Quality Improvement in the Wooden Ware Manufacturing Process

by

Mr. Anuchit Chingchuangchai

A Final Report of the Three-Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

Nowadays, the (lain and customer satisfactions have become the key drive behind some of the most profound changes that occurred in the world of vork. Strong emphasis upon product. and service quality has become the major key to the successful 'on of this economic goal by concerns. L.N.s a result, this project concentrates on how to i n.lov 1 lity to reduce the nurnb(.1 of failures in Wooden Ware Manufacture by using principles of coi, tinuous improvement. For effectiveness and efficiency, co r. improvement d sev en-tool techniques are fundamental to finding out the defective items.

Thus the root causes are cause of problem for reducing the percentage of f • '1 reject and optimi- benefit in order to minimize the defective; • antity to reduce the cosi of non conformingproduct by using Pareto analysis alyze the root causes. The live defective products are large ti tp, poor surface, bending, poor color,and wrong align cnt. The n aje7r causes are machine, measurernent, method and materials. These major causes result .from no job description policies for employees and lack of knowledge and skill of emplo ees. We reduce the percentage of final reject and improve quality of this product by finding out the root cause and :inl.plementi.ng tI possible solutions, monitoring quality continuously.

After improving quality of large gap of wooden ware manufacturing rOCegS the final project decrease from 1.3% to 0.90% i aid D5 the company gain more benefits.

ACKNOWLEDGEMENTS

The writer is indebted to the following people and organizations. Without them, this project would not have been possible.

He wishes to express his sincere gratitude to the Dean and Advisor of the Advisory Committee. Dr.Chamnong Jungthirapanich. The Dean's patient assistance, guidance, and constant encouragement had led the writer from the project inception to the project completion

The writer would like to thank Mr. Pramoet Rojsurakitti, Manager of World Wide Brush Co., Ltd., Ms. Chotima Rojsurakitti, CEM friends and the employees of all departments for their help in providing the information, convenience, constructive comments and advice throughout the research.

Finally to his parents, who all played majors roles in his life, the writer wishes to extend his love and thanks for their support, encouragement and patience.

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I. INTRODUCTION

1.1 General Background of the Project

At present, Thai economy is recovering from the economic crisis, which spreads to the whole world. Hence quality improvement is one of the many activities, which is useful for reducing investment cost and increasing profit.

Thus, World Wide Brush Co., Ltd. or the other industries try quality improvement by using many techniques to reduce the manufacturing cost in the current market. Top management of the company implements the policies to reduce cost and improve product quality. Unfortunately, it is still in the process. Quality improvement can support new and present products without additional costs, which enhance a high profit to factory.

In addition, Strong emphasis upon product and service quality has become the major key to the successful realization of this economic goal by concerns. Total quality has become the key to the effectiveness of the modem industrial firm. No matter how large and important a company or a factory may be, it cannot succeed in offering poor quality products in the modern international marketplace today. The principle is that a concern must have quality leadership if it is to retain quality leadership in its traditional domestic markets. Moreover, the costs of quality achievement are now so very important a proportion of the total costs of the concern that the efficiency of quality programs are a fundamental consideration in themselves to company economy today. While today's buyers continue to purchase with strong attention to price, unlike the buyers of only a few years ago, they place increasingly high emphasis upon quality, expecting acceptable products at any price level. The customer judges quality. Quality and customer satisfaction have become the key drivers behind some of most profound

changes that have occurred in the world of work in all of reworked history. It has explosively increased customer demand for greater durability and reliability in product and services. While today's buyers continue to purchase with strong attention to price, unlike the buyers of only a few years ago, they place increasingly high emphasis upon quality, expecting acceptable products at any price level. It is quality as well as price that sell today, and quality that brings customers back for the second, third, and fifteenth time.

Absolutely, quality improvement can help us to improve and to increase quality of product and reduce loss, which occur from defects. In addition, quality improvement still helps indirectly to increase productivity by changing defects to good products.

1.2 Project Objectives and Scope

This project studies and gathers the related information of quality of goods in the system for probable analyzing of the data, determining solution, conclusions and recommendations. This project is aimed to recommend quality improvement in Wooden Ware Manufacture in order to create customer satisfaction and high confidence in company's finished goods. If we implement the quality improvement in Wooden Ware Manufacture following my procedure, we will get a better quality product, save time and costs.

The importance of the project is to solve the problem, which affects quality of product. In addition, this project wants to suggest about knowledge of improvement theory with manufacturing department that does not know excellent methods to get more quality improvement.

Thus if they study and bring various techniques of quality improvement to apply in their production line, they will help them to analyze and find out the problem, and

know what is the main defect, cause of defect that should be solved firstly to improve quality of product. Then continuous improvement is one method that is necessary for monitoring and improving.

This project focuses on the possible alternatives in Wooden Ware Manufacture improvement for reducing the number of failures, waste and nonconforming finished goods by using quality control. In addition, the project recommends the quality improvement in the Wooden Ware Manufacture. Then I will study the factory's actual status, Wooden Ware Manufacture, manufacturing process and the details of quality in finished goods. In my research, I assumed that men, machines, raw materials and manufacturing process in the factory have no change during the period of studying.

1.3 Methodology

The principle of quality improvement, seven tools, continuous improvement or Kaizen method will be used to find out the main defects and root causes then it will be solved by implementation of various solutions. So this project has the advantage for production section that is directly concerned with the output in order to get more profit on the production line. However, the methodology of this project is explained as follows:

(1) Use principle of Pareto Analysis and Cause and Effect Analysis to find out the main defect and the possible root causes.

(2) Create and implement many solutions to solve the root causes.

(3) Combine the effective solutions together in order to reduce more rejects and gain profit.

II. LITERATURE REVIEW

2.1 The Meaning of "Quality" (Bank 1989)

Quality can mean different things to different people and can be interpreted in a variety of ways by an individual. Quality may be thought to have two main divisions: the quality of a manufactured product and the quality of services received. From a manufacturing standpoint quality is simply conformance to specifications. The ultimate customer could describe Quality as fitness for use. When trying to edge out the competition, quality can be interpreted as producing the very best product or providing the very best service. In some industries a set of classifications have been established by design quality. For example, several levels of design quality exist in the automotive industry, from top-of-the-line luxury models down to economy cars. At each level, however, the buyer would expect good conformance quality. In fact, auto manufactures encourage in-class comparisons to show that they have the best conformance quality in their class. Buyers who are not pleased with the overall quality of a specific model car are encouraged to "step up" a class or two (for more money, of course!). In the service sector, the hotel industry provides a good example of differences in design quality. All hotels and motels provide a place to sleep, but many features of design quality, such as services available, comfortable to luxurious surroundings, exercise rooms, pools, and hot tubs, separate the bargain hotel from a five-star hotel. Companies that produce products at the higher levels of design quality and companies that produce products for a market that has primarily a single level of design quality would be more inclined to use the combination of the two categories which stresses excellence in the quality definition.

Furthermore, we must understand the meaning of quality first. When the expression "quality" is used, we usually think in terms of an excellent product or service

that fulfills or exceeds our expectations. These expectations are based on the intended use and the selling price.

According to ANSFASQC Standard A3-1987, quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated needs or implied needs. These needs involve safety, availability, maintainability, reliability, usability, economics (price), and environment. The stated need is the explicit need. For example, the stated need of studying is graduation. On the other hand, the implied need is a hidden need one that is not necessarily expressed, and is basically just expected or assumed. For instance, while the expressed need is graduation, the implied need is the increase in knowledge. Quality is a customer determination, not an engineer's determination, not a marketing determination. So the quality is customer satisfaction, fitness for use or compliance with specification. It can only be achieved if it is planned and managed to be achieved.

Product and service quality can be defined as the total complex product and service characteristics which the product and service in use will meet the customer satisfaction such as reliability, serviceability and maintainability, etc. It is very important to recognize this fact because the key requirement for establishing what is to be the quality of a product requires the balance of the various individual quality characteristics. The product must have appearance suitable to customer requirements so it must be attractive. Another essential element in defining the term of quality is quality control, which will provide additional explanation in the part.

2.2 Quality Control Concept (Juran and Gryna 1993)

Quality control is discussed from a business point of view in the terms of the economics of profitability, of market leadership and of productivity and cost control. It

is considered in the managerial terms of organization, participate management, and strategic planning as well as of the systems approach to quality. In addition, quality control is examined by starting with the purchasing actions from vendor selection for supplier quality, manufacturing planning, process control, and automation to equipment capability evaluation and final product assurance. So quality control refers to the use of specification and inspection of completed parts, subassemblies, and products to design, produce, sustain, and improve the quality of a product and service.

With production processes equipped with quality control functions, the manufacturer can analyze the outcome of the process. This will facilitate evaluation of the products and their conformance to the standards. If the products do not comply with the standards, then the defect must be corrected. Then corrective action will be taken to support the correction plan.

Quality control (QC) concerns the techniques and activities, which sustain quality to specified requirements and improve the quality of a product and service. It is the practical means of securing product or service quality as laid out in a product specification. Quality control may be viewed as a subset of quality assurance although quality control was used first. The basis of quality control is inspection. An important outcome of this statement is that quality control is an 'after the fact' activity which measures product that has not been produced to customer satisfaction. In other words, defects are detected through postproduction inspection by a QC- system and not prevented. Quality control involves integrating the following related techniques and activities:

(1) Establishing a standard for the product or service based on the customer needs requirements, and expectations.

(2) Ensuring conformance to these standards, poor quality is evaluated to determine the reason why the parts or services provide are incorrect.

(3) Taking action if there is a lack of conformance to standards. These actions may include sorting out the product to find the defects. In service industries, actions may involve the customer and correcting the situation.

(4) Implementing plans to prevent future nonconformance. These plans may include design of manufacturing changes; in service industry they include procedure changes.

These four activities work together to improve the production of product or provision of service. Utilization of these activities provides the customer with the best product or service at the lowest cost. The aim should be continued quality improvement.

Moreover, we must know the way to collect data and the purpose of collecting data. A great deal of data can be collected in factory situations. First consider the purpose of collecting these data. When we introduce a particular method of doing a job, it is natural to consider whether the method is appropriate or not. The decision is usually based on past results and experience, or perhaps on conventional methods. However, in the case of factory work, where data are collected through the actual manufacturing process, the procedural methods are introduced on the basis of the information obtained. The manufacturing procedure will be most effective if a proper evaluation is made, and on-the-job data are essential for making a proper evaluation.

Before collecting the data, the team needs to establish a plan that defines how much data are needed, where and how they should be collected, how long and by whom they should be collected and what assumptions. Collecting data is usually helpful when gathering data to identify and capture the information. Collecting data needs statistically

significant and unbiased data. There are several considerations in collecting data, purpose, ease, validity and reliability. The keys of the data are what are the data needs, what will it tell you, and how will you use it? Because data collection is time consuming, it is important to limit the vital data. The data plan should address the ease of collecting data. You must prepare to explain the purpose of collecting data and the information involved. The special forms are often needed to be designed to simplify the process. A well-designed survey form eases both data collection and tabulation. Finally the data collection plan to cover the potential validity and reliability in the data collection.

The proper use of analytical and statistical tools can often mean the difference between success and failure; the screen tools are proper for the quality control. The screening QC tools are used more often. In this project we will select the form of failure to be the collecting data, then the Pareto diagram as a tool for categorizing the type and number of failure in the production line. After that we verify the root cause by using the cause and effect diagram. Next we monitor the 2 variables by using the scatter diagram to see the relationships between them. Normally the QC tools are presented in many types and we can select each proper to use because it will help you to clarify the cause and the problem. So we will briefly explain in the other items.

Quality is:

(1) Fitness for use

(2) Conformance to specifications

(3) Producing the very best products

(4) Excellence in products and services

(5) Total customer satisfaction

(6) Exceeding customer expectations

Although there is no universally accepted definition of quality, the various definitions have enough similarity to extract the following common elements

(a) Quality involves meeting or exceeding customer expectations.

(b) Quality applies to products, services, people, processes, and environments.

(c) Quality is an ever-changing state - what is considered quality today may not be good enough to be considered quality tomorrow.

With these common elements identified, the following definition of quality is provided: "Quality is a dynamic state associated with products, service, people, processes, and environments that meet or exceed current expectations" (Goetsch 1995).

