



QUALITY IMPROVEMENT IN THE PAPER MAKING PROCESS

by

Mr. Kamol Kittinuntakul

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
in Computer and Engineering Management
Assumption University

April 2001

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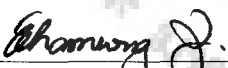

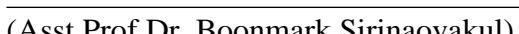
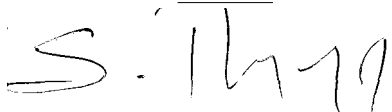
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

This project is concerned with the study of paper making process through quality control for quality improvement in the process, which was studied at Siam Paper Box Co., LTD. The objective of this project is to study the factory's actual status and quality problems. Collected information and seven quality improvement tools are used to analyze and diagnose the vital causes of quality problem. Finally, we get a solution to solve the causes of quality problem. In the research, we assumed that men, machine, raw materials and manufacturing process in the factory had no change during the period of studying.

From analysis of all details about paper making process, we find that the actual quality problem for this process is nonconforming finished goods resulting from symptom of non-complying grammate standard. In addition, the basic weight is the most interesting property of customers. This symptom is caused by men, raw material, method, machine and measurement used in the process. In the analysis of the root causes of quality problems, the main root causes are unable to control the quality of stock which was inputted to paper making machines, no job description policy and the lack of knowledge and skill of employees. The company can solve it by setting a employee to monitor and solve the stock status at flow box before the stock flow into the paper making machine, setting job description policy by giving work instruction and providing training to the employees.

From this, the number of failure, waste and nonconforming finished goods will reduce and the company can create customer satisfaction and high confidence in its finished goods. Because of economic status, the company don't prepare to manage immediately for the quality improvement. It agrees with the proposed measures and will apply it in the future.

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I. INTRODUCTION

1.1 The Significance of Quality Improvement

We are living at a time of great economic challenge to all of us in our respective companies and countries. Increasingly strong business results are now the major policy demand for chief executive officers throughout the world. They are essential to maintain suitably high levels of output, of employment, and of income that are necessary to continuing economic and social progress of the firm.

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 modern industrial firm. No matter how large and important a company or a factory may be, it cannot succeed in offering a poor quality product 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.

Quality is the basic customer decision factor for an explosively growing number of products and services today-whether the buyer is a housewife, industrial corporation, a government agency, a department store chain, or a military defense program. Quality has become the single most important force leading to organizational success and company growth in national and international markets. The return-on-investment from strong and effective quality programs is providing excellent profitability results in firms with effective quality strategies. This is demonstrated by substantial increases in market penetration, by major improvements in total productivity, by much lower costs of quality, and by stronger competitive leadership.

Success in the implementation of this business strategy varies widely, however, among the organizations of the world. More than at any time in memory, buyers perceive that the products of certain companies are significantly higher in quality than those of their competition and they buy accordingly. A wider variation of effectiveness than ever before also exists among the quality programs of companies. Some are strong in depth and in commitment. Others deal in half measures and try to meet fundamental quality requirements with the fireworks display of one-time quality encouragement programs or through dusting off the application of a few traditional quality-control techniques. Because of the wide variation in quality results, the search for the genuine key to success in quality has become a matter of deep concern to management of companies the world over. And experience is disclosing a fundamental basis for achieving this success.

The business of paper manufacturer is highly competitive. There are many entrepreneurs who increase the market. So quality improvement is the key to success and survival in today's rapidly changing world. To compete in today's global market, every industry-domestic and international-must provide world-class quality products and services that satisfy the customer at a competitive price. Quality improvement begins with an in-depth understanding of customers and processes. Continuous quality improvement is the only path to increase customer satisfaction, market share, profits, and success in today's rapidly changing global economy.

This project is to study and recommend improvement in paper making process. I do feasibility studies in many parts of the production including working condition of factory and quality control techniques. From studying status of factory and quality problem of factory, I propose possible alternatives to the owner to reestablish or to reengineer the current manufacturing system in order to achieve maximum benefits of

quality control. The project also mentions the way to reduce the number of failures, which frequently occurs in the production of paper making factory. To solve the various problems for increasing quality reduces the number of failures, waste and nonconforming finished goods in paper making process. So I project the plan by determining objective, scope, step of study for fulfillment the predetermined objective and deliverables.

In this project, some parts of conclusion already have been improved by paper manufacturer however there are almost all parts of conclusion about quality improvement that are new evaluation and that I use our objective as the significance of quality control in study.

1.2 Project Objectives

I do this project by studying and gathering the related information of quality of goods in the system for probably analyzing the data, determining solution, conclusions and recommendations. Because this project focuses on the paper making process, I study the factory's actual status and quality problems of the factory. After studying and collecting the data, the number of defects and the types of defects will be listed. Then, the Pareto chart and the cause-effect diagram may be employed in order to identify the main defect to find out the root cause and to map out a list of factors thought to affect the problem. This project is aimed to recommend quality improvement in paper making process in order to create customer satisfaction and high confidence in company's finished goods. In addition, I proposed a procedure for solving the cause of quality problems and reducing the number of failures, waste and nonconforming finished goods. If we implement the quality improvement in paper making process following my procedure, we will get a better quality product, save time and cost.

1.3 Project Scope

This project focuses on the possible alternatives in paper quality 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 paper making process. Then I will study the factory's actual status, paper making process, 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 has no change during the period of studying.



II. LITERATURE REVIEW

Today, our daily lives and schedules depend totally upon the satisfactory performance and operation of products and services. 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 sells today, and quality that brings customers back for the second, third, and fifteenth time.

2.1 The Meaning of "Quality" (Bank 1989)

First of all, 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 ANSI/ASQC 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 needs 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 next 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, participative 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 word, 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.

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, 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 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 Significant Seven Quality Improvement Tools and Techniques

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 improvement. The screening quality improvement 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. Normally the quality

improvement 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.

Seven quality improvement tools are the following (Swanson 1995).

(1) Flow chart

(a) Description

A flow chart is a diagram that shows all the major steps of a job operation or process. Preparing a flow chart is one of the first things to do in analyzing a process. It uses a set of standard symbols to document the process steps, presenting them in a pictorial format that is easy to understand.

Through flow charting, employees can better understand the processes for which they are responsible. The flow chart demonstrates how the different steps in a process are related to each other. It provides insight for identifying value-added activities, control points, data-collection points, inefficiencies in the work flow and obvious key points in the process. It is also an excellent training tool for new employees.

(b) Applications

- (1) To analyze relationships between sequential activities
- (2) As a technique for fully understanding a problem
- (3) As a source of information for problem identification and resolution
- (4) To analyze customer or supplier activities

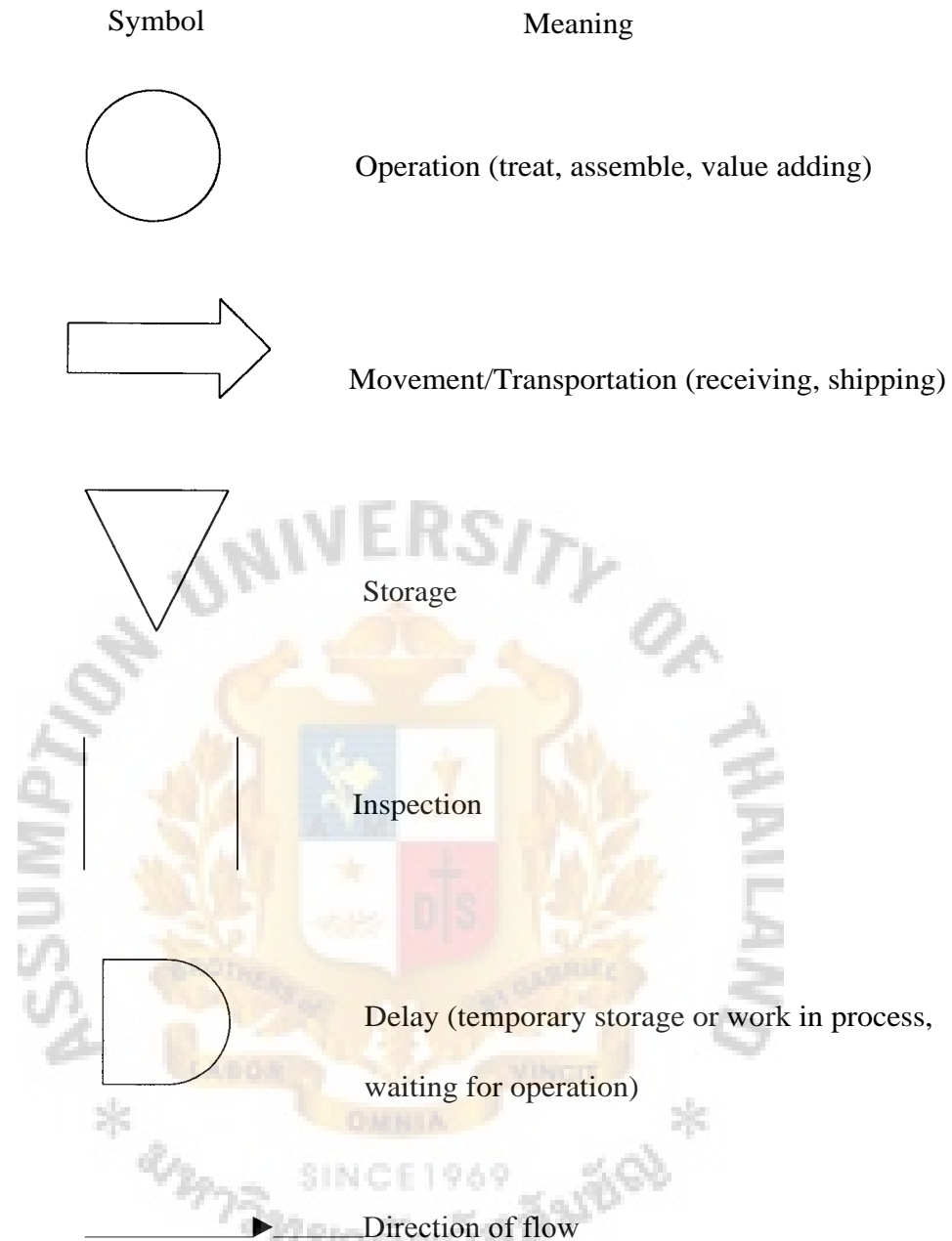


Figure 2.1. Standard Flow Chart Symbols.

(c) 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 Figure 2.1, 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) Pareto analysis

(a) Description

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.

A Pareto diagram is a vertical bar chart that displays the relative frequency of the various categories of the problem. Data are classified in descending order from left to right, as shown in Figure 2.2. In this case, the data classifications are types of field failure. Other possible data classifications are problems, causes, types of non-conformities,

and so forth. The vital few are on the left and the useful many are on the right. When the other category is used, it is always on the far right. The vertical scale is dollars, frequency, or percent. Pareto diagrams can be distinguished from histograms by the fact that the horizontal scale of a Pareto is categorical, whereas the scale for the histogram is numerical.

