PRIORITIZATION AND RECTIFICATION OF PRODUCTION PROBLEMS FOR A RUBBER WOOD FURNITURE MANUFACTURER

by

Ms. Siriwan Chantra

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

November, 2000

PRIORITIZATION AND RECTIFICATION OF PRODUCTION PROBLEMS FOR A RUBBER WOOD FURNITURE MANUFACTURER

by
Ms. Siriwan Chantra

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

November 2000

Project Title	Prioritization and Rectification of Production Problems for a Rubber Wood Furniture Manufacturer
Name	Ms. Siriwan Chantra
Project Advisor	Dr. Chamnong Jungthirapanich
Academic Year	November 2000

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.

Approval Committee:

(Dr. Chamnong Jungthirapanich)
Dean and Advisor

(Prof.Dr. Srisakdi Charmonman)
Chairman

(Asst.Prof.Dr. Boonmark Sirinaovakul)
Member

(Dr. Prapon Phasukyud)
Member

(Assoc.Prof. Somchai Thayarnyong)
MUA Representative

November 2000

ABSTRACT

This project is to solve the production problems in the existing processes through the application of many approaches such as Pareto analysis, process chart, job design method, and PERT/CPM.

The details of each approach are explained and that include concept, techniques, benefits and limitation. The figures and tables are also illustrated in order to provide a better understanding.

Furthermore, background of the company is described and analyzed to find out all possible problems. Also, such problems are prioritized to know the most severe ones.

Then, such problems are grouped according to similarity and relatedness. Each problem in each group is discussed and rectified by different ways. Moreover, it also provides an example of the production process of party wagon which is the best sold product and the solutions to the existing problems through the application of process chart, PERT, and job analysis method.

Further, the processes of production are reduced by applying PERT technique. As a result, the new process has less procedures, thus it takes less time for the production. Also, job design method is used to improve worker performance so that they can perform the jobs efficiently.

Since the implementation of this project takes a long time, the result of the implementation cannot be produced within the limited time frame. Therefore, it will be a continuous flow of work which needs to be adjusted to ensure the effective solution to the problems.

ACKNOWLEDGEMENTS

I am indebted to the following people and organizations, without them, this project would not have been possible.

I wish to express my extreme sincere gratitude to my advisor and Dean of Graduate School, Dr. Chamnong Jungthirapanich. His patient assistance, guidance, and constant encouragement had led me from the research inception to the research completion. I would like to express appreciation for my Advisory Committee members: Prof.Dr. Srisakdi Charmonman, Asst.Prof.Dr. Boonmark Sirinaovakul, Dr. Prapon Phasukyud and Assoc.Prof. Somchai Thayarnyong for their constructive comments and advice throughout the research.

Special appreciation is due to my family for their fervent and continuous encouragement. Further, I would like to thank my friends for their motivation and encouragement on doing the project. Above all, I am forever grateful to my parents whose willingness to invest in my future has enabled me to achieve my educational goals.

TABLE OF CONTENTS

Chapter		Page
ABSTRACT		i
ACKNOWLEDGEMENTS		ii
LIST OF FIGURES		v
LIST OF TABLES		vi
I.	INTRODUCTION	1
	1.1 Background of the Project	1
	1.2 Objective of the Project	1
	1.3 Scope of the Project	1
II.	LITERATURE REVIEW	3
	2.1 Job Analysis and Design	3
	2.2 Pareto Analysis and Design	8
	2.3 Process Chart	12
	2.4 PERT/CPM Network	17
III	PRODUCTION PROBLEMS PRIORITIZATION	23
	3.1 Background of the Company	23
	3.2 Problem Prioritization	23
	3.3 Sales Volume Analysis	30
IV.	PROBLEM RECTIFICATION PLANS	33
	4.1 Groups of Problems	33
	4.2 The Detailed Rectification Plan for Production Problem	40
	4.3 Process Charting-	42

Chapter Page

V. PLAN EVALUATION 58

5.1 Process Charting 58

5.2 Job Analysis and Design 63

VI. CONCLUSIONS AND RECOMMENDATIONS 69

6.1 Conclusions 69

6.2 Recommendations 72

BIBLIOGRAPHY 74

LIST OF FIGURES

Figure		Page
2.1	A Pareto Chart	10
2.2	Process Chart Symbols	13
2.3	A Worker-Machine Chart	16
2.4	A Simple Project Network Diagram	18
3.1	General Problems of the Company	28
3.2	The Top Eight Sale Volume of Product	32
4.1	Production Problems Classification	36
4.2	Cause-and-Effect Diagram	41
4.3	The Existing Process Chart	46
4.4	The New Process Chart	50
4.5	The Existing PERT Diagram	53
4.6	The New PERT Diagram	54