The dynamic state element speaks of the fact that what is considered quality can and often does change as time passes and circumstances are altered.

The products, service, people, processes, and environments element is criteria. It makes a point that quality applies not just to the products and services provided, but also to people and processes that provide them and the environments in which they are provided.

Total quality in an organization means simply that quality work is expected in every job. There are no exemptions. When something is done, it should be done right the first time. When a product is made, it should be defect-free. When a service is provided, the customer should be pleased with the result. Total quality has evolved as a necessary process for delivering a quality product or service as Figure 2.1 (Smith 1998). Moreover, a number of authors have put forth definitions based on both customer

benefits as well as customer burdens (primarily regarding products). Some definitions are pressed in many manners:

Quality should be aimed at the needs of the consumer, present and future; Deming

Quality is the total composite product and service characteristics of marketing, engineering, manufacture, and maintenance through which the product and service in use will meet the expectations of the customer; Feigenbaum.

There are two common aspects of quality. One of these has to do with the consideration of the quality of a thing as an objective reality independent of the existence of humans. The other has to do with what we think, feel, or sense as a result of the objective reality; this subjective side of quality is closely linked to value; Shewhart

The extent of quality is determined by how well the true quality characteristics (customer needs, expressed in customer language) match substitute quality characteristics (product specifications, expressed by a producer in technical language); Ishikawa.

From many manners of quality, they lead us to view quality through the customer's eyes. True quality characteristics echo customer needs and set up subjective customer expectations. We translate these expectations into substitute quality characteristic that are defined in technical terms sufficient to design and produce products. Ultimately, customer satisfaction results from the degree of correspondence between the customer's true quality characteristics and our substitute characteristics.

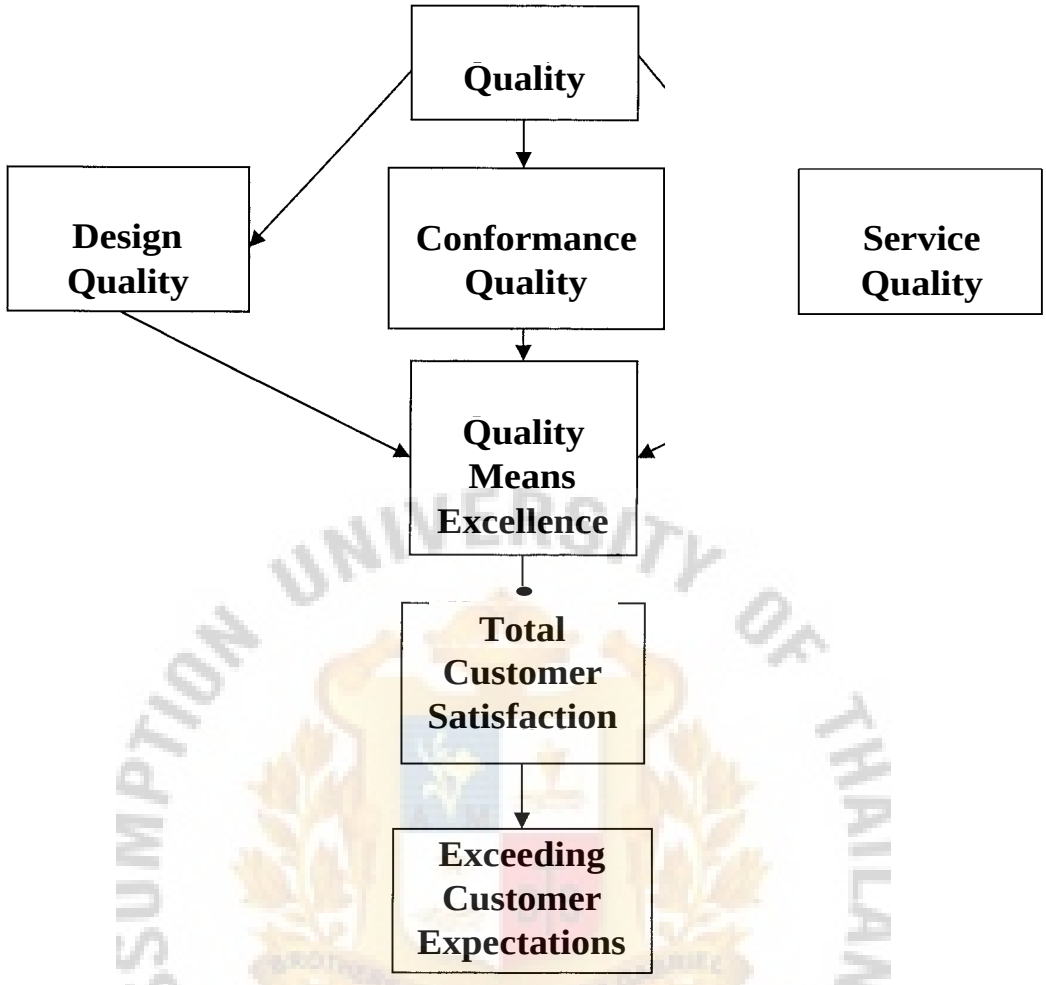


Figure 2.1. Quality Definitions (Kolarik 1999).

2.3 Quality Control Costs (Bell 1994)

During the 1950s the concept of "quality costs" emerged. Different people assigned different meanings to the term. In the company's view, quality cost is often described as the cost of doing things wrong. In fact Mr. Phil Crosby speaks of this cost as price of nonconformance. Sorting inspection, rework, repeat testing, and time spent resolving customer complaints, material scrapped, downtime, and return are a few good examples of the waste we want to avoid. In this project the emphasis will be on the cost

of poor quality. This component of assessment will prove to be important in reducing costs.

Many companies summarize these costs into four broad categories. These categories and examples of typical subcategories are discussed below:

2.3.1 Internal Failure Costs

These are costs associated with nonconforming materials, components, or products that cause losses due to rework, repair, retest, scrap, sorting, and so on, prior to release the product to the customer. They are costs that incurred because something was not done "right first time". They would disappear if no defects existed in the product before shipment, no need for rectification or redesign and no delays to the production process due to non-conformance and non conformance-generated shortages. Internal failure costs are most readily identified and examined for quality cost reduction

2.3.2 External Failure Costs

These are costs associated with nonconforming products that cause losses due to warranties, returns, allowances, and so on, after product is shipped to the customer. These costs would also disappear if there were no external defects, warranty claims, replacement costs, etc. Care must be exercised interpreting this category as only a partial story is told. Quantification may not reflect the loss of customer goodwill or future loss of sales, both of which are examples of external failure costs. These costs have traditionally been reduced by high level of checking, which increases internal failure costs as more failures are detected in-house.

2.3.3 Appraisal Costs

These are the costs incurred in determining and assessing the degree of conformance to quality requirements. This category would include such things as receipt testing of goods and all inspection and testing during production. It is arguable that appraisal costs are capable of reduction when there is an emphasis on quality improvement. Some examples are incoming in process and final inspecting, evaluation of stock, product and quality audits.

2.3.4 Prevention Costs

These are costs incurred in keeping failure and appraisal costs to a minimum and preventing quality problems arising. The costs of any action taken to investigate prevent or reduce non-conformities or defects and the cost of planning, introduction and maintenance of the quality system would be included in this category. It is reasonable to expect that expenditure here would reduce all other quality costs. Some examples are quality planning, quality audits, process control, supplier quality evaluation and training.

2.4 Quality Improvement

One reason that the competitive position of firms can falter is that the quality of goods and services produced does not meet the customer's expectations. When quality the appropriateness of design specifications to function and use as well as the degree to which outputs conform to the design specifications-is poor, demand for products and services can dimity quickly (Adam and Ebert 1989).

Quality improvement shows that the productivity of a quality system can be measured by its contribution to the profits of a business. The proven key for obtaining the maximum profits available via product quality is the development of a quality

system which can achieve and maintain the competent design of a product and the process by which it is manufactured (Broh 1982).

In addition, improving quality is one important way to maintain a competitive position in the global marketplace. Quality can be promoted to customers and employees. Consumers want quality products and services, and employees at all levels in the organization like to be associated with a winner.

From an economic perspective, when quality is emphasized and subsequently improved, waste is decreased or eliminated. Hours are not wasted reworking products. Material is not thrown away. Operations costs are reduced. At the same time, the customer receives products and services that are "fit" for use (Adam and Ebert 1989).

One of the most fundamental elements of total quality is continuous improvement. The concept applies to process and the people who operate them. It also applies to products. However, a fundamental total-quality philosophy is that the best way to improve a product is to continually improve the processes by which it is made.

Continuous improvement is fundamental to success in the global marketplace. Companies that are just maintaining the status quo in such key areas as quality' new product development, the adoption of new technologies, and process performance are like a runner who is standing still in a race. Competing in the global marketplace is like competing in the Olympics. Last year's records are sure to be broken this year. Athletes who don't improve continually are not likely to remain long in the winner's circle. The same is true of companies that must compete globally.

Moreover, Continuous improvement is not about solving isolated problems as they occur. Advocates of total quality view such an approach as putting out fires. Solving a problem without correcting the fault that caused it-in other words, simply

putting out the fire just means the problem will occur again. Quality expert Peter R. Scholtes recommends the following five activities that he sees as crucial to continuous improvement

Customer needs are not static. They change continually. A special product feature that is considered innovative today will be considered just routine tomorrow. A product cast that is considered a bargain today will be too high to complete tomorrow. A good case in point in this regard is the ever-falling price for each new feature introduced in the personal computer. The only way a company can hope to compete in the modern marketplace is to continually improve.

Improvement must be continuous: "Improve constantly and forever the system of production and service. Improvement is not a one-time effort. Management is obligated to continually look for ways to reduce waste and improve quality" (W. Edwards Damming)

2.5 Seven Tools and Techniques

Tools for quality improvement also enable today's employees, whether engineers, technologists, production workers, managers, or office staff, to do their jobs. Virtually no one can function in an organization that has embraced total quality without some or all of these tools. They are tools for collecting and displaying information in ways to help the human brain grasp thoughts and ideas that, when applied to physical processes, cause the processes to yield better results.

The seven tools exist to help do a job which involves with quality improvement. Each of these tools is some foini of chart for the collection and display of specific kinds of data. Through the collection and display facility, the data becomes useful

information-information that can be used to solve problems, keep track of work being done, and even predict future performance and problems.

2.5.1 Pareto Analysis

Vilfredo Pareto (1848-1923) found that there were a few people with a lot of money, and many people with little money. This unequal distribution of wealth became an integral part of economic theory.

The purpose of a Pareto analysis is to systematically stratify and rank causes or results associated with past performance so as to help us visualize the misdistribution thereof

The numbers of occurrences of the cost of occurrences for specific problems are charted on a bar graph. All occurrences data will be ordered by type, category, or other classification. The largest bars indicate the major problems and are used to determine the priorities for problem solving. This tool will use the bar graph that ranks problems in decreasing order of frequency, was adapted to quality control by Joseph M. Juran.

Moreover, A Pareto chart is a vertical bar chart that displays the relative frequency of the various categories of the problem. The bars are arrayed in descending magnitude from the left to right. The Pareto chart helps to identify the vital few items that contribute to the majority of the problem. As shown in Figure 2.2 the Paerto chart is usually accompanied by a cumulative frequency of percentage line. The cumulative frequency of items starting which the most frequent category and adding the remaining categories until 100%. The focus of problem solving and process improvement is generally on the vital few or the contribution should be 80-20% rule because the correcting or improving the

problem will often has the largest payback. Pareto charts require the collection of the data using Check sheets or the data collection forms. In some cases, the data categories need to be varied in order to uncover the 80-20 relationship.

The procedure for making a Pareto Chart is as follows:

(1) Decide on the subject of the chart. Usually the need to set data priorities suggests the use of a Pareto chart. Determine what data are collected. Where is the problem? What are the categories? Where the data should be gathered? Should they come directly off a line? Should they come from a bin of nonconformance that has accumulated in the specified time period?

(2) Be sure the time period for all the categories is the same: Use the number of nonconformance per hour, per shift, or per week.

(3) What type of chart is needed? Should you track the number in each category, the percentage in each category, or the costs in each category? A cost chart is usually included with either a number chart or a percentage chart.

(4) Make a table by gathering the data and tallying the numbers in each category. Find the total number of nonconformance and calculate the percentage of the total in each category. Make a cost of nonconformance column and cumulative percent column.