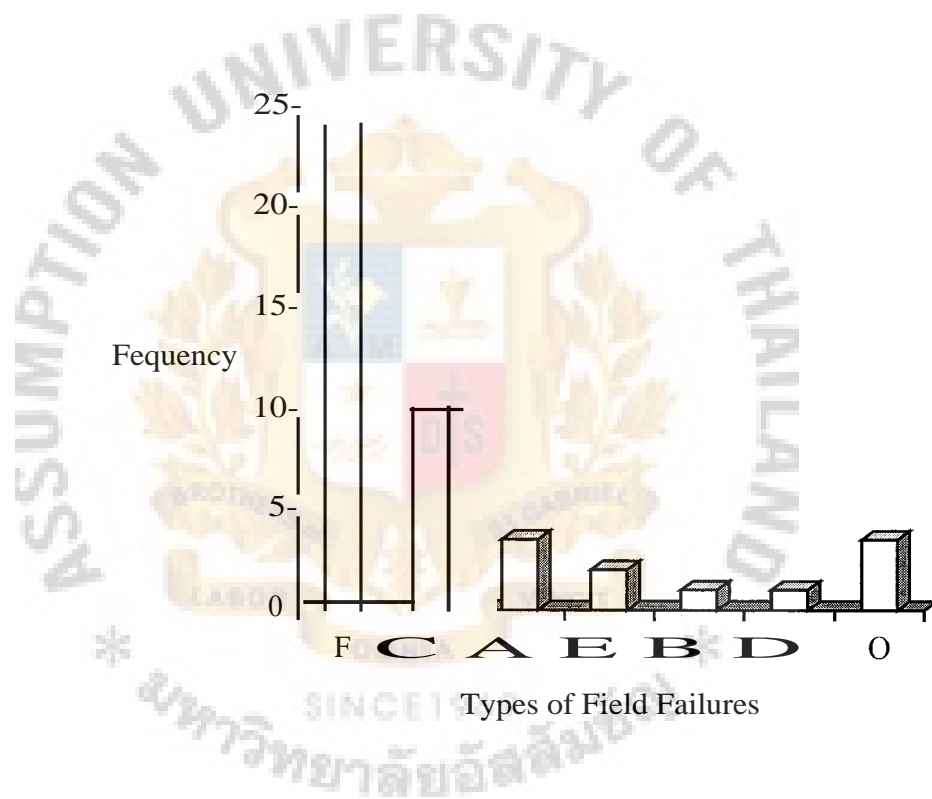


Figure 2.2. Pareto Diagram.

Pareto diagram is usually accompanied by a cumulative line, as shown in Figure 2.3. This line represents the sum of the data as they are added to gather from left to right. Two scales are used: The one on the left is either frequency or dollars, and the one on the right is percent. Pareto diagrams are used to identify the most important problems. Usually, 80% of the total results from 20% of the items.

The focus of problem solving and process improvement is generally on the vital few or the contribution should be 80-20% rule. The cumulative percentage scale must match with the dollar or frequency scale such that 100% is at the same height as the total dollars or frequency. See the arrow in Figure 2.3. It is noted that a quality improvement of the vital few, of say 50%, is a much greater return on investment than a 50% improvement of the useful many. It is easier to make a 50% improvement in the vital few.

(b) Applications

- (1) Display causes of problems in order of importance
- (2) Verify root causes of problems

(c) Steps for Pareto diagram

- (1) Determine the method of classifying the data: by problem, cause, type of nonconformity, and so forth.
- (2) Decide if dollars (best) or frequency is to be used to rank the characteristics.
- (3) Collect data for an appropriate time interval.
- (4) Summarize the data and rank order categories from largest to smallest.
- (5) Compute the cumulative percentage if it is to be used.
- (6) Construct the diagram and find the vital few.
- (7) Title the graph and briefly write the source of the data on which the graph is based. With quality control, the source of the data must be clear.

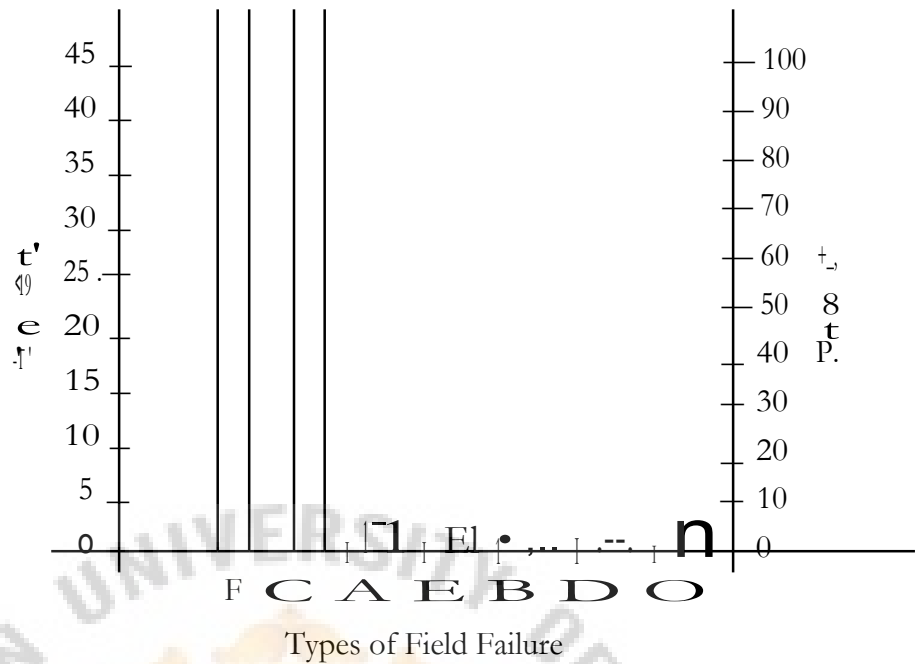


Figure 2.3. Cumulative Line.

(3) Check sheet

(a) Description

A Check Sheet is a list of causes of quality problems with the number of defects resulting from each cause. The main purpose of check sheet is to ensure the data that is collected carefully and accurately by operating personnel. Data should be presented in such a form that it can be quickly and easily used and analyzed. The form of the check sheet is individualized for each situation and is designed by the project team. Checks are made on a daily and weekly basis, and some checks, such as temperature, are measured.

Check sheets are used to record data. They are therefore used in every project stage that includes data collection so we could have put them anywhere in our sequence and be correct. The best check sheets

are simple to use and visually display the data in a format that can reveal underlying patterns. It should be user-friendly and, whenever possible, include information on time and location.

(b) Applications

Gather data on the number of occurrences of various issues, problems, inputs, outputs, or outcomes during specified time periods. Record occurrences of a variety of activities such as work or inspection in a variety of categories such as shift or machine during a sampling time period. Count errors or failure by type during a time period.

(4) Histogram

(a) Description

A Histogram is a bar chart showing the frequency of occurrence of causes of defects. The histogram graphically shows the process capability and the relationship to the specifications and the nominal. It also suggests the shape of the population and indicates if there are any gaps in the data. It is, like Pareto chart, a graphic representation of frequency table. 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 range and the shape of the data. Usually data fall into a bell-shaped curve called the normal distribution.

(b) Applications

- (1) Display and compare process variability with expected variability
- (2) Determine the variables are producing with the same median, mean and variability

(c) Steps to constructing a histogram

- (1) Identify and define data to be collected
- (2) Construct a data-collection sheet
- (3) Collect data
- (4) Locate smallest and largest measurements
- (5) Calculate range
- (6) Select a number of intervals
- (7) Determine class interval size
- (8) Determine class limit end points
- (9) Tally measurements by class intervals
- (10) Draw bars and labels.

(5) Scatter diagram

(a) Description

The scatter diagram is a graphical method of determining the relationship between the cause and effect through pattern analysis and shows how two process variables relate to each other. Suppose salt content of cheese is an important quality characteristic. To see what factors influence this characteristic, you measure both the salt content of a piece of cheese and the time it stayed in a salt bath of known salinity. For each piece of cheese, there is a pair of measurements:

salt content and time in the bath. Instead of making two separate dot plots, you can combine the two: indicating time along the horizontal axis (sometimes called the X axis) and salt content along the vertical axis (sometimes called the Y axis). You place points where the values of each pair intersect (see Figure 2.4). The shape of the resulting scatter of points tells you if the two factors are related. If they are unrelated, the points will be randomly scattered around the graph. If larger values of one occur with larger values of the other, the points will group towards a line running from lower left to upper right. If larger values of one are associated with smaller values of the other, the points will cluster on a line running from upper left to lower right.

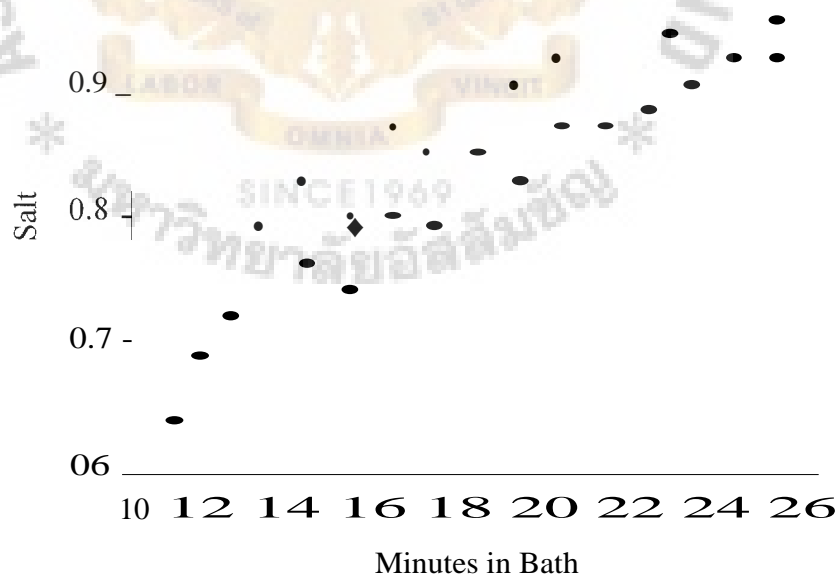


Figure 2.4. Scatter Diagram.

(b) Applications

- (1) Plot suspected causes versus undesirable effects in support of cause-and-effect analysis
- (2) Compare a series of paired variables to determine if a relationship exists
- (3) Indicate whether additional analysis is warranted to determine the exact nature of a cause-and-effect relationship (i.e., to predict the relationship by fitting a line or curve to the data point)

(c) General steps for constructing a scatter diagram

- (1) Identify dependent and independent parameters and take measurements 50-100 would be useful
- (2) Draw the axes and plot the points. The independent factor should be on the horizontal axis
- (3) Draw a best-fit line through the points
- (4) Analyze the resulting scatter diagram.

(6) A Cause-and-Effect or Fishbone Diagram

(a) Description

The cause-and-effect diagram, also called a "fishbone diagram" because of its appearance, allows you to map out a list of factors thought to affect a problem or desired outcome. A chart identifies and organizes possible causes of problems, or factors needed to insure success of some effort. The problem, situation, or event is listed on the right. Branches off the central arrow indicate main categories of items. Use of this format allows people to easily see the relationship

between factors. This type of diagram was invented by Kaoru Ishikawa, and hence is also called an "Ishikawa diagram." It is an effective tool for studying processes and situations, and for planning.