LIST OF TABLES

Table		Page
3.1	The Sample Form for Ranking Problems	24
3.2	The Evaluation of Problems	26
4.1	The Calculation of Critical Path of the Existing Process	55
4.2	The Calculation of Critical Path of the New Process	56
5.1	The Comparison of Production Time between the Existing and the Proposed Process	59
5.2	The Total Summary between the Existing and the Proposed Process	62

I. INTRODUCTION

1.1 Background of the Project

Our company, a manufacturer for rubber wood furniture, has been facing a lot of problems such as order, delivery, production and other problems that cannot be completely solved. These problems have negative effect on our organization and may cause the organization to stop running the business.

Therefore, our organization has attempted to solve these problems in order to maintain the business. Since we realize the importance and benefits of process chart and job design methods and other approaches, this project is conducted in order to solve the existing problems or problems that may occur in the near future by applying such methods. This application can improve worker performance. The company can also achieve the goal of productivity and efficiency it needs to survive economically and improve the customer satisfaction as well.

1.2 Objective of the Project

The objective is to solve the production problems in order to improve the production processes and worker performance so that the workers can perform their works to achieve the organization's goal and also the organization can obtain the profits as it wants.

The solution is achieved through the application of Pareto analysis, job design method, process charting, and PERT/CPM which each problem is, thus, solved by suitable approaches.

1.3 Scope of the Project

All company's problems are prioritized though the Pareto analysis. The most priority problem is production problem which is the cause of this problem is analyzed by using cause and effect diagram, then it is to be solved by applying job design process chart method, and PERT/CPM. This project toward an application of many approaches is likely to be useful for any organization that needs to improve and solve some existing problems about the production. Each part will be proposed the suitable technique which is systematically described and illustrated for a clearer understanding.

II. LITERATURE REVIEW

This chapter will propose the definition of job analysis and design, its objectives, and methods analysis and improvement. It also proposes the theory of Pareto analysis, Process charting and PERT/CPM. Each theory includes the definition, methods, examples shown in tables and figures and other aspects involved.

2.1 Job Analyses and Design

Since a company is dependent on its employees for its success, anything that affects the employee's job performance should be of interest to the management level because it is the management's responsibility to get work accomplished through others. Therefore, first thing the management team has to do is to consider job design in order to improve job performance so that both the employees and the organization obtain these mutual benefits.

2.1.1 Definition of Job Analysis and Design

Russell and Taylor III (1998) supported that part of job design is to study the methods used in the work included in the job to see how it should be done. This has traditionally been referred to as methods analysis or simply works methods.

According to Stevenson (1999), job design is defined as the specification of the tasks, methods, and relationships of jobs in order to satisfy technological and organizational requirements as well as the social and personal requirements of the jobholder.

Job design can be grouped into two broad categories:

(1) Technical-physical factors

(a) Task content is the operations that must be performed to convert inputs into the desired output.

(b) Physical context is the heat, light, noise, fumes or pollution, appearance, and safety precautions that surround the jobholder.

(2) Sociopsychological factors

(a) Social factors is the personal interactions that occur because of the organizational structure and job assignments.

(b) Intrinsic factors is the internal psychological feeling that are engendered as a result of performing the job.

Simplification, specialization, mechanization, job enlargement and motion economy may prove helpful in redesigning jobs so that the overall operation is improved.

2.1.2 Objectives of Job Design

There are three main objectives that a manager should strive for in specifying jobs technical, economic and behavioral feasibility.

Technical feasibility. A job is a set of tasks or duties assigned to be performed. The person who holds the job must be capable of performing the assignment with the equipment and systems available, and the job must make the necessary transformations of inputs into outputs. A job must be beyond the reasonable limits of a person's skills or physical and mental endurance. Proper selection of processes and equipment as well as proper selection and training of employees helps ensure technical feasibility.