   (a) Arrange the table data from the largest category to the smallest.

   (b) Set the scales and draw a Pareto chart.

   (c) Include all pertinent information on the chart. Are the categories clear? Has the time frame been specified?

(d) Analyze the chart. The largest bars represent the vital few. The cumulative percentage line levels off and emphasizes the trivial many. If the chart does not show a vital few, check to see if it is possible to recategorized for another analysis. Refer to Figure 2.3

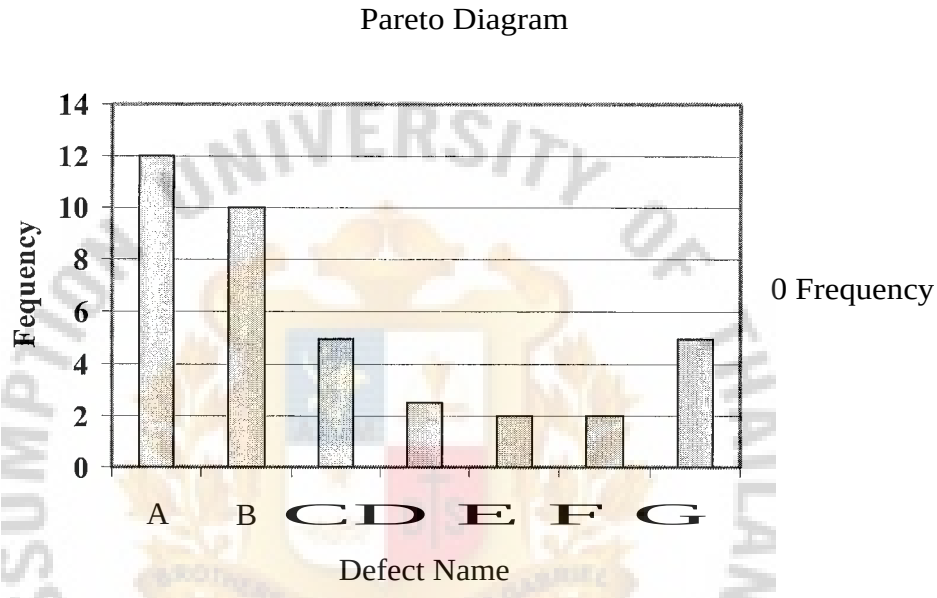


Figure 2.2. Pareto Control Chart of Defect.

(5) Interpret the Pareto diagram. Because of the 80-20 rule, we typically interpret the few categories that produce roughly 80 percent of the cumulative result or cause total.

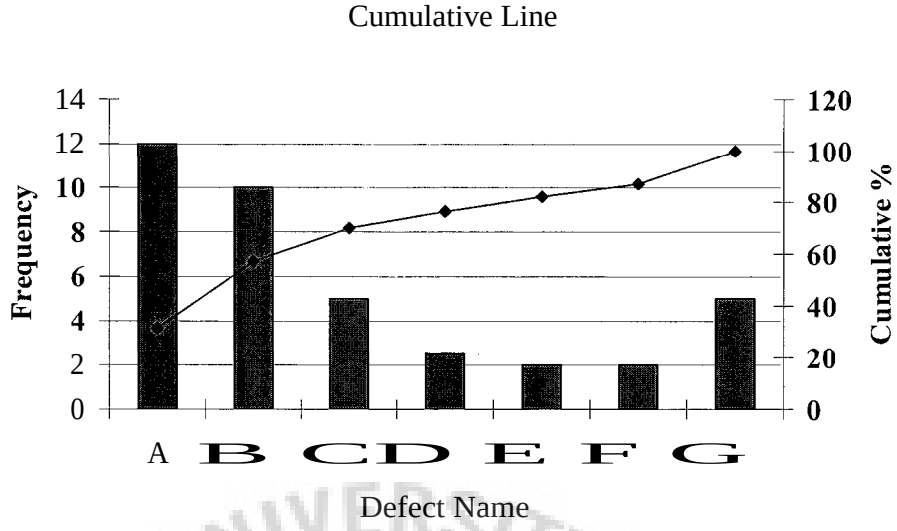


Figure 2.3. Cumulative Line.

2.5.2 Flow chart

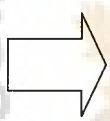
The entire process is diagrammed from start to finish with each step clearly indicated. All involved in the process should know their positions on the flow chart and at least a partial upstream trace from their positions. All should know who their suppliers are and who their customers are in the process flow. Different symbols specify what is being done as it progresses from the input stage to the output stage of the process. When problem exist within a process or process segment, the problem solving team should clearly understand what is being done to the product at the various stages in the process. A complete flowchart should make the step-by-step procedure within the entire team. In addition, the complete flow can help to find the root cause of the problems. The flowchart will bring the product back and forth in the process until the cause of

the problem is found or until several good candidates for the root cause have been uncovered, leading the way to further data gathering and analysis.

Flowchart symbol definition: More complicated processes can be flowcharted with the use of standardized symbols to indicate what is being done to the product. This chart requires that everyone using it understand the symbols.

The process chart symbols used in the illustrations in this volume are those shown and described as follows:

Operation, An operation is performed when an object is intentionally changed in any of its physical or chemical characteristic, assembled, or disassembled from another object. An operation is also performed when information is changed (e.g., mathematical calculations) or when planning or control decision are made.

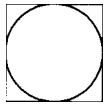


Transportation, Transportation occurs when an object is moved from one place to another, except when such movement is a part of an operation or is caused by the operator at the workstation during and operation or inspection. Transportation occurs between, not within, operational stages of the process.

Inspection, An inspection is made when an object is compared against a standard for quality or quantity in any of its characteristics.

Delay, A delay occurs when conditions (except those that intentionally change the physical or chemical characteristics of the object) do not permit or require immediate performance the next planned action. Objects may be delayed a queue or waiting line before the next stage of the process.

 **Storage,** Storage is affected when an object is retained and protected against unauthorized removal.

 **Combined activity,** to show activities performed either concurrently or by the same operator at the same workstation, the symbols for those activities are combined.

Making steps of flow chart:

(1) Bring together representatives from all departments responsible for the process so they can perform the analysis together

(2) Title the chart with the name of the process analyzed. If there is more than one, diagram them on separate charts and number them sequentially

(3) List sequentially all major steps involved in the process. In some cases it may be easier to start at the end of the process and work towards the beginning However, the flow is always shown beginning at the top-left corner of the chart. Make sure that process boundaries are clearly defined

(4) Using the set of symbols shown in, draw a flow diagram. Concentrate on major processes so that the flow chart will fit on a single page if possible. The chart should represent the way things are, not the way they are supposed to be

(5) When processes are complex, create second and third flow charts as necessary to adequately break down all major processes into the component parts.

2.5.3 Cause and Effect diagram: fishbone diagram (Ishikawa 1990)

A Cause-and-Effect Diagram is a graphic technique used to identify and relate possible causes with effects. The effect under analysis can be either the

current "as is" state that needs to be corrected or the "desired state" sought. Its strength in analyzing relationship lies in the structured way in which it is developed by using categories of causes that help focus attention beyond symptoms to rot, or primary, causes.

The purpose of a cause-effect diagram is to aid in discovering cause and effect by providing a systematic picture of effects and causes. A cause is a fundamental condition or stimulus that ultimately creates an effect or result of some type. Cause-effect analyses are essentially systematic inquiries into potential causes, given an effect of interest, or consequently a systematic inquiry as to potential effects resulting from given causes. Ishikawa developed the concept of the cause-effect (C-E) diagram-also known as a fishbone diagram-as one of the seven indispensable tools for quality improvement.

The first application of the Cause-and-Effect Diagram to Statistical Process control was by Dr. Kaoru Ishikawa in 1950. He found that this diagram was helpful to Japanese personnel in organizing the factors that influence a process. In addition to being called an Ishikawa diagram, it is also known as a fishbone chart because of its appearance.

(a) Effective for team problem solving or dissecting complex problems.

(b) Separates and relates problem causes into logical categories.

(c) Applicable to a wide variety of problems.

(d) Helps to focus attention on the vital few root causes.

(e) Helps to separate causes due to either judgment or execution.

(f) Graphically represents the relationship that exists between effects and their causes.

(g) Participants often finds it easier to generate causes when the effect is the "as is" statement.

Making step of cause-and-effect diagrams

The factors involved in problem with quality at our factories are almost uncountable. A cause-and-effect diagram is useful in sorting out the causes of dispersion and organizing mutual relationships.

(1) Determine the quality characteristic. This is something we would want to improve and control. Clearly state and identify the effect to be analyzed.

(2) Draw the diagram structure (a " fishbone") with the effect in a box at the right side of the head of the fish. The several factors that may be causing the cause, directing a branch arrow to the main arrow to main arrow. It is recommended to group the major possible cause factors of dispersion into such items as raw materials (materials), equipment (machines or tools), method of work (workers), measuring method (inspection), etc. each individual group will form a branch.

(3) Onto each of these branch items, write in the detailed factors which may be regarded as the causes; these will be like twigs. Onto each of these, write in even more detailed factors, making smaller twigs for defining and linking the relationships of the possible causal factors should lead to the source of the quality characteristic. One must check to make certain all the items that may be causing dispersion are included. Group members must speak openly with one another to

adequately construct cause and effect diagrams. If they are, and the relationships of causes to effects are properly illustrated, then the diagram is complete.

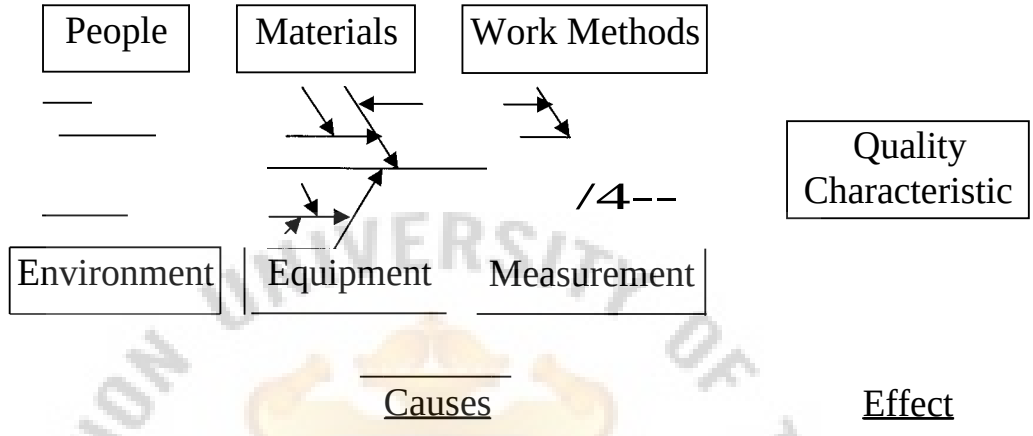


Figure 2.4. Cause-and-Effect Diagrams.

A cause-and-effect diagram is essentially a pictorial display of a list. See Figure 2.4 Each diagram has a large arrow pointing to the name of a problem. The branches off the large arrow represent main categories of potential causes (or solutions). Typical categories are equipment, personnel, method, materials, and environment. You can customize these categories to fit the processes. Smaller arrows, representing subcategories (list items), are drawn off each main branch.

2.5.4 Control Chart

A broken-line graph illustrates how a process or a point in the process behaves over time. Samples are periodically taken, checked, or measured, and the results plotted on the chart. Control charts are the tools that are used in

statistical process control to indicate when special-cause variation is present in a process.

Their use can provide more information about a process than workers with years of experience. They will tell us if a process is showing stable (or consistent) variation. A stable process is often called an in-control process, a predictable process, or a common cause process. It is said to be in a state of Statistical control. An unstable process is also known as out-of-control, unpredictable, or a "common plus special cause" process. A control chart tells us whether or not a process is stable. All processes have the common variation due to common causes.

Common causes are those that are inherent in the process over time; affect everyone working in the process, and after all outcomes of the process. Common causes are at work, the only way to reduce or remove them is make the fundamental changes in the system or the process.

Special causes are those that are not part of the process all the time, do n affect everyone, but arise due to circumstances. If special causes are work, they can be eliminated by attacking their underlying specific causes. Variable control charts use actual measurements for charting.