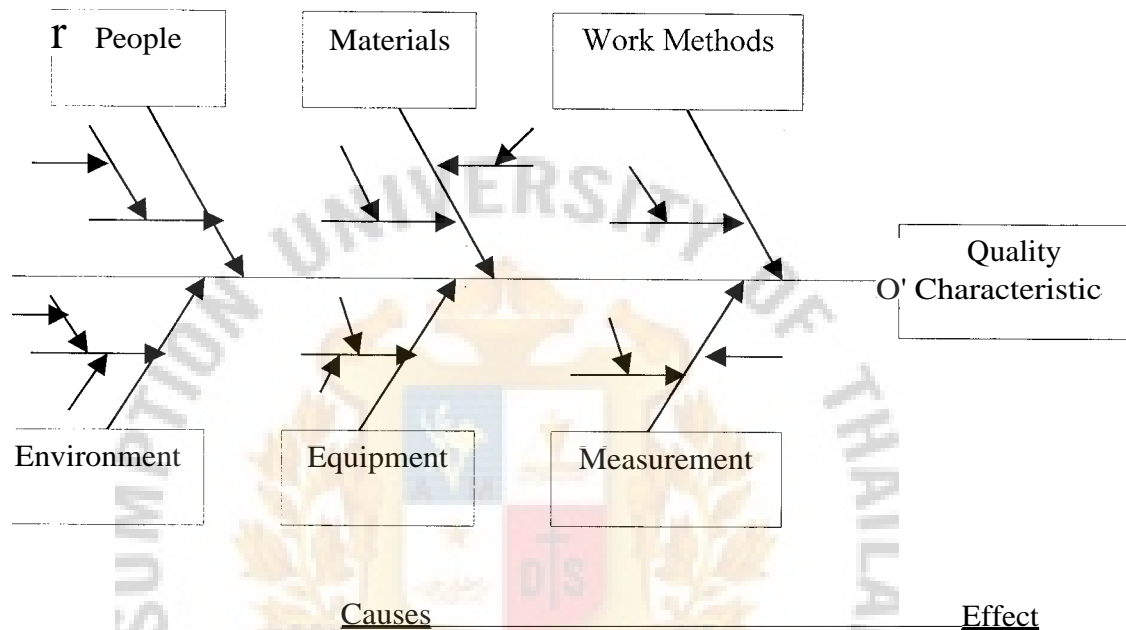


Figure 2.5. Cause-and-Effect Diagram.

A cause-and-effect diagram is essentially a pictorial display of a list. See Figure 2.5. 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.

(b) Applications

- (1) Analyzing actual conditions for the purpose of product or service quality improvement, more efficient use of resources, and reduced costs
- (2) Identify root causes, or key drivers, contributing to some effect, or measurable outcome
- (3) Elimination of conditions causing nonconforming product and customer complaints
- (4) Standardization of existing and proposed operations
- (5) Education and training of personnel in decision making and corrective action activities

(c) Making a cause-and-effect diagram

- (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 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, equipment, method of work, measuring method, 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.

(7) Control Charts

(a) Description

A Control chart is monitoring of a production process using the statistical quality control techniques. The UCL and LCL or upper and lower control limits, respectively indicate how much variation is typical for the process. Points that fall outside the limits or into particular patterns indicate the presence of a special cause of variation, a cause that deserves investigation. The control chart is a time plot with one extra feature. It also indicates the range of variation built into the system. The boundaries of this range are marked by upper and lower statistical control limits, which are calculated according to statistical formulas from data collected on the process.

Control charts help you distinguish between variation inherent in a process (variation from a "common cause") and variation arising from sources that come and go unpredictably ("special causes"). Points that occur outside the control limits are signals of special causes of variation, meaning it should be relatively easy to track down that source and prevent its recurrence. Data points that stay within the

control limits indicate that most variation is coming from common causes. If all points stay within the control limits, the only way to make improvements is to fundamentally change some aspect of the process (materials, procedures, equipment, training, etc.). Control limits only indicate what the process is capable of doing and can only pinpoint possible problems with the process. They do not help correct the problem. The operator, instead, is responsible for rectifying the problem or initiating the corrective action.

(b) Applications

- (1) Determine whether or not the current process is stable or in control and is capable of meeting expectations or specifications
- (2) Decide whether the process has changed due to special causes and will require adjustment to perform normally
- (3) Provide a baseline of data for process improvement (i.e., a change in the process to alter common causes) in order to reduce variation and increase productivity by shifting the process mean

2.5 Quality Management (Besterfield 1998)

Quality management is the process of identifying and administering the activities needed to achieve the quality objectives of an organization. One useful way to illustrate the basic elements of quality management is to draw a parallel to a well-established function, namely finance (Juran 1986).

Financial management is accomplished by the use of three managerial processes: planning, control, and improvement. Some key elements of these three processes are shown in Table 2.1. The same three processes apply to quality. The three financial processes provide a methodical approach to addressing finance; the three quality

processes provide a methodical approach to addressing quality. The particular importance is that each of the three quality processes can be further defined in a sequence of activities. Table 2.2 summarizes these sequences.

Table 2.1. Financial Processes.

Process	Some elements
Financial planning	Budgeting
Financial control	Expense measurement
Financial improvement	Cost reduction

The three processes of the quality trilogy are interrelated. The interrelationship applied to one of the two components of the quality definition and freedom from deficiencies. It is of uncommon importance. For example, not the graphic distinction between the noisy sporadic quality problem and the muted chronic waste. The sporadic problem is detected and acted upon by the process of quality control. The chronic problem requires a different process, namely, quality improvement. Such chronic problems are traceable to an inadequate quality planning process.

For the trilogy of quality processes to be a successful framework for achieving quality objectives, it is necessary that the processes rest on a foundation of inspirational leadership and environment and practices strongly supportive to quality. Without such a quality "culture," the trilogy of quality processes cannot be fully effective. These elements have an impact on people at all levels.

Table 2.2. Processes for Managing Quality.

Quality planning	Quality control	Quality improvement
Establish quality goals	Choose control subjects	Prove the need
Identify customers	Choose units of measure	Identify projects
Discover customer needs	Set goals	Organize project teams
Develop product features	Create a sensor	Diagnose the causes
Develop process feature	Measure actual performance	Provide remedies, prove that the remedies are effective
Establish process controls, transfer to operations	Interpret the difference	Deal with resistance to change
	Take action on the difference	Control to hold the gains

2.6 5W1H Method for Quality Improvement (Bell 1994)

5W1H method is a technical method of setting questions for developing the alternative solutions. It is a useful method using in quality Improvement. To solve the problems efficiently, the setting questions and the answers must be related reasonably. 5W1H method includes the questions of why, what, where, who, when and how which have the following additional detail.

2.6.1 Why Question (Why?)

At present the manufacturing industry is highly competitive; as a result, there are high volumes of product exceeding the demand of customers in the market. The customers gain benefits from this situation. They choose product that has cheap price and high quality. Therefore, the factory must concentrate on quality control for

competing with other competitors in business survival era. Quality control and quality improvement are applied in all procedures of operation in order to control, improve and assure the quality of product. Why question is used to discover the various reasons and causes of all activities about quality.

2.6.2 What Question (What?)

Quality control and quality improvement should be in all procedures of operation starting from ordering raw material, production and inspecting the quality of finished products. This question is used to tell what activities are done about quality control and improvement and what problems occur in the process.

2.6.3 Where Question (Where?)

This question is used to tell where it must be controlled and improved in quality. The question is about a place, process, department such as flow box, paper making process and stock department. Quality control and improvement systems are necessary to apply in the whole organization including both management level and operational level in order to coordinate together with efficiency.

2.6.4 Who Question (Who?)

All people in organization starting from executive to employees in the factory have very important roles in quality control and improvement. Executive must encourage conscientiously in providing the quality control and improvement system and set the clear policy. In addition, awareness of information and policy must be distributed to all departments for cooperation in fulfillment. On the part of employees, they must participate and collaborate with an all out effort by working hard in their jobs. The employees of all departments have very important role to push forward the quality control and improvement. Who question is used to tell persons who perform the activities such questions as "who should do the quality control and improvement?".

2.6.5 When Question (When?)

The quality control and improvement is necessary to be performed continuously by all employees. The employees in quality control department have to inspect and gather information according to work instruction. For quality improvement, the company must study firstly in quality problems and develop the optimum solution. Then implementation in the process is the next step and its effect on the time used in production should be at the least. When question concerns the time such questions as when should we do quality control and improvement.

2.6.6 How Question (How?)

How question is used to explain the detail of all activities in step and process. It gives more particular information resulting from serious analysis. Some examples are "how can we improve the quality?" and "how about the present employees work?".

III. OVERVIEW OF OPERATIONS OF PAPER MANUFACTURER

This part is designed to give you a brief of company profile, the factory's actual status and working condition, operation of paper manufacturing and paper making process in order to know the factory's statement of problem and the important reasons of the project's objective about quality improvement.

3.1 Company Profile

Name:	Siam Paper Box Co., LTD.
Location:	34 Moo 1 Soi Rajburana 29 Rajburana Road Rajburana District, Bangkok 10140
Area:	35,200 M ²
Area of factory:	28,977 M ²
Type of business:	Production of paper box and paper core
Registered capital:	4,000 million bahts
Stock:	Held by only Thai people
Number of worker:	About 300 workers
Factory layout:	See Appendix A

Siam Paper Box Co., LTD. Was established in 1969. When established, the company was on Chan Road, Sathupadit where it produced corrugated paper boxes. Its head office is at present there. In order to expand business, the company established the second factory at Soi Chai Yong (Soi Rajburana 29) in 1975 which have produced special raw material for its only affiliated factory.

The company firstly installed paper production system and 3 paper making machines which was cylinder mold system for producing corrugated paper only. In 1989 additional 2 paper making machines were installed to produce kraft liner paper. The company changed the first machine for a new upgraded machine in 1992.

In 1993 company's executive had a policy to expand the production in order to sell to other companies; so the company installed additional 3 new paper making machines. From the increased 3 machines, the company increased productivity from 150 tons per day to 300 tons per day. In 1996 the company established paper core production department for a complete production cycle.

3.1.1 Objectives of the Company

- (a) To provide the 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

3.1.2 Business Plan (Strategies)

- (a) To emphasize the 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

3.1.3 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 Organization

The company divides organization into many departments as follows (see Figure 3.1 for Organization Chart):

- (1) Steam department
- (2) **Pond** department
- (3) Lab department
- (4) Paper weight and measurement department
- (5) Raw material department
- (6) Maintenance department
- (7) Electricity department
- (8) Motor department
- (9) Inspecting and admitting fragment department
- (10) Receiving and shipping department
- (11) Paper core department
- (12) Paper making department
- (13) Stock preparation department

3.3 The Process of Operation of the Company

3.3.1 Ordering Raw Materials

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

3.3.2 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.

3.3.3 Production

When the raw materials pass inspecting quality, they will be used in production of all kinds of products indicated by master production schedule (MPS).

3.3.4 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 3.2 shows the process of operation of the company.

3.4 Paper Making Process

In paper making process, the company starts process with stock preparation and forwards stock to convert to paper sheet by paper machine. After that, paper sheets will be forwarded in the process of press, dryness and slither respectively until obtaining the size of paper according to customer's order.

