. First, the company needs to specify the problems by identifying the true and false precisely. Second, investigate actual location (Ganba) and real circumstance (Genbutsu) in order to learn to understand every detail, which are structure and responsibility/ duty of the problems/ false/ mistakes. Third, look at the problem as it should and set the criteria to prevent the same mistakes. Fourth, by viewing an actual situation, start the analyzing step by first asking "why" to the problem subjects/ area step by step while you come to the root cause and finally, find the measure to the same mistakes.

2.8 Literature Survey

These books and research are supported to demonstrate the quality improvement tools. Each item helps user get a better understanding, the purpose of quality improvement tools, and how to use it to for high efficiency.

Susan M. Garrity, basic quality improvement, approaches the statistical process control. It includes an evolution of statistical process control, defining problems and setting priorities, analyzing the process, describing data using statistics, process capability, control charts, and determining the cause. Gerald M. Smith, statistical process control and quality improvement, approaches the statistical process control in the same way. Moreover, it includes quality seven tools, Deming's contribution to quality, total quality management, total customer satisfaction, and ISO-9000.

Hitoshi Kume, statistical methods for quality improvement, approaches in deep detail of Pareto analysis, cause-and-effect diagrams, histograms, check sheet, scatter diagrams, and control chart. For example, what are control charts, types of it, how to make and read it, and process analysis by control charts.

Kaoru Ishikawa, what is total quality control?, describes the quality control in Japanese way such as characteristics of Japanese quality control. In addition, he gives detail in quality assurance, total quality control, quality control circle activities, quality control for subcontracting and purchasing, quality control in marketing, and quality control audit.

Xiujie Li studied on quality of cost reduction in electronics appliance manufacturing company. She used Pareto analysis and cause-and-effect to analyze the product and also used quality control in the quality activity cycle. Deming's cycle was used in quality improvement activities and summarizes the result data. She found the failure mode and effect analysis could be used as a technique to assist company achieving proactive continuous process improvement.

Sayom Surijamongkol studied on quality assurance for the distributed control system project. He used failure mode and effect analysis and fault tree analysis as a quality tools for analyze the potential failure modes and the effects in the project. The results by using failure mode and effect analysis technique have leaded to establish the quality assurance system for the project.

Dechakom Boonma used Pareto analysis to identify the priority of problems and then used cause-and-effect diagrams to analyse the potential problem in a case study of steel manufacturing, design of a customer complaint management. Finally, he used the 3M (Muri, Mura, Muda) technique to eliminate the waste in the system. After implementation, the company could reduce the process time from 69.3 days to 39.7 days.

Kasem Kidwas studied on an improvement of performance index in production process, a case study of a compress gases company. He focused on cause-and-effect diagrams and relation diagrams for problem solving. Then the new standard and process operating instruction has been set up to control and monitor the production process in the final. The result of Nitrogen loss was reduced from 25.2% to 19.7%.

Mali Sae-ung, used cause-and-effect diagrams to define the potential factors that effect to plating thickness in electro-plating process. From the diagrams, six factors are considered to have major contribution. These factors are comprised of tin, additive and electrolyze concentration, shield height, plating time, and current density.

These are several books that focus on quality improvement tools because quality improvement tools is an important tool for manufacturing, business operation and business owners to reduce defective products and gain business profit in long term.