Average and range chart (x and R) : The average and range chart commonly called the x- and R chart, consist of two separate charts on t same sheet of chart paper. One graph tracks the sample mean and the otter tracks the sample range R. Small samples of consecutive pieces are take the sample size must be the same for all samples and usually consist three to seven pieces. The dimension of interest is measured, and the measurements are recorded on the

chart for each sample. The mean a range for each sample are calculated, recorded, and charted. The chart analyzed as it develops for indications of special-cause variation, and after about 20 samples, it is analyzed again to determine the location, spread, and shape of the distribution of measurements.

Figure 2.5 shows a typical control chart. Data is plotted over time, just as with a run chart; the difference is that the data stay between the upper control limit (UCL) and the lower control limit (LCL) while varying about the center line or average. Whenever a special cause (no statistical cause) impacts the process, one of two things will happen: either a plot point will penetrate UCL or LCL, or there will be a "run" of several points in a row above or below the average line. When a penetration or a lengthy run appear, this is the control chart's signal that something is wrong that requires immediate attention.

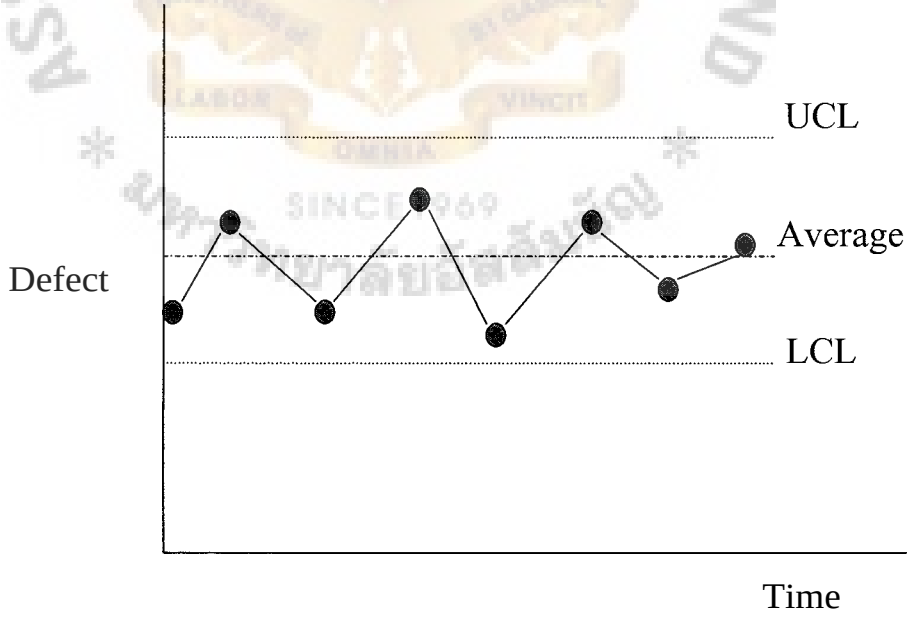


Figure 2.5. Control Chart Diagrams.

As long as the plots stay between the limits and don't congregate on one side or the other of the process average line, the process is in statistical control. If either of these conditions is not met, then we can say that the process is not in statistical control, or simply, is "out of control."

2.5.5 Scatter Diagram

A Scatter Diagram provides a graphic plot of two variables. The data are generally interval data. The resulting pattern, which can range form a shotgun pattern to a near perfect line of data points, indicates the degree of correlation, or strength of the relationship, between the two variables. The existence of the relationship does not infer a cause and-effect relationship, however, since a third variable may be the causal factor. The relationships can be either positive (i.e., both variables increase together) or negative (i.e., one increases while the other decreases); they can also be either linear or non-linear. Correlation determines the strength of a relationship between two variables, while regression analysis is required in order to fit a line or a curve to the data points (i.e., equation of a line or curve determined by the mathematical relationship between variables). Correlation analysis is beyond the scope of this book. The development of a scatter diagram or plot involves several steps:

(1) Identify the variables of interest. Identify the metric, sensor, and data collection means.

(2) Collect the data in multivariate sets. Each set represents one observation and contains one data point for each variable. For example, for a bi-variety set, say X1 and X2, we collect data pairs.

(3) Develop a set of axes. Each variable occupies one axis. Two variables require two axes; three variables require three axes.

(4) Plot the data observations on the axes. Typically, the time order or sequence is not important or noted on the plot.

(5) Interpret the plot. We assess relationships in terms of correlation, looking for increasing or decreasing patterns in the plots. For example, as in Figure 2.6, a position correlation is seen when large values of one variable correspond to large values of another variable. Or, negative correlation occurs when large values of one variable correspond to small values of another variable. No correlation implies a scattered arrangement of points without any noticeable shape or direction.

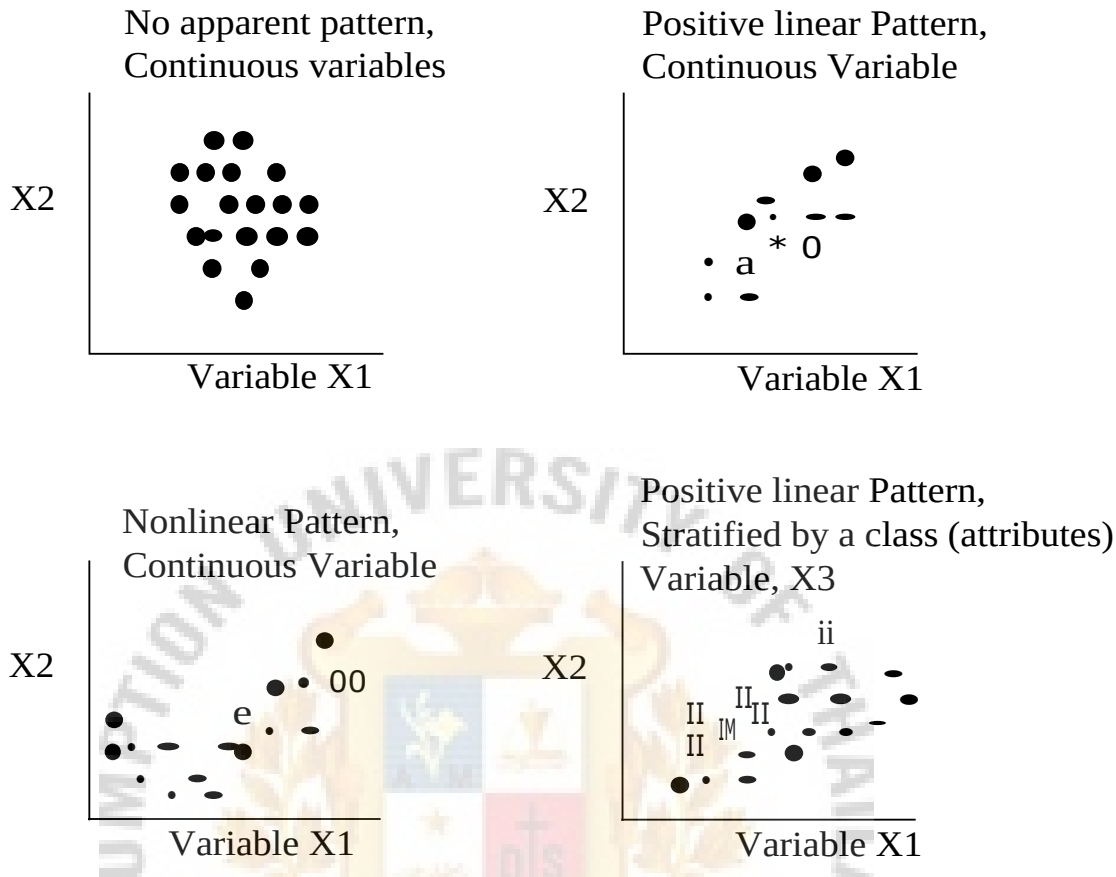


Figure 2.6. Selected Scatter Diagram Patterns.

Scatter diagrams provide a graphic picture of quantitative relationships. The correlation tool described previously provides a counterpart quantitative measure of numerical (linear) association. Patterns that are not of a linear nature, e.g., an arc of some type, are readily apparent on a scatter diagram or plot, whereas they are not picked up with a linear correlation metric (Kolarik 1999).

2.5.6 Check sheet

A data gathering sheet is prepared that categorizes problems or defects. It will consist of a list of the different types of data to be gathered and a column in which to put tally marks or brief descriptive remarks. The heading on the check

sheet should contain information such as the name of the individual gathering data, time frame in which the data are gathered, and any specific information about the source and type of data. Check sheet information may be put on a Pareto chart for prioritized problems or if a time analysis is included, may be used to investigate problem trends over time. A simple check sheet might be designed to collect data in the form of "check marks". The categories in which check marks are placed should be well defined so that there is no overlap between them. Nearly all data must be converted into information. Plotting the data on a Pareto chart, frequency plot, scatter plot, control chart, or other device are common methods of making sense out of data. Another type of check sheet is used in the process, where the check sheet contains a list of specific items that have to be checked if it could contain a picture of the item being inspected with inspection areas highlighted or numbered. Some codes are used to specify the problem area and type of problem product has competition from companies throughout the world because modern communication and transportation have created a world marketplace. The quality of product has to be world class, as good as the best in the world, in order to compete. Consumers are looking for the best combination of price and quality before they buy.

Although the check sheet is a simple tool, it is an indispensable aid in helping to collect data regarding both products and processes. By gather data on the number of occurrences of various issues, problems, inputs, outputs, or outcomes during specified time periods. Record occurrences of activities such as works or inspection in a variety of categories by shift or machine during a sampling time period. Count errors or failure by type during a time period. It is

extremely useful in initial data collection and monitoring for process improvement efforts.

2.5.7 Histograms

A Histogram is a chart that displays the frequency distribution of one characteristic of data form a process. Unlike the Pareto chart, which generally displays nominal data, the Histogram is used to display the patterns of variation of either discrete or continuous data. The picture of data shows the patterns of variation, which helps in order to understand the process. Histogram is created by dividing raw collected data into equal intervals. The number of measurements falling into each interval is counted and bars are then constructed so that their heights are proportional to their frequency of occurrence. The histogram thus produced graphically illustrates three characteristics of these raw data that are the central tendency or average, the rage and the shape of the data. Usually data fall into a bell-shaped curve called the normal distribution as in Figure 2.8.

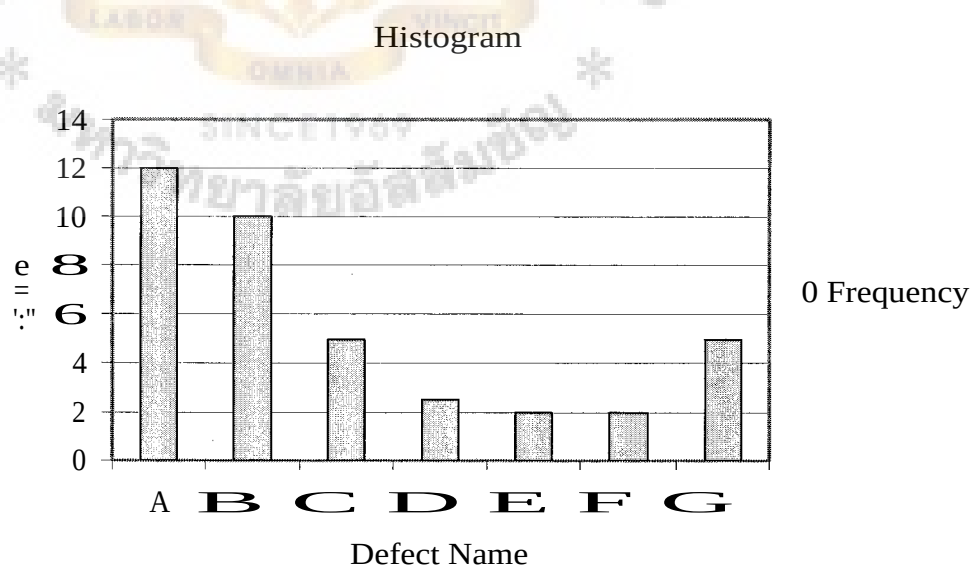


Figure 2.7. Histogram.