The process of stock preparation starts by conducting paper pulp to soak in water; as a result, fiber of paper pulp will split singly and will also float on water called stock. Quality of stock is a result of many following factors:

- (1) Quality of raw material including consistence of quality in raw material
- (2) Technology in the process of stock preparation

- (3) Required characteristics of paper such as smoothness, specific edge load, tensile strength, tearing strength, ring crush, etc.
- (4) Technology in paper making process

In general raw material used in paper making process can be divided into two kinds, long fiber and short fiber. Siam Paper Box Co., LTD. uses 100% recycle paper from domestic and exterior source. The paper making process includes:

- (1) Selecting the quality of raw material: The objective of this process is to separate paper pulp with its different quality. The kinds of long fiber and short fiber are also separated before starting production.
- (2) Hydropulper: It is a process of beating paper pulp combined with water to be fiber and soaking in water. Fiber of paper pulp will split and float on water called stock. Stock will be forwarded to grind in a mill and screened by sieve. Large material mingling with stock which cannot disintegrate such as stone will be separated from stock and paper making process.
- (3) Stock's cleaning: It is a process of using high density cleaner machine for separating high dense material from stock by applying a principle of difference of density. The acceptable stock will be sieved with stock grate by pressure screen machine in order to separate material which has smaller size than the acceptable stock and will be stored in pond. Later we select the proportion of required stock (about 3 meshes) by PH-screen. Vibration screen is used to select rejected stock again in case of rejection in PH-screen. Finishing above processes, the rest of material mingling with acceptable stock which have the same size are mud, slush, sand, etc. So centicleaner machine working with centrifugal force is used for separating

mud, slush, sand, etc. After we finish the stock's cleaning, we obtain pure stock and store it in pond.

- (4) **Thickener:** It is used to increase intensity of the stock to conform with the requirement. The stock will be stored in pond again after this process.
- (5) **Formation:** It is a process of beating and refining by refining machine in order to obtain subtle and soft fiber with high solidity between each fiber. So the company has to control delicately in formation process for good quality in fiber. Later, the stock will be forwarded to store in pond for combining with various substances and water.
- (6) **Inspecting the quality of stock:** Inspecting for quality can be divided into two types. One is the percentage of consistency. Another is seeping of water (freeness value). The company has to do this inspecting process all the time when variations of two values occur in the process. Now the company has no inspecting processes for quality of stock because of no measuring instrument and no worker fixed in this position.
- (7) **Wet part forming:** It is process of joining the fiber to a paper sheet. This process starts from floating the stock to pass wire part and using vacuum force to join each fiber in each layer together. We press ply-bond for high solidity between each layer and use the scatter of stock on a surface of canvas for carrying stock to form a paper sheet. Thickness of paper sheet depends on the number of running roller of sieve.
- (8) **Press Part:** After finishing wet part forming process, wet paper will be pressed water out for dry and sticky paper.
- (9) **Dry Part:** This process steams paper with hot vapour by dryer and presses paper for thinness by press machine.

- (10) Slither and rewinder: In this process, paper rolled by rolling machine will be conducted to cut the size of paper according to customer's order by using slither and rewinder.
- (11) Inspecting the quality of paper: Finally, inspecting process for the quality is very necessary. We use a unit of a grammate or a grammate per square meter in ordering for production. For example, 500 grammates mean that one square meter of paper has a weight of 500 grams. We inspect the quality by selecting randomly 5 portions of width of paper area and calculating the average to compare with standard value, 20% of desired weight. Furthermore, we test for smoothness, special edge load, bursting strength, tearing strength, tensile strength, ring crush, etc.

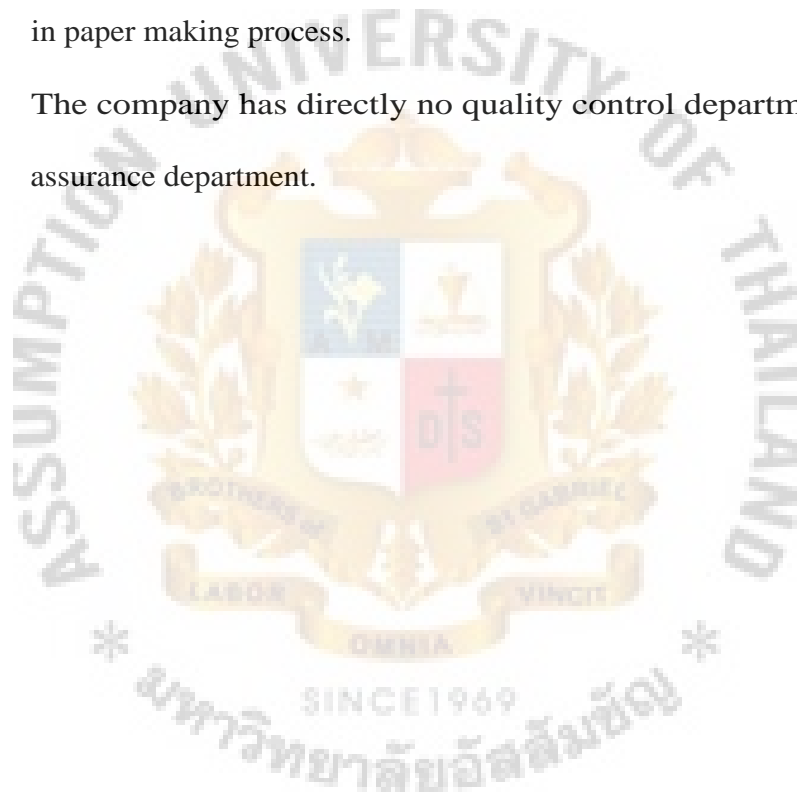
Finishing the last process, inspecting the quality of paper, the company completes the paper making process and obtains paper available for sale. The paper making process is summarized in Table 3.1 in which the substantial raw material in the process is 100% recycle paper.

3.5 Statement of Problem in the Factory

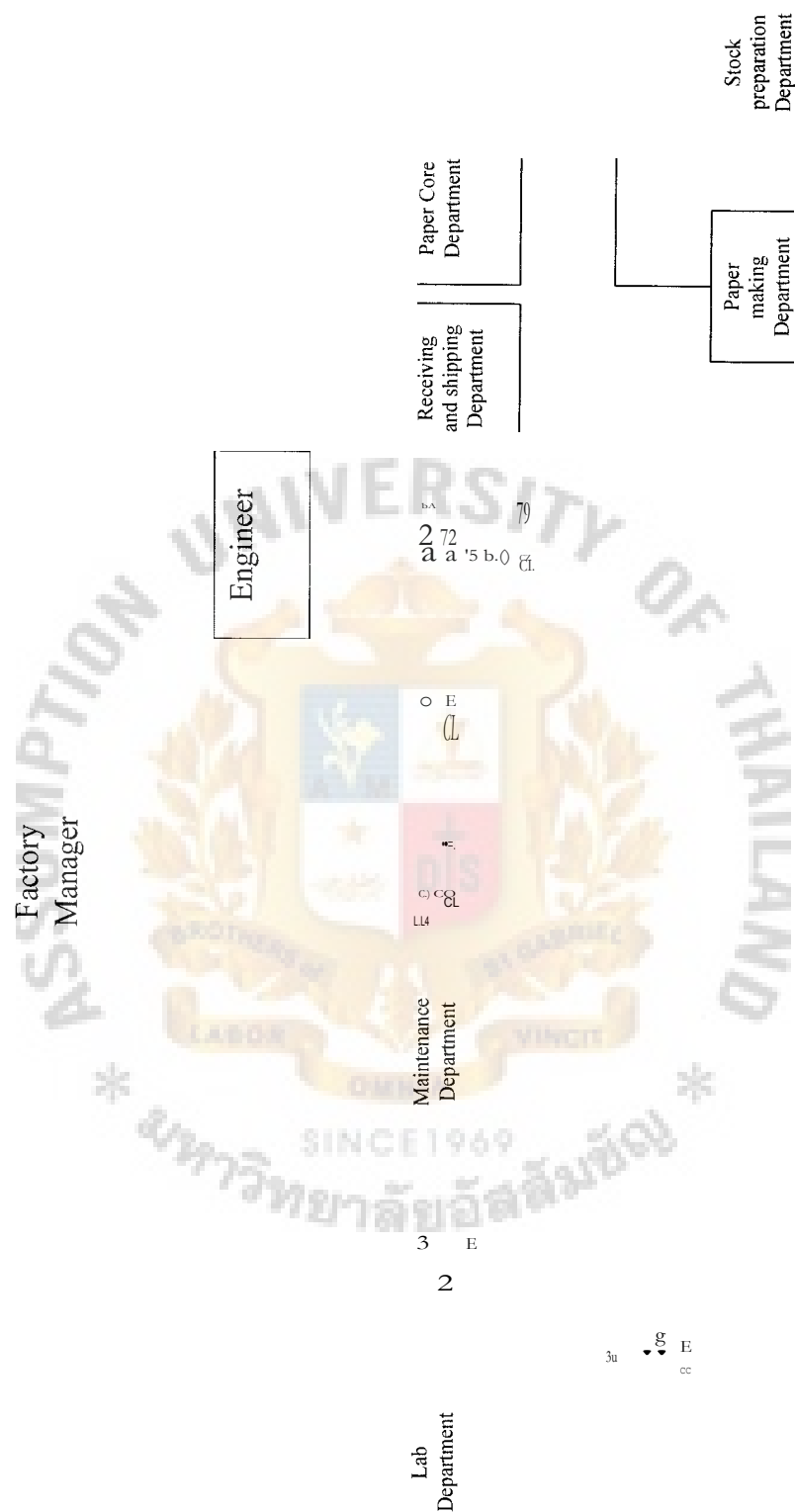
From studying the factory's actual status and working condition, operation of company and paper making process, I use the information to list the situation of quality in factory. The various problems in factory are caused by no appropriate quality control system. The situation of the factory is summarized 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 the controllable circumstance.

- (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. Thence, the company changes to a new one.
- (5) Because raw materials are paper pulp and stock and company's product is paper, the company has problems about moisture and condition of weather in paper making process.
- (6) The company has directly no quality control department and quality assurance department.



Siam Paper Box Co., Ltd.



Organization Chart.