Economic feasibility. The cost of performing the job should not be too high, Overall a business must be able to collect for its services more than the cost of providing them so that some revenue will be left to pay for the use and risk of the owners' and lenders' capital. Since many businesses and other institutions must perform in a competitive environment, they are subject to some pressure to keep prices and costs at reasonable levels. Regulated monopolies such as utilities are subjected to pressures to keep their rates low. Government agencies compete with each other for funds, which it is hoped are limited by the taxpayers' representatives. As a whole, the collection of jobs within an organization must remain solvent. Some jobholders may be paid more than the value they add to the product or service. There is a limit, however, to the amount of money can pay for the jobholders support equipment, and facilities necessary to affect the desired transformation processes.

Behavioral feasibility. Some characteristics of a job may affect the jobholders' perception of themselves, their perception of others, and their relationships with others. A task role may give people a feeling of great worth - of being an important part of the organization. The feelings that people derive from a job affect their motivation to perform it. Since a job is often more than just a set of mechanical motions to be performed, it requires motivation and mental simulation if it is to be performed successfully. Unstructured jobs often require so much of a person's creativity and mental attention that a good attitude is vital to its satisfactory performance. Even routine, structured jobs require that a person be motivated enough to be present at the job and contribute the necessary effort. Beyond the individual, jobs carry with them social interactions that lead to group reactions. Informal organizations or work groups have a large impact on the effectiveness of an organization, for either good or bad. Attitudes are contagious and peer relations or peer pressure may be responsible for many of the motivational reactions of workers.

2.1.3 Methods Analysis and Improvement

Russell and Taylor III (1998) supported that part of the design process for a job is to study the methods used in the work included in the job to see how the job is done or should be done. As a result, this area of job design has traditionally been referred to as methods analysis, or simply work methods. Methods analysis is typically an activity conducted by someone trained in the study of work methods, such as an industrial engineer or a methods analyst.

The most frequent application of methods analysis is for the redesign or improvement of existing jobs. An analyst will study an existing job to see how the work is accomplished in order to determine if the tasks are performed in the most should be added. The analyst might also want to see how the job fits in with other jobs-that is how well a job is integrated into the overall production process or a sequence of jobs.

Methods analysis is also used to develop new jobs. In this case the analyst must work with a description or outline of a proposed job and attempt to develop a mental picture of how the job will be performed.

The primary tools of methods analysis are a variety of charts that illustrate in different ways how a job or a work process is done. A primary benefit of these charts is that they are more easily understood by supervisors, managers and workers than a written description might be. The charts enable the methods analyst to show these individuals how a job is accomplished and get their input and feedback on the design or redesign process.

Thomas Edison, Henry Ford, George Westinghouse and many others are well known today since they succeeded in developing new methods that help their companies to become successful. Often a company's objective is to achieve a cost saving, but other objectives, such as improved quality, may cause the undertaking of a methods study.

Method improvement involves examination of any aspect of a job and work to redesign it to a more efficient level. The basic aim is to develop a more efficient system for producing goods or providing services, taking into account both the technical and behavioral aspects of the job.

Opportunities for improvement may result from any of several circumstances, some of which are:

(1) a change in the demanded volume of a product at a particular location.

(2) a change in some other product that shares the use of some of the same facilities.

(3) introduction of a new product or service.

(4) a change in the product's design.

(5) a change in technology, making available some new method or equipment.

(6) consolidation or departmentalization of the organization.

(7) dissatisfaction with some aspect of the operation.

The overall procedure for performing a methods improvement study may be summarized in the five basic steps listed below:

(1) Observe and understand the current method.

(2) Document the current methods. It is usually helpful to have detailed description of a method to be studied. Charting methods such as the left-and right-hand chart or multiple-activity chart.

(3) Critically evaluate the current method and any proposed changes in it. This is the most important step in a methods study because it is here that any ideas for improvement will occur. Creativity, ingenuity and persistence can pay other factors that may affect performance and costs

(4) Implement the improvement. Naturally, ideas alone will accomplish little: an improvement must be put into effect before any benefit will be achieved. Someone must specify a plan of action, assign responsibilities, and follow up to see that the new method is used. Any new method that is implemented

should show promise of a potential cost saving or an improvement in quality that is at least large enough to pay for its cost.

(5) Reevaluate the new method after sufficient time has passed to see that it is working as intended.

2.2 Pareto

Pareto is the concept originated by an Italian economist, Vifredo Pareto, that a relatively few factors generally account for a large percentage of the total cases (e.g., complaints, defects, problems). The idea is to classify the cases according to degree of importance, and focus on resolving the most important, leaving the less important for later resolution.