2.6 Why-Why Diagram

The Why-Why diagram, an excellent technique for finding the root cause(s) of a problem is to ask "why" five times. It is the method for determining what factor has to be in place in order to respond to an opportunity. The why-why diagrams organize the thinking of a problem solving group and illustrate a chain of symptoms leading to the true root cause of the problem (Summer 1997). At the end of a session it should be possible to make a positively worded, straightforward statement defining the true problem to be investigated. By using the why-why diagram, the focus group can gain a clear picture of the interrelationships of the cause and the problem.

For the Why-Why technique, the why-why diagram flows from left to right. The diagram will start on the left with the statement of the problem to be resolved. There may be only one cause or there may be several causes that can be separated or interrelated. Regardless of the number of causes or their relationships, the cause should be written on the diagram in a single, clear statement. The investigation is continued through as many levels as needed until a root cause is found for each of the problem statements and the original problem. At the end, this process leads to a network o - reasons why the original problem occurred. The ending points indicate the area the needs to be addressed to resolve the original problem. The Why-Why diagram can be expanded to include notations concerning who will be responsible for action items and when the actions will be completed as in Figure 2.8.

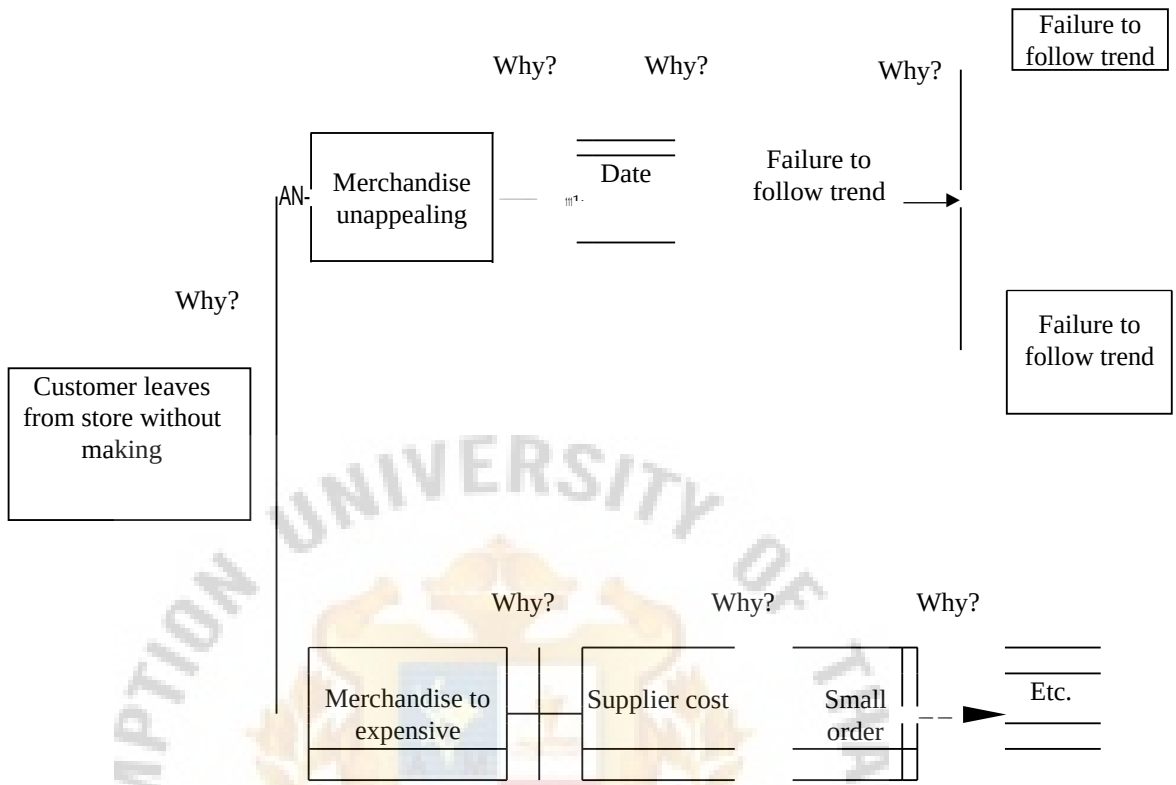


Figure 2.8. Why-Why Diagram.

III. OVERVIEW OF OPERATIONS

3.1 Company Profile

World Wide Brush Co., Ltd. is one of the most experienced manufacturers of house ware and brush products. The company has provided a number of high quality brushes for nearby 40 years. World Wide Brush was first founded in 1973. In addition to brushes, World Wide Brush also makes woodenware. The wooden factory is located at 54 moo 10 Soi Petchkasem 81, Petchkasem Rd., Suangluang, Krathumban, Samutsakorn 74110

For more than 14 years of experience and proficiency in manufacturing and distributing these products, World Wide Brush has understood and is more concerned about the needs of our customers in every country. In addition World Wide Brush now has satisfied customers in more than 60 countries worldwide. To scope with the rapid market growth, World Wide Brush uses rubber wood from plantation forest, a renewable resource in our production. A major portion of our production of wood heads for the US, the European, and the Japanese markets where quality is the major concern. We have a team of industrial designers and graphic designers in-house to constantly create new products, new designs, and new packaging. World Wide Brush is capable of production to any specifications with any customized packaging. Moreover, World Wide Brush's policy is centered on satisfying the customers' demand. Among the essential areas of emphasis of our wood factory, the four key areas are quality, value, service and variety.

3.1.1 Quality

The quality of wood products including the wood materials, the coating and staining materials used, and the workmanship is consistent and of fine

quality. World Wide Brush employs strict quality control with proper statistical techniques at every process of production. The incoming materials, work-in-process, and finished products are tested and inspected to conform to standard requirements.

3.1.2 Value

World Wide Brush concentrates on making sure that our customers receive the best value for their money. In addition, World Wide Brush always keeps adding value to products and also has a product combination of wood and glass. Other combination ranges will be added continuously.

3.1.3 Services

World Wide Brush services start from fast response. They provide timely samples, and samples making case of custom design. They have well over 2,000 meter of indoor storage space for only raw materials to make sure that they have continuous supplies of raw materials even in the rainy season when raw materials become scarce. The labor pool in the area is abundant. All of these are to ensure punctual deliveries.

Then documentation is precise, and all after sales services are conducted in a timely manner.

3.1.4 Variety

As they do carry a wide variety of items in product lines for the customers to choose from, they can cater to both large scale customers as well as medium-sized and small ones. They are flexible and able to deliver many items in one container in accordance with the customers' demand to save the customers' time as well as energy under the slogan "ONE STOP SHOPPING".

Contact us and let us discuss your specific needs and requirements today. Large and small orders and customers' specifications are welcome.

3.1.5 Objectives of the Company

(a) To provide high confidence and acceptable products for customer satisfaction in both domestic and international markets.

(b) To compete in today's global market for an increasing market share

(c) To develop new business in order to increase profits and to reinforce the stability of the company

(d) To make a step forward to global standard

3.1.6 Business Plan (Strategies)

(a) To emphasize direct sales

(b) To make a step forward to global standard by developing and competing in today's global market for increasing the market share

(c) To produce mostly paper for its affiliated company

3.1.7 Marketing Plan

Marketing Plan of the company is continuous quality development and quality improvement of product for high quality and standard. All customers of the company are in the domestic market. The company will give high priority and more importance to the affiliated company than outside customers.

3.2 The Process of Operation

3.2.1 Ordering Raw Materials

The company will order raw materials for production when it receives the order form the company's customer.

3.2.2 Inspection of Quality of Raw Materials

When supplier delivers the raw materials in accordance with the order, the company will check and inspect the raw materials for standard with pre-agreement. If the raw materials are non standard according to pre-agreement, they will be returned to claim to supplier. However, if they have real standard quality, the company will keep it in warehouse for production.

3.2.3 Production

When the raw materials pass inspecting quality, they will be used in production of all kinds of products.

3.2.4 Inspection of Quality of Finishing Products

After finishing production, the company will check and inspect all kinds of products to see whether they have standard according to pre-agreement with customer or not. If the products have standard according to pre-agreement with customer, the company will keep it in warehouse for delivery.

On the other hand, if they are substandard, the company will correct and improve until they are standard. And then the company will keep it in warehouse for delivering to customer. But if the products still are substandard after improvement or the company cannot improve, the non standard products will be forwarded to convert to other kinds of products. Figure 3.1 shows the process of operation of the company.

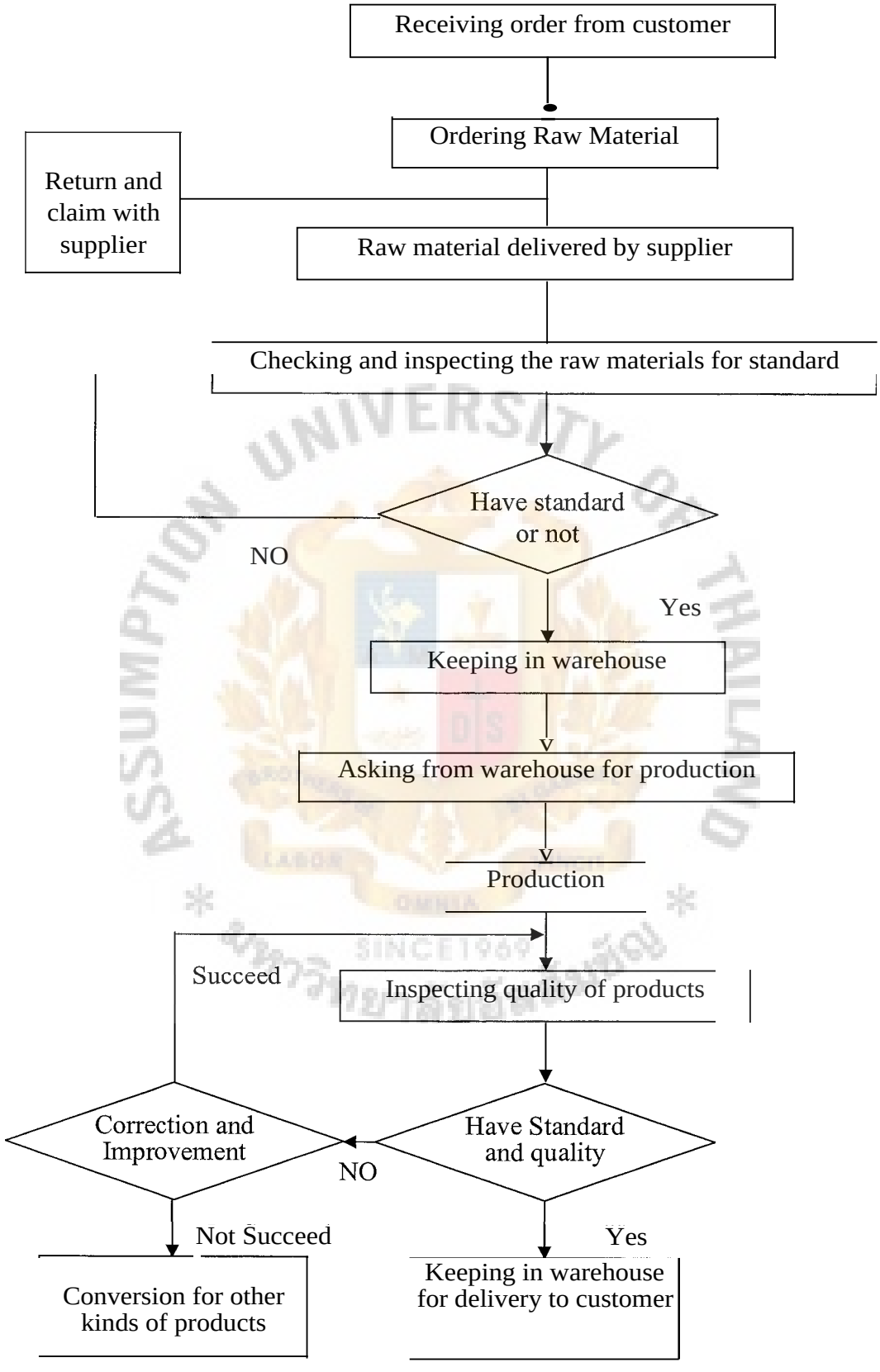


Figure 3.1. Process of Operation.

Moreover, the researcher would like to describe the overall production process and station concerned in wooden ware manufacturing. Normally, the company orders parts which have been already formed from the approval customers for both direct and indirect materials. The direct materials include the wood, board and color for painting. The indirect materials include the screws, glue and nail. These parts are categorized as the work in process units in the final process. However, the company also orders the raw material to be processed in its own plant facilities as other parts for final process.