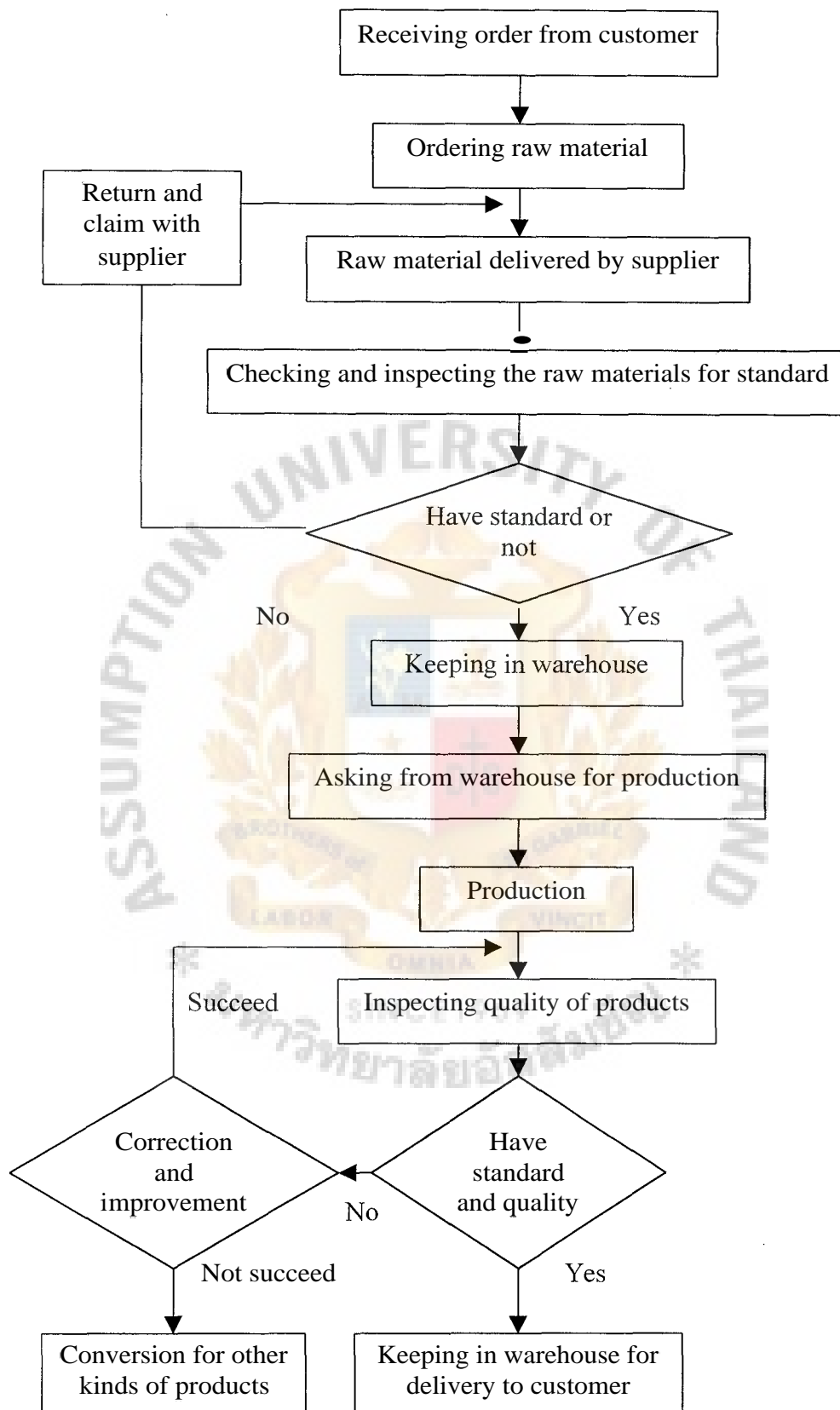


Figure 3.2. The Process of Operation of the Company.

Table 3.1. A Process Chart of the Paper Making Process.

	Process	Description	Symbol				
			O	=	V		D
1.	Hydropulper	To beat paper pulp combined with water to be fiber	-I				
2.	Stock's cleaning	By high density cleaner for separation high dense material from stock	Ai				
3.	Storage	To store stock in pond			√		
4.	PH-screen	Selecting the proportion of required stock (about 3 Mesh)	J				
	Vibraton screen	Selecting rejected stock again	-4				
5.	Centicleaner	Conducting the acceptable stock to separate sand, mud, slush, etc.	4				
6.	Storage	To store stock in pond			√		
7.	Thickener	Increasing intensity of stock	4				
8.	Storage	To store stock in pond			√		
9.	Refine	By beating and refining the stock for formation	Ai				
10.	Storage	To store stock combining with various substances and water in pond			V		
11.	Paper machine	Using wet part forming for joining the fiber to be a paper sheet	√				
12.	Press-part	To press out water from the paper	√				
13.	Dry-part	To dry the paper	√				
14.	Press machine	Pressing the paper for thinness	4				
15.	Rolling machine	Rolling the paper	√				
16.	Slither and rewinder	Cutting the size of the paper according to customer's order	J				
17.	Quality inspection	Inspecting the quality of the paper				4	

IV. STATEMENT OF QUALITY PROBLEMS

Nowadays, the business of paper industries is highly competitive. There are many paper manufacturers increasing in the market. So the way to survive or run the business in this situation is to produce the 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. Do 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. So the project uses this idea for the 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 are developed further detail in the following:

4.1 Characteristics of the Company's Product

Before studying the situation of quality problems in the company, we must know and understand about the characteristics of product in order to know the scope in production and productivity of each machine in factory. The company produces four different types of paper including as follows:

- (1) Corrugate grade A (CA)
- (2) Corrugate medium (CM)
- (3) Corrugate grade B (CB)
- (4) Kraft grade A (KA)

CA 125 means that corrugate grade A has weight of 125 grams per one square meter or 125 grammates.

Table 4.1. Different Types of Paper Produced by Each Paper Making Machine.

Paper making machine	Product
Machine 1	Producing all sizes of corrugate grade A
Machine 2	Producing all sizes of corrugate grade A Producing corrugate medium size 125 grammates Producing corrugate grade B size 350 and 450 grammates Producing all sizes of kraft grade A
Machine 3	Producing all sizes of corrugate grade A Producing all sizes of corrugate grade B
Machine 4	Producing all sizes of corrugate grade A Producing all sizes of kraft grade A
Machine 5	Producing all sizes of corrugate grade A Producing all sizes of kraft grade A

From studying operation of the company and paper making process in factory, I discovered that each paper making machine forms different types of paper in a process of formation. The different types of paper produced by each machine are shown in Table 4.1. All types of paper produced in paper making process will be controlled under standard for customer satisfaction. The standard which the company agrees with customer is industrial standard for paper manufacturing which permits standard weight of paper in each grade as +5%. See Appendix B.

4.2 Analysis for the Situation of Quality Problems

Because paper making department of the company has 5 paper making machines and there is limitation in the period of study; in addition, other paper making machines often stop production, I cannot study all machines in this department. Therefore, I use the information about volume of productivity of each paper making machine to consider which machine has the highest productivity. The information about volume of productivity of each machine in 1999, is summarized in Table 4.2 and is shown in a form of histogram in Figure 4.1.

Table 4.2. Volume of Productivity of Each Machine in 1999.

Paper making machine	Volume of productivity (ton/year)
Machine 1	Stop production
Machine 2	12,480
Machine 3	5,161
Machine 4	7,800
Machine 5	Stop production

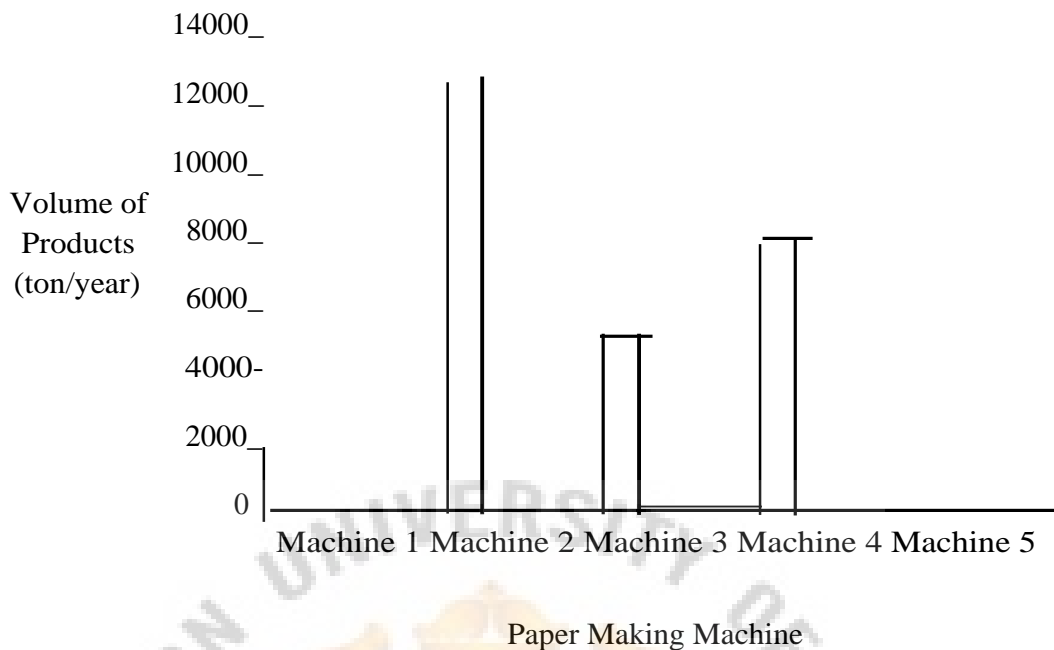


Figure 4.1. Histogram for Volume of Products of Each Machine in 1999.

Considering the histogram we obviously recognize that the second paper making machine has the highest productivity per year. So I choose the second paper making machine to study and analyze.

Because 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 the product. It leads to damage. For example, dash during delivery to customers causes the damage in edge of paper. 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 paper is humid, soggy and ragged. However, this problem seldom occurs. I also don't consider this problem.
- (c) Late delivery problem: Some time 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 receives 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 satisfy 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.

From the information associated with inspecting the product produced by the second paper making machine before storing in warehouse in 1999 (see Appendix B), there are nine main symptoms which the defective product has. They are high grammate, low grammate, over joining, high moisture, rough edge of paper, crack of edge, wrinkle, dirtiness and over soft which are shown in Table 4.3.

Table 4.3. Volume of the Defective Products in 1999 (Rolls).

Symptom	Grade									Sum
	CA	CA	CA	CA	CA	CM	CB	CB	KA	
	110	125	140	160	180	125	350	450	160	
High grammate	105	307	188	4		53	13	166	8	844
Low grammate	10	47	198		12	19	21	118	64	489
Over joining	7	23	24	3		6	8	22	8	101
High moisture		21	7	2		4	2	32	6	74
Rough edge	2	13	23		1		2	11	2	54
Crack of edge	2	5	11			1	3	18	2	42
Wrinkle			12							12
Dirtiness			1			1		3	2	7
Over soft			2							2

I use the information from Table 4.3 about volume of the defective product in analysis by using Pareto diagram which is presented in Figure 4.2.