The Pareto's concept is also referred to the 80-20 rule which means that the approximately 80 percent of machine breakdowns come from 20 percent of the items. For instance, 80 percent of machine breakdowns come from 20 percent of the machines, and 80 percent of the product defects come from 20 percent of the causes of defects. The principle of this rule is that a few causes are usually responsible for most of the problems (Stevenson 1999).

2.2.1 Pareto Analysis

According to Russell and Taylor III (1998), Pareto analysis is a technique that classifies problem areas according to the degree of importance of the defect.

It determines the relative frequency of various problems or causes for problems so that primary attention can be focused on the most important ones (Dilworth 1993).

Furthermore, Finch and Luebbe (1995) also proposed that pareto analysis provides a way to focus on the vital few rather the trivial many.

Pareto analysis can help prioritize and focus resources where they are most needed. It can also help measure the impact of an improvement by comparing before and after. When giving presentation, Pareto Diagram is a visually effective means of displaying the relative importance of causes, problems or other conditions (http://dipoli.hut.fi/org/TechNet/org/eurocinet/tool9.html).

Pareto Analysis is a method of identifying the causes of poor quality. It was devised in the early 1950s. By the well known quality expert Joseph Juran. He named this method after a turn-of-the-century Italian economist, Vilfredo Pareto, who determined that in Milan fewer than 20 percent of the people had more than 80 percent of the wealth. Pareto theorized that this was true of other economies as well. Pareto analysis is base on Juran's finding that most quality problems and costs resulted from only a few causes. For example, he discovered in a textile mill that almost 75 percent of all defective cloth were caused by only a few weavers and in a paper mill he studied, more than 60 percent of the cost of poor quality was attributable to a single category of defects. In other words, he discovered the relatively few major causes of most of the quality problems will result in the greatest cost impact. He also added that Pareto analysis can be applied by simply tallying the number of defects for all the different possible causes of poor quality in a product and then developing a frequency distribution from the data. This frequency distribution is referred to as a Pareto Diagram, and it is a very useful visual aid for focusing on major quality problems (Russell and Tayler III 1998).

2.2.2 Pareto Chart/Diagram

According to Muhlemann, Oakland and Lookyer (1997), a pareto diagram is simply a histogram in which frequencies are ordered from largest to smallest.

Heizer and Render (1999) supported that pareto chart are a method of organizing errors, problems or defects to help focus on problem solving effects.

Pareto chart is a simple bar chart that is used after data have been collected to identify and rank problem. It is a vertical bar graph showing problems in a prioritized order, so it can be determined which problems should be tackled first. Pareto charts are typically used to prioritize competing or conflicting "problems" so that resources are allocated to most significant areas. Pareto chart is shown in Figure 2.1.

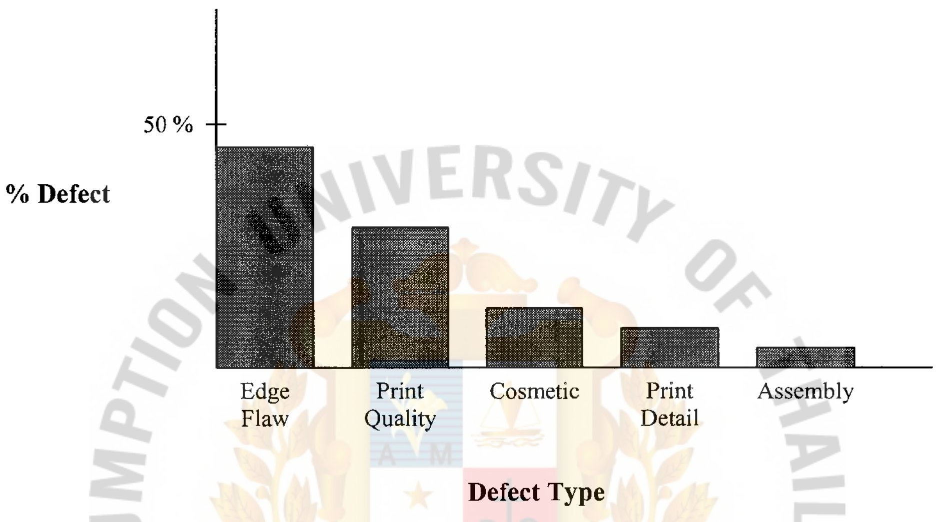

Figure 2.1. A Pareto Chart (Heizer and Render 1999).