In order to improve the quality of output and achieve customer satisfaction, the company has many quality controls for every production unit. Wooden ware Audit station is the final inspection audit of finished goods to assure that the finished goods conform to customer specification and requirements before being shipped to the customers.

IV. QUALITY IMPROVEMENT PLAN AND EVALUATION

Nowadays, the business of wooden ware industries is highly competitive. There are many wooden ware manufacturers increasing in the market. So the way to survive or run the business in this situation is to produce cheap price but high quality. Quality is the key to success in today's rapidly changing world and for customer satisfaction. The way to build the product at cheap prices is by reducing the cost which is the way to reduce the number of failures, waste and nonconforming finished goods in the production. We are talking about quality control which creates high confidence and customer satisfaction.

Quality control for customer satisfaction is customer-defined quality because customer is the god. The key to an effective quality control is its focus on the customer, both internally and externally. An excellent place to start is by satisfying internal customers. We must listen to the "voice of the customer" and emphasize to design quality and defect prevention. Does it right the first time and every time, for customer satisfaction is the most important consideration. All above statements are the idea about quality control in business survival era. Hence, the project uses this idea for tile basis of all analysis.

To make appropriate quality control system, it is necessary to know firstly the situation of quality problems that the company encounters. When we already know all quality problems, we use significant statistical tools and techniques to solve the causes of problems. The exploration of the situation of quality problems developed further detail in the following:

4.1 Problem Solution Requirements

The Wooden ware audit station has no formal report to identify the main defect. So, this project will use proper techniques to focus on the main defect by using the data collection at Wooden ware audit station. This project needs to minimize the defects of the Wooden ware, controls and improve the quality of the Wooden ware. On the other hand, Wooden ware audit's responsibility for quality control can also decrease the internal failure cost; return, rework, and replacement.

However, the project steps are classified into several steps which are as follows:

(1) Data collection

Firstly, this project has focused on one Wooden ware model which is Model A at Wooden ware audit station. The data has been collected for 1 month and focused on two significant inputs. These are defect quantity and defect types of Wooden ware audit.

(2) Pareto analysis

The Pareto chart will be employed to recognize the problem and establish the problem priority. These tools can only define which problems exist and which one should have the highest priority. In general terms, at this point in the problem-solving process, the specific problem has not been clearly defined.

(3) Defining the problem

After the main defects are defined, the why-why diagram will be implemented. This method will determine what factors have to be in place in order to respond to the opportunity. It organizes the chain of

symptoms leading to identifying the root causes of the defect. This will explain how to fit the possible root cause.

(4) Analyzing the problem and process

In this stage, the possible root cause is determined and the involved production process will be measured. All information has been gathered by trial and error and analyzed what happened at the Wooden ware audit station and recorded the defective Wooden ware for 1 month. In addition, all information will be used to generate possible solutions.

(5) Developing solution alternatives

After the concerned processes are defined, the possible solutions will be generated. This project will focus on the maintenance program which are the preventive and the predictive maintenance program.

(6) Implementing the solutions

The potential solutions have been defined in order to judge whether or not the implementation of the SPC tools would be helpful to the production process.

4.2 Data Collection

Data collection is the beginning step to identify the main defect. Prior to Pareto analysis step, we need to get two components of Pareto which are the types and the number of defect occurrence at the Wooden ware audit station. The data will be collected daily within one month. We focus on only one model which is model A at the Wooden ware audit station. The data will be collected in the fon 1 of a daily record as Figure 4.1. Then all records are concluded at the end of month to summarize the defect types, summation of quantity of each defect, inspected quantity, and the defective part

per million (DPPM) as shown in Table 4.1. The DPPM is calculated by using the formula as below:

$$\text{DPPM} = \frac{\text{Defective Quantity x 1,000,000}}{\text{Total Inspection Quantity}}$$

$$= \frac{52 \text{ X } 1{,}000{,}000}{5{,}000}$$

4.3 Pareto Analysis

After I have collected the defective wooden ware for both defect quantity and defect types of Model A for one month period. I present this data by using the Pareto charts. The data gathered gives the defect types and the number of occurrences for each defect.

Table 4.1. Summary of Model A Wooden Ware Audit Records.

Defect	Defect Quantity	Defective Rate (DPPM)
Large Gap	15	3,000
Poor Color	6	1,200
Bending	8	1,600
Poor Surface	10	2,000
Wrong Alignment	5	1,000
Total	44	8,800

Firstly, I make the table by gathering data and tallying the number in each category. Then, the percentages and cumulative percentage will be tabulated. The main

defects have the highest number of occurrences from the table. The category is listed by the number of occurrences.

Refer to Table 4.2. The percentage column shows Large gap 34 %, Poor surface 23%, Bending 18%, Poor Color 14% and Wrong Alignment 11%, respectively. We can monitor that the main defect is large gap because the number of occurrences has the highest frequency.

Table 4.2. Summary of Model A Wooden Ware Percent Cumulative Audit Records.

Defect Category	Number	Percent	Cumulative %
Large Gap	15	34	34
Poor Surface	10	23	57
Bending	8	18	75
Poor Color	6	14	89
Wrong Alignment	5	11	100

This is prioritized by the descending order which is as follows:

(a) Large Gap which is described as incomplete character, wrong alignment, and character distortion. This defect is concerned with process.

(b) Poor Surface refers to the wooden ware which has a failure in process. The surface does not smooth hence feeling's customer do not good for the product.

(c) Bending which describes that the woods are not good when they picked up. We must have more force while they picked up the materials.

(d) Poor Color is the defect in which the manpower is not active after painting the wooden ware.

(e) Wrong alignment which occurs when the operators insert the wood in the cut machine which does not clean the saw cut. After we look through the wooden ware from left to right viewpoint, we will see a button if standing in an abnormal position.

All of this information is shown in the Figure 4.1, the categories are ordered from largest to smallest occurrences. The left scale tracks the number of defects per category with the bar graph which are the large gap on the wooden ware, poor surface, bending, poor color, and wrong alignment and the right scale tracks the accumulated percentage of all defects with a line graph. Eventually, sum of the cumulative percentage must be 100 percent.

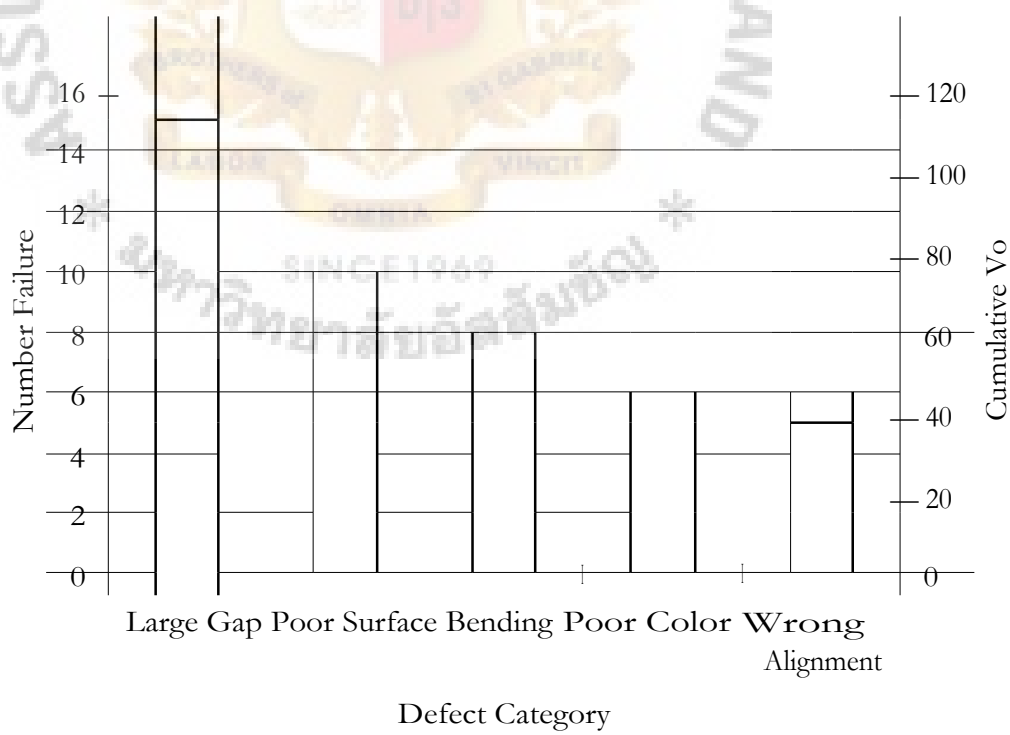
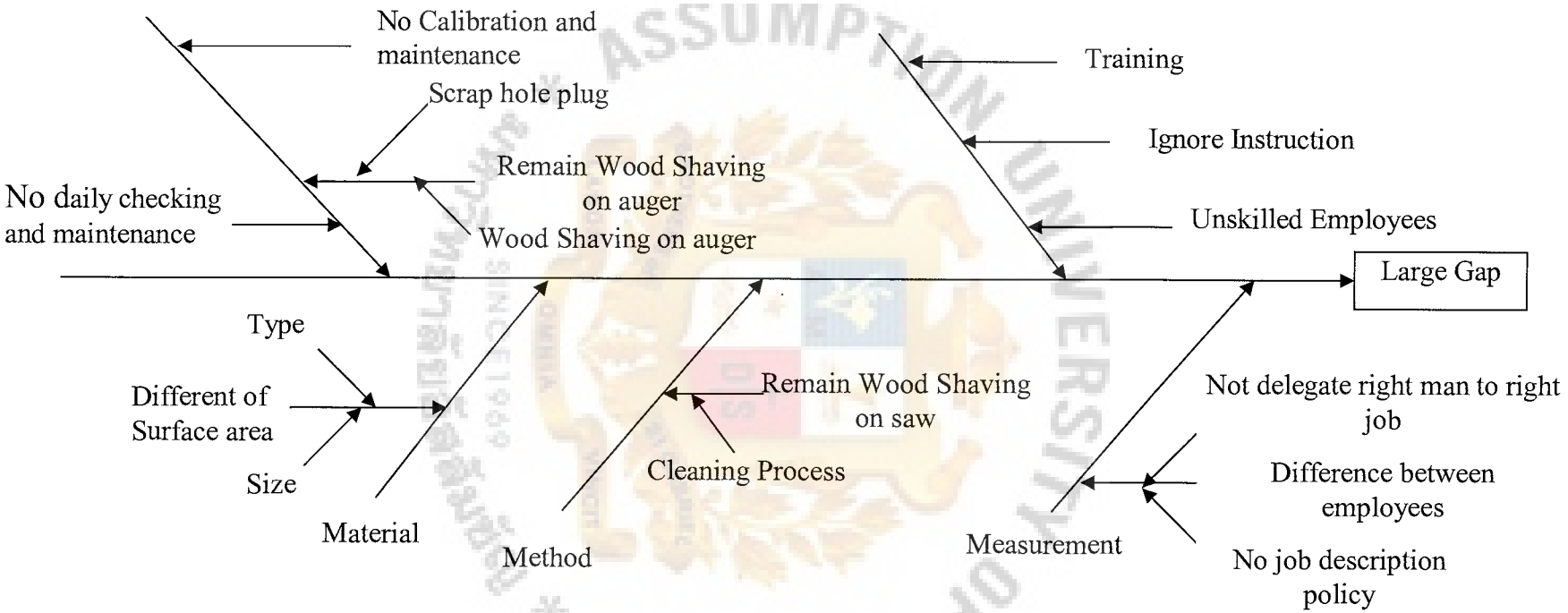


Figure 4.1. Pareto Chart of Defect Priority.

4.4 Cause and Effect Analysis

From the main defect investigation by Pareto diagram, it can identify the involved process, and then define the possible problems. In the case of this project, the main defect is large gap. Thus the researcher will solve large gap defect and improve quality.

The reject sample of large gap are investigated and found that most character of large gap is at around joint. From analyzing at such joint areas, the researcher found that it is large gap that occurs from drill of wood because such hole areas are drilled by auger of drill process. Then drill process will be analyzed to find out the root cause by cause and effect analysis. The application of cause and effect analysis will show and identity the problem, which may concern and be the root cause of large gap as shown on figure 4.2 about cause and effect analysis, it can be called "Fishbone Diagram"



Cause and Effect Diagram of Wooden Ware Defect.