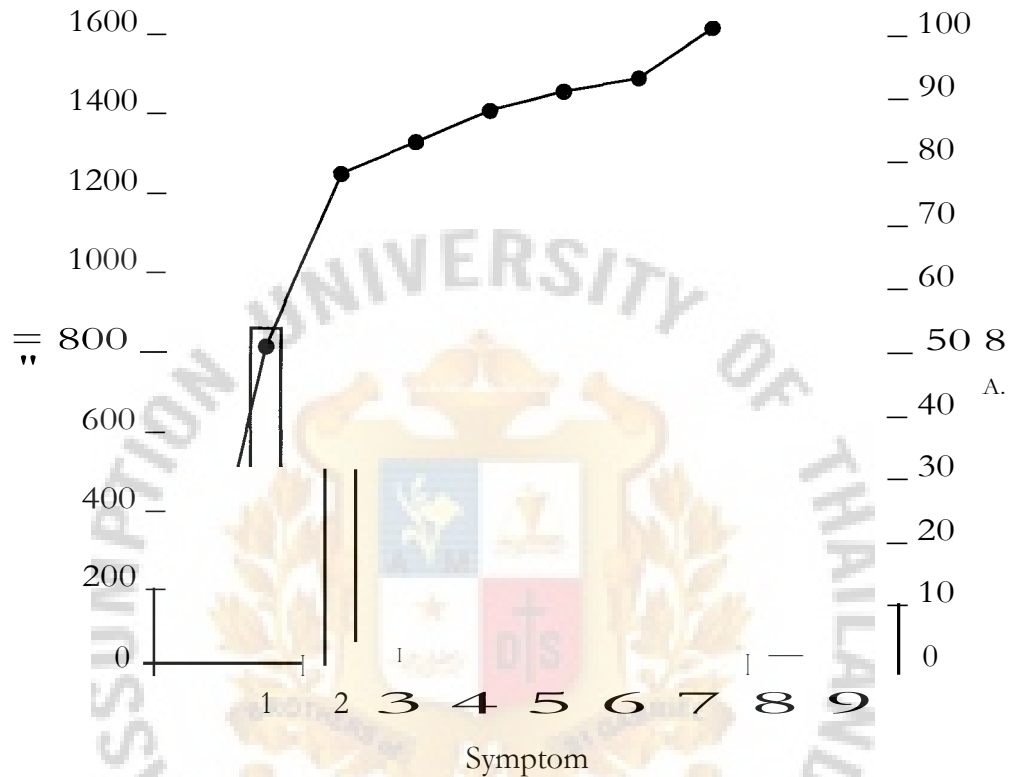


Figure 4.2. Pareto Diagram of Symptoms.

Nine symptoms which the defective product has in Figure 4.2 include:

- (1) High grammate
- (2) Low grammate
- (3) Over joining
- (4) High moisture
- (5) Rough edge of paper
- (6) Crack of edge
- (7) Wrinkle

- (8) Dirtiness
- (9) Over soft

When analyzing Pareto diagram for symptoms, a Pareto principle is used to identify the most important problem by the vital few (20%) and the trivial many (80%). Usually, 80% of the problems are the result of 20% of the causes. One key to improvement is to identify those crucial 20% and focus attention on them. It is noted that a quality improvement of the vital few, of say 50%, is a much greater return on investment than a 50% improvement of the useful many. From Figure 4.2 the vital few is a symptom of non-complying grammate standard including both high grammate and low grammate. We believe that if the company still produces under the existing process, the company will encounter extremely defective products resulting from non-complying grammate standard.

Therefore, nonconforming products problem is the most important problem in running business of the company. If the company don't handle the defective problem, the company will not survive in this highly competitive industry. The main symptom of quality problems in the products unsatisfied by customer is non-complying grammate standard. Later chapter will provide the analysis of possible root causes of problems and propose alternative solutions for solving the causes of quality problems.

V. ALTERNATIVE SOLUTIONS FOR SOLVING QUALITY PROBLEMS

In Chapter 4, I discuss the characteristics of the company's product, the important quality problems and the analysis of those problems for identifying their symptoms. In this chapter I will provide the analysis of possible root causes of quality problems and propose alternative solutions for solving the quality problems.

5.1 The Analysis of Causes of Quality Problems

When considering the operation process chart shown in Table 3.1 in Chapter 3, quality inspection process involves inspecting the basic weight of paper, which the unit used, is grammate. It is the last step of the paper making process which inspects all paper rolls and handle with elaboration especially equipment used, 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 weighting device which is a digital system, there is no calibration comparing with standard before inspecting and no resolution for the difference. Therefore, some error occurs from the weighting device and the method of inspecting done by employees.

The process of inspecting the weight of paper has the following steps:

- (1) Tearing the paper along the width of the head of paper roll for optimum size
- (2) Tearing randomly the paper in (1) into five parts
- (3) Bringing the paper in (2) to cut in standard size by using determining standard pattern
- (4) Weighting the paper and recording

- (5) Tearing the paper along the width of the end of paper roll for optimum size
- (6) Repeating the step of (2) - (4)

Examining the process mentioned above and employees who work in inspecting process, I discover that the aim of this process is to inspect the grammate value of every paper roll. For each roll, the inspection is made randomly at only the head and the end of the roll and cannot make at the other parts of the roll because the customer accepts paper roll not exceeding three times in joining. Moreover, in the step of tearing randomly the paper 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 paper rolls 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 grammate standard by using the information from paper making department and stock preparation department, I find that non-complying grammate standard depends on five factors which are man, material, method, machine and measurement. The causes of non-complying grammate standard are shown in a form of cause and effect diagram in Figure 5.1.

The principle of Pareto stated that the vital few (20%) and the trivial many (80%). We can apply this principle in each problem that has symptom in the vital few and the trivial many and each symptom has root cause in the vital few and the trivial many. It means that the major cause consists of small amounts but its role is large in part compared with the minor cause. So the problem of the basic weight of paper is not the

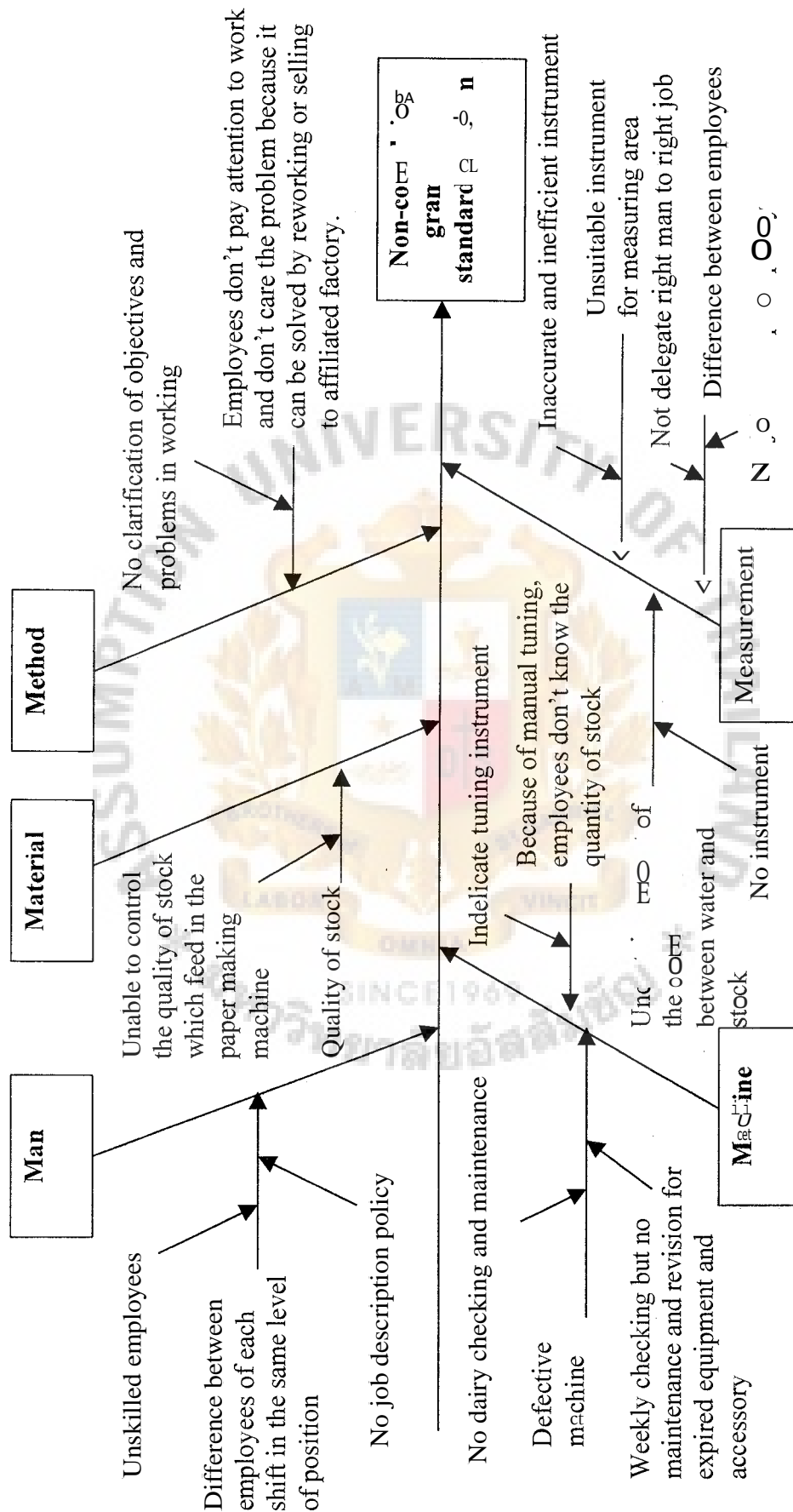


Figure 5.1. Cause-and-Effect Diagram of Non-Complying Grammate Standard Problem.

major root cause in the vital few. 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 manager, engineer, high skill and experienced employee, the major causes of the problems in paper making department shown in Figure 5.1 come from three main reasons which are:

- (a) Unable to control the quality of stock which feeds in paper making process
- (b) No job description policy for employees
- (c) Unskilled employees

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

5.1.1 Unable to Control the Quality of Stock Which Feeds in Paper Making Process

At present the problem of non-complying grammate standard is caused by inability to control the quality of stock which feeds paper making process according to the management opinion. Consequently I study the factory's actual status including working condition of both paper making department and stock preparation department in order to prove that the problem is a result of uncontrolled quality of stock.

From the survey in working condition of paper making department, each shift of employees work somewhat in the difference including method and step for working. So I follow up to survey the method and step for working of employees in each shift for the performance of shift which does not make any effect to the quality problems and study specially in that shift. The consideration follows the information collected from factory manager, chief of shift and skilled and experienced employee. I also study the factor of

the difference between employees in each position and its effect on the quality of company's product. There is no significant cause of the quality of product but the non-complying grammate standard still occurs. Therefore, I studied further on the condition of machine.

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

When I study the quality of raw material and the process of inspecting the quality, I discover that the raw materials which enter into the paper making department is stock prepared by stock preparation department. The stock is fed along the pipe from the flow box. In the paper making department, there is no measuring device to test the quality of the fed stock. As a result, the employees in this department cannot know the quality of the fed stock and necessarily receive the unknown quality stock. The fed stock must be formed into plate to be a paper sheet then the employees can test the quality of the paper and this will make them know the quality of the feeding stock as the result. Therefore, in the study of the causes of the quality problems resulting from material, it is suggested to study in the stock preparation department for testing the quality of the stock before feeding to paper making department.

After finishing the study about the quality of raw materials in the stock preparation department, I find that now the stock preparation department has to produce the stock and the quality of the stock in a certain limit set by the paper making department. But when asking chief and skilled and experienced employees who work in charge of inspecting the stock at flow box and storing pond, I find that the quality of

the fed stock varies uncertainly. This department often has many problems for the quality of the stock because the prepared stock cannot meet the requirement and the standard set by the paper making department.

In the stock preparation department, only chief or skilled and experienced employees who works in charge of inspection at the flow box and the storage pond of stock inspects the quality of the stock. They walk around to study the condition of stock. The inspection is based on personal judgement by experience with no measurement device to support his judgement at all. As a result, there is some limitation in quality control of stock and their judgement is not exactly accurate. The range of quality control in stock of the stock preparation department is extensively wide and cannot meet the requirement of the paper making department. 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 flow box and the storage pond. If the quality problems of stock occur within the time when nobody walks to inspect, the stock preparation department will not recognize the problem. Therefore, I can conclude that at present there is no standard for quality control of the stock at this department and when the problems often arises, it is too late to make any correction.