There are eight steps for constructing a Pareto diagram as follows:

(1) Assemble the data to be analyzed. You may need to design a checksheet to collect it.

(2) Add up the total of each item under analysis.

(3) List the items in order of magnitude, starting with the largest.

(4) Calculate the total of all the items, and the percentage that each item represents of the total. Beside each item write the cumulative total and cumulative percentage.

(5) Draw a bar chart. Use the y-axis (vertical) to show the volume of what you are comparing (frequency, cost, time etc.) list the items from left to right in

the x-axis (horizontal), arranged according to size, with the largest on the left. If there are a lot of items, you may group together those containing the fewest number into an "Other" category placed on the far right as the last bar. Above each item draw a bar to a height that matches its frequency or count on the y-axis. The bars should all be the same width and have gaps between them. Under the horizontal axis label each of these bars.

(6) Draw in the cumulative curve. To do this, draw a line from where the axes start to the upper right-hand corner of the first bar. Place a dot here and next to it write the percentage calculated for that item. Make a second dot directly above the top-right hand corner of the second bar to represent the cumulative total (i.e. the total of the first an second item added together). Join it to the first dot and write the cumulative percentage beside it. Continue until the last cumulative total has been plotted. On the right-hand side of the diagram, next to the last bar, draw in a second vertical axis, which starts at zero and has 100% aligned with the end of the cumulative curve.

(7) Label the diagram with a title and any other necessary items; the data it was drawn, the source of the data, etc.

(8) Interpret the diagram. In general, the items requiring priority action, the "vital few", will appear on the left of the diagram where the slope of the curve is steepest. When comparing before and after, if the improvement measures are effective either the order of the bars will change or the curve will be much flatter.

Sometimes it is helpful to do more than one Pareto, based on different units of measurement e.g. the type of error which occurs most frequently may be the cheapest to correct; in this case it would be appropriate to do a Pareto based on cost to see which error accounts for most of the correction cost

2.3 Process Charts

A process chart is an organized way of recording all the activities performed by a person, by a machine, at a workstation, or on materials (Stevenson 1999).

Krajewski and Ritzman (1996) added that process charts are charts in which a sequence of events is portrayed diagrammatically by means of a set of process chart symbols. Their purpose is to provide an unambiguous, succinct record of a process so that it may be examined, analyzed and desirably improved, usually away from the workplace.

Five symbols have been generally agreed and are in current use. There are illustrated as follows:

(a) Operation

(b) Transportation

(c) Inspection

(d) Delay

(e) Storage

An operation is productive work that changes, creates, or adds something. Examples are mixing tar, stone, and sand to make asphalt; drilling a hole; and serving a customer at a store.

Transportation (sometimes called materials handling) is the movement of the study's subject from one place to another. The subject can be a person, a material, a tool, or a piece of equipment. Examples of transportation are a customer walking from one end of a counter to another, a crane hoisting a steel beam to a location, and a conveyor carrying a partially completed product from one work station to the next.

An inspection checks or verifies something but does not change it. Checking for blemishes on a surface, weighing a product, and taking a temperature reading are examples of inspections.

A delay occurs when the subject is held up awaiting further action. Time spent waiting for materials or equipment, time for cleanup, and time that workers, machines, or work stations are idle because there is nothing for them to do are examples of delays.

Storage occurs when something is put away until a later time. Supplies being unloaded and placed in a storeroom as inventory, equipment put away after use, and papers put in a file cabinet are examples of storage. Depending on the situation, other activity categories can be used, such as subcontracting/outside services or distinguishing between temporary storage and permanent storage. Five symbols of process chart are shown in Figure 2.2.