4.5 Analyzing Problem and Process Concerned

With reference to the preceding part, the problems are defined and the related symptom are expressed in Cause and Effect Analysis or Fishbone Diagram in Figure 4.2, the problem of large gap will lead to the root cause and the process concerns. There are two parts of Fishbone Diagram which concerns large gap as machine and method.

(1) Method

About large gap problem, we mean technique or method of operation during working. Refer to Figure 4.2 again; it displays the probable root cause, which influences large gap.

Firstly, Frequency of cleaning is not enough. We observed the symptom of large gap and met that there are remaining scraps, which occur from cutting of previous shot. Normally, the operation of drill process is to blow the surface of auger every 100 pieces by air gun.

From original operation about blowing, it can assume that is not enough for blowing every 100 pieces. Because there may remain scraps before next time blow arrives. Researcher means from second shot in first pieces until last shot in 100 pieces. It can remain scrap for cutting and affect large gap problem.

(2) Machine

Researcher means tool or equipment, which is used to produce the product. In this project, tool that is the cause of large gap is drill process. From Fishbone Diagram, Figure 4.2, it can identify the probable root cause into two ideas, which are as follows:

(a) Scrap hole plugs

From assumption of symptom in that there remain scraps on surface of auger, researcher understands that scrap holes which are used

to drop scrap into the bottom plug and may concern with size of scrap hole which may be small so that scrap can not drop to the bottom and is the cause of large gap later.

(b) Remain Wood Shaving on auger

From both assumptions, it creates idea to solve large gap problem that there are few scraps which are in the surface of auger or on the product sheet. Scraps, which occur from wooden drill, may attach at the end of drill so that it is the cause of jumping on the large gap later.

Furthermore, the problem analysis, identifies that the problem may occur when the equipment is damaged or dirty, improper equipment and machine set-up or adjustment, and dirty materials. However, all possible root causes are concluded and shown on the fishbone diagram. The fishbone diagram will separate the root cause into four parts concerned. These are man materials, methods, and machine, Figure 4.2.

The first item, Man the problem may be concerned with improper training and the instruction ignorance due to people who lack basic knowledge.

The second item defines the problem of the materials which are the button type and different surface areas.

The third item concerns the machine and equipment.

The fourth item concerns the method of cleaning and pressure setup.

The fifth item concerns the measurement

4.6 Analyze the current situation

To improve the product quality, this project will focus on the preventive program to solve and protect the large gap defect. Refer to preceding part, both the problem and the root cause are identified by technique of Pareto Diagram and Cause and Effect Analysis respectively, in order to meet the main factors and select the solutions to solve large gap problem.

About the project, the researcher will implement all three causes and will select only the solution, which is effective to produce in mass production and become benchmark for other products, which may have the same problem.

From studying the factory's actual status and working condition, operation of company and wooden ware making process, I use the information to list the situation of quality in factory. The various problems in factory are caused by not appropriate quality control system. The situation of the factory is summarized as follows:

(1) The customers including both affiliated factory and outside customer frequently blame and claim quality of company's products because the products have non-complying standard.

(2) 5 M factors involving man, material, method, machine and measurement are not in controllable circumstances.

(3) Some workers are unskilled and misunderstand the quality.

(4) The company makes weekly checking for state of machine. However, the company has no maintenance and revision for expired equipment and accessory. The expired equipment and accessory are still continuously used until they are out of order. Hence, the company changes to a new one.

(5) The company has directly no quality control department and quality assurance department.

There are no specific parameters to be selected to control the quality of the product. The quality of the product based on personal technique that needs more experience.

Quality is defined by customer satisfaction and customer is the god, the company must solve the cause of problems in order to create high confidence in company's finished goods. From the related information of the company, I analyze many possible problems including the following:

(a) Delivery problem: In this case, the problem occurs during delivery of the product. It leads to damage. For example, dash during delivery to customers causes the damage in edge of wooden ware. However, defective product is compromised by customers and has a few amounts. So I don't consider this problem in analysis.

(b) Storage problem: The storage problem is greatly influenced by moisture within warehouse; as a result, the wooden ware is humid. However, this problem seldom occurs. I also don't consider this problem.

(c) Late delivery problem: Some times the company may deliver the product late to customers but this problem is compromised by the customers. I don't concentrate on this problem.

(d) Nonconforming products; problem: Nonconforming product is a serious problem that affects directly the customer satisfaction and increasing cost of the company. On account of nonconforming products, when customers receive defective products, the customers will send document indicating defective products to the company. The company contemplates mistakes

in product and offers discount on price of products for the next order to the customer. However, the customers still aren't satisfied and sends document again for claim. Most customers will reduce volume of the next order and request to use the price of defective products in order to discount and to offset the price of products in the new order. This activity indicates that the customers don't trust the quality of company's products. Consequently, the company will lose the market share and the customers. In the case of increasing cost, the company checks and inspects all kinds of products before being shipped to the customers. If they are nonconforming products, the company does not ship them to the customers. Nonconforming products will be corrected and improved until they have standard. However, if they still are defective after improvement or the company cannot do it, they will be shipped to the affiliated company for conversion to other kinds of products. All the above processes increase costs and expenses of the company.

First of all we will refer to step I after one month of collecting data. There are 5 types of failure in this factory. The frequently found about 34 % are the large gap. The failure of the product is always found after passing the drilling and cutting step that is the critical process. There are the parameters related to the quality of the product in the drilling and cutting step, time and surface area. The large gap is the failure that is frequently found. So the worker must set the time to rework the goods until it passed the specification. It may consume time and lose profit. In step II we knew what is the other point that we can improve the product to meet the customer satisfaction by setting the exact specification between the entrepreneur and the

customer. In step III, following the cause and effect diagram the root cause of burned failure can come from 5 major categories:

(1) Man who are the operators or the workers including the entrepreneur? They are used to doing trial and error in the simple way. There are no fixed parameters that we can identify to be important in the wooden process. Even if they know what the related parameters are, they cannot apply them to use to prevent the failures. This is because they don't understand the basic knowledge of the wooden ware process. The operators don't know the application of the related parameters. They do not have the training of the basic knowledge of process. So the quality of the work is not good enough. Therefore the supervisors and operators should have course for basic wooden ware knowledge for better understanding in order to carry out the work more efficiently and effectively. Besides training, the workers do the monitoring of the parameters for checking the deviation of each parameter by using the charts as tools.

(2) Method, This is important because it can cause the defects, as the operators don't have the knowledge or the procedure of drilling and cutting. Then they carry out the wrong method and cause defects. When the new product is ordered, operators normally go back to the historical data or the old product for information. The information, which is obtained from the old product, is not the same. They gave only guidelines about the parameters. After that operators will set the experiment and observe the result. The operators look through the deviation and adjust the parameter until they get the optimum point.

However the large gap which is the most critical in this factory is caused from the method

(3) Material, The different size, surface of wood is the cause of defect. It means that operators shove the woods, which have different surfaces in the same. Therefore the quality of product is not good because of the difference in sizes and surface, therefore the method to shove wood should be changed to the same size.

(4) Measurement. The concerned parameters which must be measured in order to get the exact value are the size of wood. The accuracy and precision of value that we measured are important. If they deviate, it will cause defects to the product.

(5) Machines. There are measurement tools and equipment.

The important quality problems and the analysis of those problems for identifying their symptoms. I will provide the analysis of possible root causes of quality problems and propose alternative solutions for solving the quality problems.

4.7 The Analysis of Causes of Quality Problems

When considering the operation process chart shown in Table 4.1 quality inspection process involves inspecting quality of products, process of inspection and employees who have duty to follow the inspecting step. As a result, the theoretical opportunity of nonconforming product or defective product delivered to customer is zero. This will ensure the quality of finished products.

However, in practical process of the company there are many nonconforming products delivered to customer. The quality of finished products is not standard. When considering the cutting device which is a manual system, there is no calibration comparing with standard before inspecting and no resolution for the difference.

Therefore, some error occurs from the cutting device and the method of inspecting done by employees.

Employees who work in inspecting process, I discover that the aim of this process is to inspect the value of every wooden ware. For each product, the inspection is made randomly at only the head and the end of the process and cannot make the other parts of the process because the customer accepts wooden ware not exceeding three times in joining Moreover, in the step of cutting and drilling randomly the wood into five parts, sometime the employees do not make any sampling because they are overconfident and careless and they want to work quickly. So the error occurs because of employees' mistake. We can conclude that the practical inspecting process of all wooden ware does not exactly follow the right step.

However, the employees' mistake in inspecting process is not regarded as an important cause of nonconforming product problem. It is regarded as the quality assurance to the company's finished products before delivering to customers. So it is not a root cause of problems.

When I study the symptoms of non-complying gap standard by using the information from wooden ware making department and stock preparation department, I find that non-complying gap standard depends on five factors which are man, material, method, machine and measurement. The causes of non-complying gap standard are shown in a form of cause and effect diagram in Figure 4.2.

Employees don't pay attention to work and don't care for the problem because it can be solved by reworking.

According to the concept of economics, it said that the right correction of problems is to handle the major causes not the minor causes. As a result, I concentrate to find the major causes of the problems, which effect the quality of the products.

Studying the related information and interviewing opinion from factory supervisor, high skill and experienced employee, the major causes of the problems in wooden ware process shown in Figure 4.2. come from three main reasons which are:

(a) Unable to control the materials

(b) No job description policy for employees

(c) Unskilled employees

I analyze that non-complying gap standard occurs from these three main reasons mentioned by executives of the company. Therefore I analyzed the three main reasons as follows:

4.7.1 Unable to Control the Materials.

At present the problem of non-complying wooden ware standard is caused by inability to control the quality of materials which are ordered from outside or outsource. Consequently I study the factory's actual status including working condition of materials in order to prove that the problem is a result of uncontrolled quality of materials.

From the survey in working condition of wooden ware process, I follow up to survey the method and step for working of employees in the performance which does make any effect to the quality problems and study specially. The consideration follows the information collected from factory supervisor, chief and skilled and experienced employee. I also study the factor of the difference between employees in each position and its effects on the quality of company's product. There is no significant cause of the quality of product but the non complying wooden ware standard still occurs. Therefore, I studied further on the condition of machines.

From the study of the condition of machine based on report and interviewing the supervisor who works in the charge of maintenance, I find that the machine usually works in the time; however, the non-complying wooden ware standard still occurs. So I conclude that there are other causes of this problem, which come from material, method and measurement.

Furthermore, the chief and the employees who are in charge of inspection will spend only two or three hours per shift, not all the time, to walk around the woodenware process. If the quality problems occur within the time when nobody walks to inspect, the process will not recognize the problem. Therefore, I can conclude that at present there is no standard for quality control at this process and when the problems often arises, it is too late to make any correction.

4.7.2 No Job Description Policy for Employees

Under the assumption, which the management made, the quality problems may occur from the steps of working or job description; therefore, I also study this area to prove its effect to the quality.

From the survey I find that the employee can do his job smoothly and there is no problem. So I recognize that the problems may arise from human errors I think that if the employees in work according to the steps of working or job description, the problems will not occur because the outputs have standard. Then I ask for document identifying the steps of working or job description but such document is not available. I have to ask the employees directly about their job in each step. I find that each employee understands and performs the steps of working and has knowledge differently. Then I asked the supervisor about the right steps of working and also asked whether the company set the job description for practice or not. As a result, at present the company has not set

any job description for practice. The new employees have learned the methods and the steps of working from prior employees to perform their jobs.

On account of the above analysis I can conclude that the company has not provided any job description for employees, which effects the knowledge and understanding of their jobs and the steps of working. Each employee works in his own way. As a result, there is difference between the employees in the same level of position. The result of their performance is different and finally effects the quality of the company's product. Therefore, lack of job description policy is one of the reasons, which makes the problem of non-complying standard.

4.7.3 Unskilled Employees

From the assumption, one of many reasons that effect the quality may arise from the lack of knowledge among the employees and unskilled employees. Then I surveyed the condition, procedure, steps and technique of working and also interviewed the employees about their work in order to prove our assumption.