Besides walking around for inspecting the quality of the stock, the stock preparation department has laboratory checking for the quality of the stock; however, each test spends time around three hours to get the result. Such long hours of lab test is too late to make immediate correction because the stock in the stage pond is no more being used within one hour or one hour and a half. So the result from laboratory testing is not used in the quality control of the stock in the stock preparation department and the paper making department.

From the above analysis and the information gathered about the quality of raw material which is provided by the stock preparation department, I can conclude that the quality of the stock often does not meet the requirement set by the paper making department. The stock preparation department has no good quality control system. The employees at the paper making department have no report about the quality of the stock feeding in the paper making process. They cannot make any adjustment or correction to the problems occurred and it is often too late to make correction and control within the time. As a result, this effects the quality of company's product. Therefore, one reason behind the non-complying grammate standard occurs from the inability to control the quality of stock, which feeds in paper making process.

5.1.2 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 during each shift. The flow of the stock in paper making process is quite steady. However, there are problems during the time of changing each shift and the quality of paper during this time often varies. The grammate of paper sometimes is too high and sometimes is too low although the flow of the stock is still the same. When the new shift works for about one hour, everything becomes smooth again. From this survey I conclude that the problems arise because of the difference between employees of each shift in the same level of position. Hence, I focus to study the difference between employees of each shift to find the underlined causes of the problems.

Studying the difference between employees in each shift, I find that the employees who work in charge of wet canvas adjust the press too much. Consequently,

it makes the output paper becoming thin and lower in its weight. In the meantime the employees who work in charge of controlling the dry canvas set the different temperature of drying. Some employees set high temperature while some employees set low temperature. Thus the output of paper has different moisture. This situation often occurs during the time of changing each shift. When such problems arise, I check the condition of stock and the condition of the machine in the operation and find no mistakes at those points at all. So I recognize that the problems may arise from human errors. I think that if the employees in each shift 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 for each shift 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 manager 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 each shift 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 grammate standard.

5.1.3 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. I divided the period of time in study into two parts; the first part focuses on during the shift and the second part on during changing each shift.

On the study of during changing each shift, I find that the causes of problems result from quality of raw material (stock) and no job description, which have already been analyzed in 5.1.1 and 5.1.2. There is no significant reason to support our assumption, lack of knowledge among the employees and unskilled employees. So I go on to the second part.

The second part is to study the overall condition of work during each shift. There is no problem that arises from the raw material of fed stock and the machine as well. However, I notice that the procedure of working among the employees in each shift is somewhat different. Each shift, the employees have their own way, step and procedure of working. For instance, the employee who controls wet canvas makes no right decision in adjusting the press roll resulting in the overweight of pressing which breaks the fiber and the paper becomes thinner. Thus the grammate of paper is lower than standard. Also, the employee who controls dry canvas makes no right decision in controlling the temperature setting for drying. Sometimes he sets too high temperature, which makes the output, becomes crispy. From the interview of the employees about their procedure and step of working, I found that those people have no right in understanding the steps of working since the company does not set any job description to be a guide for practice. This problem has already been mentioned in 5.1.2.

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 concerning of the quality. Although some employees think about the quality, their knowledge of paper and technique of production is in the low level. From the interview of the employee who controls the roll and the one who controls the temperature, 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 paper has certain steps of procedure and also depends on many factors concerned. For example, in the quality of paper, the optimum pressure of blower makes the stock spreading on the canvas and evacuates the water out of the paper and so on. The employees should know their work effect to other parts of the operation and on the quality of product as well. Some examples are the effect of adjusting too much weight used for pressing the paper, and the effect of setting too high a temperature for drying. The way employees think shows that some employees still lack the general knowledge of paper, and technique of production. Some employees have a low level of knowledge of paper production.

Although some employees possess knowledge and know how of the technique, I find that these people still perform to effect the quality of paper 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 of paper. Also, the company will sell the non standard paper to the affiliated company or recycle to make other products such as the hard paper core or rework again. 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.

Moreover, recently the company has brought in the new technology. However, some employees do not know the changes and how to use them. They still keep on old methods. So the new technology cannot help effectively contribute to the quality. Some examples are the steps of adjusting the blower and adjusting the pressure of the press roller. Checking at the gauge of the panel control can control these two steps. Some employees do not use the gauge for aiding the control. They still use their personal experience by considering the outflow of water. If the volume of outflow is high, they will stop adjusting the blower and the pressure. This practice brings about the low quality on the product.

From the analysis above, most employees still lack knowledge. They do not know and understand general knowledge of paper, 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 manager 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 grammate standard as well.

5.2 Alternative Solutions for Solving Quality Problems

From the analysis of causes of problems in 5.1, unable to control the quality of stock that was inputted to the paper making process, no job description policy and lack of knowledge among employees are the important root causes of the quality problems of non-complying grammate standard. To solve the problem for increasing quality reduces number of failures, waste and nonconforming finished goods in paper making process. Therefore, alternative solutions to solve the causes of quality problems are developed by using 5W1H method in order to provide the quality improvement in the paper making 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 paper making 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.

5.2.1 Alternative Solutions for Inability to Control the Quality of Stock Which Feeds in Paper Making Process

The alternative solutions for this problem are developed by applying the method of 5W1H for setting questions which are:

Question: What makes the stock, which feeds in paper making process uncontrollable?

Answer: Not know exactly the certain condition of the stock at any point of time.

Question: Why do you not know certain conditions of the stock?

Answer: Because the inspecting employees have no continuous record of the condition of the stock.

Question: What can be done if the stock cannot be inspected often?

Answer: Providing some control in the condition of the stock within the stock preparation department.

Question: At present who does this job?

Answer: The chief of shift and his assistant.

Question: Why do these two persons have to perform this job?

Answer: Because at present, the company has no delegation on this job to any person. So the chief of each shift has to take responsibility.

Question: Who should do this job?

Answer: The company should set a position to inspect the condition of the stock. All employees should take turns to do the job.

Question: At present, where is a place for performing inspection?

Answer: At the flow box.

Question: Where is another place?

Answer: At the groove of the paper making machine.

Question: What is the method used in the inspection?

Answer: By observation.

Question: Why?

Answer: Because there is no measuring device for inspecting the condition of the stock.

Question: How to make the method becoming easier?

Answer: The company should purchase a measuring device to inspect the condition of the stock.

From the above questions I proposed the following alternative solutions to solve the present quality problem.

- (a) Setting the quality control of the stock in the stock preparation department
- (b) Purchasing a measuring device to inspect the condition of the stock
- (c) Setting a position to handle the inspection at the groove of the paper making machine at all times
- (d) Setting a position to handle the inspection at the flow box all the time

I analyzed the related information to screen for suitable solution, which can meet the limitation and constraint, mentioned before. The analysis includes the following:

- (1) Setting the quality control of the stock in the stock preparation department

This solution is not within the boundary of my study; however, I hope that it will contribute benefits to the company to make consideration in the near future.

- (2) The purchase of a measuring device to inspect the condition of the stock.

This alternative may not be suitable at present because the company has some financial problems. Also, the company may have some questions about the efficiency of the measuring device because the quality of the stock depends on many factors such as the performance of employees and the raw material.

- (3) Setting a position to inspect the stock at the groove of the paper making machine all the time and delegating the duty participated by all employees

This alternative is good on the lookout for the condition of the stock but it may have some technical problem because the groove of the paper making machine has limited space and has many amounts. For example, there are seven grooves in the second paper making machine. The amounts of employees in the paper making department are not enough to do this inspection. Moreover the management has no policy to change and adjust the grooves. So I have no consideration for this alternative.

- (4) Setting a position to inspect the stock at the flow box all the times and providing an employee to perform this duty

This alternative has immediate impact and this will speed up the report of emergency action for solving the problem. It also is feasible because each machine has only one flow box. It requires only one

employee to make inspection with no adjustment of machine and process as well. Moreover, the cost of this alternative is also low.

From the analysis of each alternative above, the suitable solutions for this problem is to set a position to inspect the stock at flow box all the time. The employee who is assigned to inspect the quality of stock must work coordinately with the paper making department and the stock preparation departments. The quality of the stock will meet certain requirements and if a problem arises, it can be solved immediately. This alternative may not give high precision and accuracy. However, it contributes some control to the quality of stock before feeding in the paper making machine. So I propose this alternative solution to the company.

5.2.2 Alternative Solutions for Non Standardized Performance of Employees

No standard in working of employees is the main cause of the quality problem. From the study at production line in the paper making department includes observation and interviews with the employees about the process. So I conclude the reasons why most employees' performance is substandard as follows:

(a) No job description policy for employees

To find the alternative solutions to solve this problem, 5W1H method is used for setting questions which are:

Question: What do we require from setting job description policy?

Answer: We require the employees to work uniformly in each shift.

Question: Why can job description policy decrease the difference among employees?

Answer: Because job description policy is a guide for working. At present, the employees perform their job differently. For instance, adjusting the pressure of the roller, they adjust

differently with different pressures and make different grammate of paper too. If the employees work uniformly, the variation of grammate value will reduce.

Question: How about the procedure used in the process at present?

Answer: The job of some positions are quite loaded such as the employee who control slither and rewinder process.

Question: Why?

Answer: Most machines used in the process are manual and are quite complicated to perform the job.

Question: How can we improve this?

Answer: Adjusting the controlling system of the machine for simplicity will make it easier for operation.

From the above questions I find two alternative solutions which are:

- (a) Setting job description for each employee in each shift
- (b) Adjusting the controlling system of the machine for simplicity and easy using such as introduction of automatic controlling system instead of manual system

The analysis of each alternative for suitable solution are as follows:

- (1) Setting job description for each employee in each shift

With this solution the company should provide some training together with the job description so that the worker will gain more understanding. Furthermore, it will decrease the overall cost of training in the long run.

- (2) Adjusting the controlling system of the machine for simplicity

I analyze that the improvement of the machine requires a lot of investment, which may be against the management's purpose mentioned

earlier. The company has no investment policy because of liquidity problem in finance. So it will be out of the scope of study for breakeven in the new system.

From the analysis of each alternative, I conclude that the suitable alternative solution to solve the problem is to set the clear job description for each employee in each shift. All employees have to study and understand the work requirement. This job description must be approved by the management and already tested in the fieldwork. This makes the employees have better understanding in their jobs. However, at present the company does not provide training so I cannot find out the result of training, which will impact on the performance.

(b) Unskilled employees

5W1H method is developed in order to find the alternative solutions to solve the problem for which the questions are:

Question: What is the result of the present working?

Answer: The employees cannot produce the standard grammate paper.

Question: Why?

Answer: Because the employees lack knowledge and understanding about procedure and technique in production.

Question: Where are the employees who still lack knowledge in the production?

Answer: They work in the paper making department and the stock preparation department.

Question: Why does the company let them work in their jobs?

Answer: Because they work for many years and the management expects them to have the skill for their jobs.

Question: Who is suitable for working in the paper making process?

Answer: The company should select the employees who have knowledge and know how to work efficiently and also recruit new employees.