Furthermore, I find that most employees have long years of working with the company and have not too high a level of education. The style of their working still sticks to old concepts about productivity and quality. They think that good working is the effort to put for high volume and productivity and to speed with no concern of the quality. Although some employees think about the quality, their knowledge of woodenware and technique of production is in the low level. From the interview of the employee, I notice that they have one common opinion, that is, the goal of working is to produce fast and high volume of products. However, in fact the production of quality has certain steps of

procedure and also depends on many factors concerned. The employees should know their work effect to other parts of the operation and on the quality of product as well.

Although some employees possess knowledge and know how of the technique, I find that these people still perform to effect the quality because they have wrong concepts of working. Most of them think that the aim of working is to produce high volume of productivity to meet the requirement of the management and to put no concern on the quality. This thinking is wrong and it is against the objectives and policies of the company. It also shows that most employees still lack quality knowledge for modern marketing and do not know and understand the objectives and policies of the company as well.

From the analysis above, most employees still lack knowledge. They do not know and understand general knowledge of woodenware, the step and procedure of production, technique in production and the concept of quality control. They also lack the capability of adaptation their working behavior to meet the objectives and policies of the company. So the question is whether the company provides enough training to its employees to perform their jobs well or not. I interviewed the supervisor about this matter and get the answer that the company does not provide any training or make any advice about the jobs. Most employees have to learn by themselves from asking among employees and prior employees. Therefore, I can conclude that the lack of knowledge among the employees and unskilled employees has effect on quality of the output paper. This is one of reasons for the problem of non-complying standard as well. Thus, this problem has to be solved immediately.

4.8 Immediate Corrective Measures for Solving Quality Problems

From the analysis of causes of problems in item 4.7, unable to control the quality of stock that was inputted to the wooden ware making process, no job description policy and lack of knowledge among employees are the important root causes of the quality problems of non-complying standard. To solve the problem for increasing quality reduces number of failures, waste and nonconforming finished goods in process. Therefore, alternative solutions to solve the causes of quality problems are developed by using 5 W 1 H methods in order to provide the quality improvement in the process.

In the evaluation for alternative solutions we have to consider firstly these three factors:

(1) The effect of solution, it means that the chosen solution can solve the problem effectively.

(2) The feasibility of solution in terms of technique

(3) The solution must be economical

The suitable solution must meet these three factors of constraint; however, there are some additional constraints concerning the conditions and limitations of the company itself. The management has set the following conditions which are:

(a) The liquidity of the company; at present the company has some financial problems.

(b) The management does not want to change the production process because the management believed that the present process has been adjusted properly.

(c) The knowledge of employees

(d) The limited responsibility of employees that the employees in the wooden ware department have responsibility only in their department. They have no responsibility for stock preparation section.

From the above conditions, I will make further analysis of alternative solutions for the current quality problems.

Table 4.3. The Proposed Plans Solution.

Categories	Causes	Solutions
Man	1.Untrained operator 2. Operator lacking knowledge of process	Provide training of the process and company policies. Inspecting employees.
Method	Large gap	Provide job description policies.
Measurement	Not accurate and precise	1. The tools should be calibrated and maintained. 2. Provide the proper tool.
Machine	Remain wood shaving on auger	1. Daily checking and maintenance including calibration. 2. Cleaning and pressure setup.
Materials	Different surface area and size	Inspecting materials during delivery from suppliers

4.8.1 The Solution Alternatives

The alternative solutions are only the opinion and suggestion for improvement. I hope that this will contribute to the company in the production planning and training in the future.

From the cause and effect diagram shown in Figure 4.2., we will see that basic weight problem which is non-complying standard is caused by five main factors, man, material, method machine and measurement. Therefore, I make suggestions for improvement into five parts.

Man is the first part. The improvement should be provided by training shop floor employees and inspecting employees. The training should emphasize the right procedure of job and the quality control of both raw material and finished products.

In raw material part, the management and the stock preparation department must pay more attention to assigning employees to inspect and quality control the condition of stock. This way will solve the problem of inability to control the quality of stock. Furthermore, the management should inform the objectives, scope and problems of work to all employees.

For method of working, the company should provide job description policy for each employee. When they know and understand clearly the steps of working, the quality problems in the process will be reduced. In part of machine, I suggest to renovate and replace the old machine and equipment by considering the breakeven point and the return on investment. Moreover, the company should have daily inspection of the running of machine and weekly maintenance in order to check the condition of machine and equipment.

The last part concerns measurement system. I consider the improvement in two parts, the measuring device and the employees in charge of measuring.

(a) For measuring device' there are many problems in this area. The old measuring device is inaccurate, inefficient, and unsuitable for measuring area; as a result, employees do not know certain quantities. Therefore, the company should purchase measuring device which is necessary to use in quality control such as the measuring device for inspecting the quality. These measuring devices should have yearly calibration to check its accuracy.

(b) For employees in charge of measuring, the company should assign the position to do this duty by delegating the right man to this position. In addition, the company should prepare instructing

document and guide lines to perform the job and also provide training.

4.8.2 Performance Evaluation

The company can make evaluation for performance in three ways, which are:

(1) The evaluation can be made by considering the data record about the quality of product whether the volume of defect decreases or not. If the quality improvement is efficient, the defect will decrease.

(2) The evaluation can be made by observation and follow up of work performance to see whether the employees always follow strictly work instruction or not.

(3) The evaluation can be made by surveying the opinion and attitude of employees about job training whether they have better understanding in their work or not. This can be done by preparing the questionnaire.

If the result of evaluation shows that the control plan mentioned above is efficient, it will contribute to the benefit to the factory and decrease waste. Then the company should set standards to become more concerned to gain maximum efficiency. The company should remind that the development must be continuously done and attempt to improve practically in the production process.

4.9 Solving the Problems in the Future

At present the company has many problems which concern the quality of product. In most problems the company cannot find the root causes so the company can only solve its effect. Sometimes it is too late for solving. Therefore, I suggest useful ways of problem solving which can be summarized into two parts.

(1) The Way of Making Problem Analysis

To make problem analysis efficiently, the company should make some improvement in its system of working. The company should follow the following steps:

(2) The company should improve the information system of quality control and customer service. The format and form should properly be prepared in order to get easily important information and necessary data for management decisions. Some examples of information are the description of the problems and defects, the complaint of customers, etc. The employees must be informed and trained to be aware of the purpose of recording and its application.

(3) Survey the symptom of product and the impact of problems by starting with customer complaint. This is a good starting point. The company should firstly concentrate on customer needs and wants because of strong competition in the paper market.

(4) The company collects the information from step (1) and (2) to check their steadiness by using Pareto diagram. This iS an important step because it effects directly on the result of analysis. The first step starts with classifying the frequency of problems for the investigation of information. Steadiness of information will follow the Pareto diagram. In general we set 80-20 in examining the steadiness. - 80% is the trivial many and 20% is the vital few. 80% of the important problems are due to 20% of the causes. It means that the amount of important problems will set the cumulative frequency at 80% and it accounts for 20% of the total

amount of causes. The level of examining steadiness of information can be properly adjusted.

However, the company should be reminded that adequate and proper preparation of information is very important for the correct analysis.

(5) The result from (3) will give the first important problem needed for action to solve because it creates extreme impact. Therefore, the company should further make analysis of its steadiness and its impact by repeating the step in (3).

(6) This last step is the most difficult. It needs brain storming to investigate the possible causes of the problems concerned and to conclude the real root causes of the problems. The best summary must be developed into the cause and effect diagram.

(7) The Way of Problem Solving

The best way of problem solving can be done by brain storming to investigate all possible causes concerned in order to find the real cause.

At the beginning of practice, the company should focus on the final inspection by making 100% inspection in order to correct the quality of production record. This information will be used as a basis for formulating the quality control methodology in the future.

4.9.1 Work Performance in the Future

From the study, I conclude recommendation for work performance for application in the future so that the quality control system can continuously develop and improve.

(1) The company should provide continuously the activities that promote quality control function such as group activities in every production department, the campaign of quality control, etc.

(2) The company should improve the information system in some parts of the factory. This information will be easily used to make analysis and evaluation of the problems.

(3) The company should set the standard methodology of work. In addition, it should prepare document and instruction to guide the correct steps of working which includes processing information and periodic update of the information.

(4) The company should set the standard quality of raw material with suppliers. This standard is used as a guideline at the receiving section and the supplier as well. Also, the company should treat suppliers as partners. The supplier quality must be outstanding. A partnering relationship rather than an adversarial one must be developed. Both parties have as much to gain or lose based on the success or failure of the product. Suppliers should be few in number so that true partnering can occur.

(5) The company should provide continuous training to employees for awareness of the importance of working and right methods in working.

(6) The company should often provide preventive maintenance for the machine and the equipment and make periodic inspection. Daily testing and inspection before running are also required.

(7) The company should often provide preventive maintenance for the apparatus, tools and devices which are used in inspecting the quality of products. In addition, it should provide training for testing so the employees can do the job correctly.

(8) The company should set the evaluation system for work performance and should perform continuously. The evaluation should be Trade on a monthly or weekly basis. This will make close follow up on the control so if any problems arise, it will be analyzed and solved immediately.

V. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents conclusions and recommendations about quality improvement in paper making process by using the related information from the study of the factory's actual status.

5.1 Conclusions

World Wide Brush Co., Ltd. is one of the most experienced manufacturers of wooden ware and brush products. This project focuses on the wooden ware to identify the main defect such as large gap, poor surface, bending, poor colors, and etc.

The aim of quality improvement in the wooden ware process is to study and to gather the related information of quality of goods in the system for probably analyzing the data, determining solution, conclusions and recommendations. Also, it is to study the factory's actual status and quality problems of factory in order to create systematic management set and useful solution for solving the causes of quality problems to the factory. As a result, the quality improvement will contribute to the production efficiently and decrease the number of failure, waste and nonconforming finished goods. Also, it increases the quality assurance for customer.

Pareto analysis tools are used to determine the major problem in this factory and analyze the root causes. The five symptoms of the defective product are large gap, poor surface, bending, poor color, wrong alignment. The major symptom in this wooden ware process is large gap that effects directly to the customer satisfaction and increasing cost of the company.

Next the analysis of root causes by cause and effect diagram shows that we will see the five major causes are man, machine, measurement, method and materials. From the analysis man is the first part, these major causes result from no job description

policies for employees and lack of knowledge and skill of employees. Thus, we can reduce the number of failure by controlling the parameter as above and train the operator to understand the concerned parameter in order to control and monitor. However, the entrepreneur must give the direction to the operator in each process. Moreover, the equipment must be provided for measuring the parameters for controlling and checking.

The successful quality improvement depends on foundation of quality control system, necessary important information and document and the optimum solution for the current problem. The company can solve it by setting a position to inspect the process, setting the clear job description for each employee and provide training to the employees. As a result, the company will get the better quality product, save the time and cost. Moreover, it can create customer satisfaction and high confidence in the company's finished goods.

5.2 Recommendations

According to quality improvement, it never finishes to improve quality, because defect and problem can occur and affect quality of product every time in manufacturing. So quality improvement should be proceeded continuously. In this project, there are many defects which are displayed by Pareto analysis in phase 3. The main defect is still defect. For the people who are interested on quality improvement and want to apply in your manufacturing, the one interesting thing that should be continuous on this project is improvement of quality which is defect. There are many methods and techniques that are recommended for helping improvement of product, to effective improving quality as follows:

(1) Data Collection

Data collection should be compiled in long periods to make sure that every different information will be taken to analyze and to find out the main defect correctly.

(2) Cause and Effect Analysis

Cause and Effect Analysis is the tool used to find out the possible root cause. But whether the root cause will be the real cause or not, depends on symptoms of defect. Researcher would like to introduce that sample rejects should be analyzed thoroughly to find out the root causes because sample rejects can identify root cause. Moreover, sample rejects are things that lead to the root cause. Hence the more the sample rejects, the easier it is to find out the root cause.

(3) Control chart

Control chart will help to monitor quality. We can set the maximum level of reject which can accept them and use control chart to monitor them. When a number of rejects increase over the setting target, it can warn us that it has abnormality of quality.

In addition, there are still other tools or activities which can improve quality of product such as SPC, QCC, etc. These tools or activities are useful to your job depending on character of both data and usage.

(4) Continuous improvement

Continuous improvement is a good activity that can monitor quality of product. To improve quality effective, we always improve to better forever. In addition, continuous improvement will eliminate reject which increase finished goods indirectly.

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