Question: How do the present employees work?

Answer: They work inefficiently and have wrong concept of quality in working.

Question: What is another way for improvement besides recruiting new employees?

Answer: The company has to provide training for employees.

From the questions above, I can set three ways of alternative solutions which are:

- (a) To lay off the employees who have no knowledge and skill and recruit new employees who have qualifications for the jobs
- (b) Selecting the qualified employees to the right jobs
- (c) Providing training to the employees

I make the analysis for each alternative solution as follows:

- (1) Laying off the unskilled employees and recruiting qualified employees

With this alternative, the company will have qualified employees in working; however, in practice, it is difficult because it will make the employees do not feel secure which will impact on their work performance and the volume of production as well. Furthermore, there is a cost of lay off which will effect the financial position of the company.

- (2) Selecting qualified employees to the right jobs

This alternative solution will build good morale and good attitude in the employees' mind. So they work efficiently resulting in a high volume of

production. However, there is some limitation since the job position in each department is limited. Transferring and changing to meet job requirement may create some problems and may not be feasible.

(3) Providing training to the employees

With this alternative solution, it will provide the knowledge about the scope of work, general background of paper production and quality concept. In the short run, this solution will contribute to the understanding of job requirement and can work coordinately with other departments. It also builds job advancement to the employees who want to fulfill their progress. This also enhances employees to develop the capability of adaptation for the rapidly changing environment. In the future, the employees can be transferred, changed and moved around the job in other positions easily because they have solid backgrounds. In addition, it has lower cost compared with recruiting new employees.

I consider that providing training to the employees is the right way to solve the problem. The employees should be trained so that they can understand the scope of work, job requirement, the production process and the right concept of quality. The purpose of training is to increase and enhance the efficiency of each position and to change the old concept of production. Also, It makes more awareness the importance of quality control, which effects directly on standard grammate value. This will provide a background of setting quality control system in the future. The objective of training course is to train the shop floor employees, chief of employees and inspecting employees to understand their jobs, concept of quality control and the correct practice. They also learn to analyze, solve and make corrections to the problems. There may be other additional training provided for manager and middle management. I surveyed the

requirement of the training curriculum by interviewing the manager and the chief, employees in all departments concerned. Therefore, I propose the training curriculum as the suitable solution for solving the quality problem.

Providing education and training the company can be done in many ways:

- (a) Self development by each employee
- (b) On the job training
- (c) Cross training
- (d) Advice by the outside consultant
- (e) Joining with outside professional training center
- (f) Inside training by the internal and external specialists

The key success of training needs cooperation among the employees, supervisor, manager and the management of the company to realize the importance of training. At the beginning the company should strictly follow the attendance of employees in the programs in order to build attention and interest of the participants. Moreover, the manager and the supervisor should closely follow the employees attending the training. However, at present the company has no training policy. The reasons are lack of budget, time and specialist for training. The company agrees with the proposed measures and will keep it for the future. It is a pity that at present the company can not provide such training so I lose the opportunity to make evaluation of the result and the impact of training contributing to the production and the quality control.

VI. 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.

6.1 Conclusions

The aim of quality improvement in the paper making process in paper industry 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.

Seven quality improvement tools are used to determine the major problem in this factory and analyze the root causes. The nine symptoms the defective product has, are high grammate, low grammate, over joining, high moisture, rough edge of paper, crack of edge, wrinkle, dirtiness and over soft. The major symptom in this paper making process is non-complying grammate standard problem that effects directly on the customer satisfaction and increasing cost of the company. Next the analysis of root causes by cause and effect diagram shows that the major causes are man, material, method, machine and measurement. From the analysis, these major causes result from the inability to control the stock which feeds the paper making machine, no job description policy for employees and the lack of knowledge and skill of employees.

The successful quality improvement depends on foundation of quality control system, necessary important information and document and the optimum solution for

the current problems. So I develop the alternative solutions for each causes of each problem and analyze the optimum solution. The company can solve it by setting a position to inspect the stock at flow box all the time, setting the clear job description for each employee in each shift and by providing 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.

6.2 Recommendation for the Alternative Solutions

The recommendation for the alternative solutions is 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 5.1 in Chapter 5 we will see that basic weight problem which is non-complying grammate 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 at flow box at all times. 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 in each shift. When they know and understand clearly the step 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 of 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 into 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 of the combination between water and stock. Therefore, the company should purchase measuring device which is necessary to use in quality control such as the measuring device for inspecting the quality of pulp feed and stock, the measuring device for flow rate, etc. 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.

6.3 Recommendation for 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.

6.4 Recommendation for 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.

6.4.1 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:

- (1) 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 the 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.

- (2) 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.
- (3) 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.
- (4) 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).
- (5) 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.

6.4.2 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.

6.5 Recommendation for 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 in 6.3 and should perform continuously. The evaluation should be made 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.



APPENDIX A

FACTORY LAYOUT OF SIAM PAPER BOX CO., LTD.

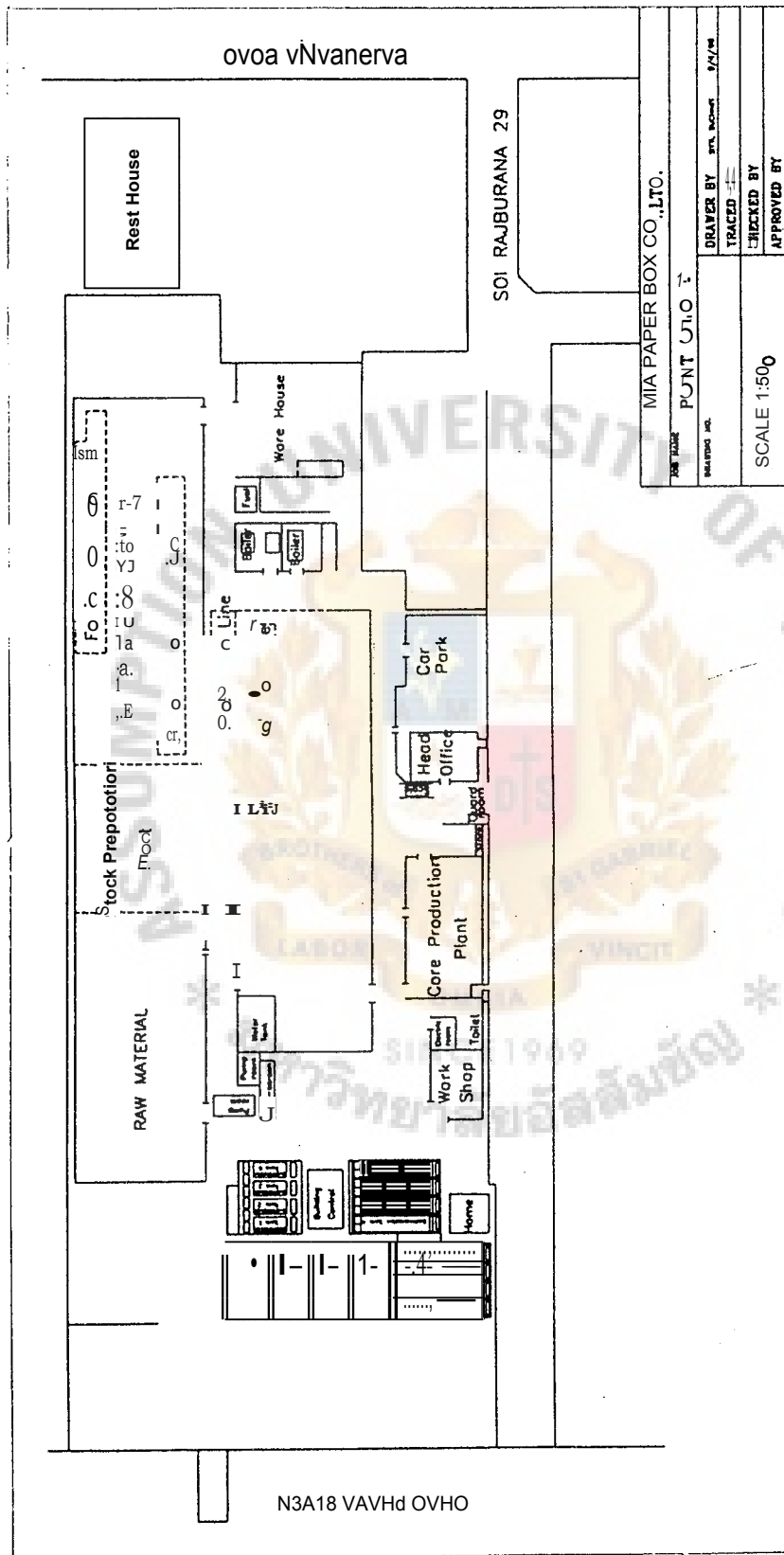


Figure A.1. Factory Layout of Siam Paper Box Co., LTD.

APPENDIX B

VOLUME OF THE DEFECTIVE PRODUCTS OF EACH GRADE IN 1999
AND INDUSTRIAL STANDARD WEIGHT OF PAPER IN EACH GRADE

Volume of the Defective Products of Grade CA 110 in 1999 (Rolls).

Grade CA 110									
Roll No	High grammate	Low grammate	Rough Edge	Crack of edge	Over joining	Dirtiness	High moisture	Over soft	Wrinkle
37	Cr)								
38	Cf)								
39	71-	Cl			CNI				
40	27								
41	80								
42	71-								
43	80								
44									
45									
46									
47									
48									
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92									
93									
94									
95									
96									
97									
98									
99									
100									

Volume of the Defective Products of Grade CA 125 in 1999 (Rolls).

Grade CA 125									
№	High grammate	Low grammate	Rough Edge	Crack of edge	Over joining	Dirtiness	High moisture	Over soft	Wrinkle
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
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95									
96									
97									
98									
99									
100									

Volume of the Defective Products of Grade CA 140 in 1999 (Rolls).

Grade CA 140									
Defective products	High grammate	Low grammate	Crack of edge	Over joining	Dirtiness	High moisture	Over soft	Wrinkle	
14	CA	—							
30	H	oo						1-1	
32	71	f-A	CNI						
34	71	00							
40								1-1	
42	kr)	H4							
48	38	cn		221	1-1		CNI	10	
52		163							
54									
kr)	7t	i							
80	71	CA							
90		Lem							
90		cr)							

[illegible]

$$\begin{array}{c} \text{C}^{\dagger} \\ \text{C} \\ \text{H} \end{array}$$

Grade CB 350

Table B.10. Industrial Standard Weight of Paper in Each Grade.

Grade	Grammates	Standard weight (Grammate /GSM)	Control limit of standard weight		
			Upper limit	Lower limit	Remark
			(+5%) (Grammate)	(-5%) (Grammate)	
CA	110	110	115.5	104.5	
CA	125	125	131.25	118.75	
CA	140	140	147	133	
CA	160	160	168	152	
CA	180	180	189	171	
CB	230	230	241.5	218.5	
CB	350	350	367.5	332.5	
CB	450	450	472.5	427.5	
CM	125	125	140	130	
CS	125	125	131.25	118.75	
CSB	125	125	131.25	118.75	
KAS	125	125	131.25	118.75	
KAS	150	150	157.5	142.05	
KAS	160	160	168	152	
KAS	180	180	189	171	

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