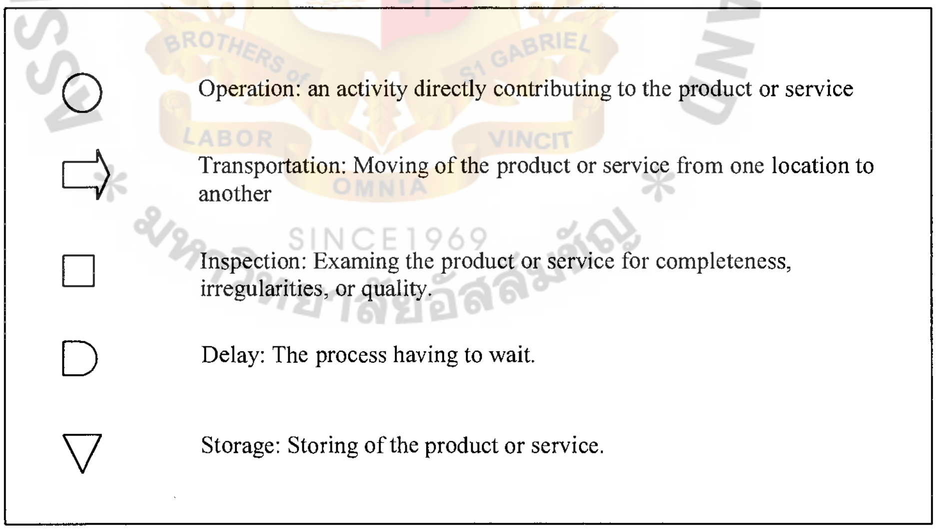

Figure 2.2. Process Chart Symbols (Award 1979).

Process charts have basically two types differing in the level of detail recorded:

(1) Outline process chart. In this, the overall picture of the sequence of events and of the introduction of materials in a process is given by recording operations and inspections, using only two symbols (the circle and the square) of the five available

(2) Flow process chart. This provides considerably more detail than the outline process chart, and all five symbols are used. Flow process charts refer either to the man (or machine/equipment) i.e. to the activities performed by the man, or to the material (the activities carried out upon the material) and not normally to both simultaneously. Pre-prioritized forms are often prepared within larger organizations.

To complete a process chart for a new process, the analyst must identify each step performed. If the process is an existing one, the analyst can actually observe the steps, categorizing each step according to the subject being studied. Changing the subject (say, from the product being made to the worker) might also change the category to which a step is assigned. The analyst then records the distance traveled and the time taken to perform each step. After recording all the activities and steps, the analyst calculates summary data on the number of steps, total times, and total distance.

After the process is charted, the analyst estimates the annual cost of the entire process. The annual cost becomes a benchmark against which other methods for performing the process can be evaluated. Annual labor cost, for example, can be estimated by finding the product of: (a) time in hours to perform the process each time, (b) variable cost per hour, (c) number of times the process is performed each week, and (d) number of weeks per year in which the process is performed.

Next come the creative part of process analysis. The analyst now asks the what, when, who, where, how long, and how questions, challenging each of the steps of the process charted. The summary of the process chart indicates which activities take the most time. To make a process more efficient, the analyst should question each delay and analyze the operation, transport inspection, and storage activities to see whether they can be combined, rearranged, or eliminated. There is always a better way, but someone must think of it, improvements in productivity can be significant.

2.3.1 Multiple Activity Charts

Gaither and Frazier (1999) wrote that this chart is helpful for visualizing the portions of a work cycle during which an operator and equipment are busy or idle. The analyst can easily see when the operator and machine are working independently well as when their overlaps or is interdependent. One use of this type of chart is to determine how many machines or how much equipment the operator can manage. An example of a worker-machine chart is shown in Figure 2.3.

Krajewski and Ritzman (1996) supported that a process chart describes the work being done by or on just one subject. However, simultaneously tracking multiple subjects may by more revealing. A multiple activity chart, sometimes called a man-machine chart, is a record of the activities performed by or on several subjects over a given time period.

The first step in preparing these charts is to determine which process to study. The analyst divides a sheet of paper into columns, with one for each person, material, or workstation. The analyst next observes the process and establishes a time standard for each activity. Finally, the analyst charts the time required to perform each activity, using vertical bars having lengths that represent these times.

Product : Produce | Operator : L. W.

Process : | Charted by : R. G.

Step	Employee	Time (second)	Machine
1	Accepts produce from customer and	0	
	Places on scale	1	
2	Punches in price/lb	2	
3		3	
4	Remove produce	4	
		5	
5	Notes price and marks on produce	6	Calculates and displays total price
		7	
6	Hands produce to customer	8	

Summary

	Employee Time (Seconds)	Employee %	Machine Time (Seconds)	Machine %
Work	7	87.5	1	12.5
Idle	1	12.5	7	87.5

Figure 2.3. A Worker-machine Chart (Krajewski and Ritzman 1996).

The next step is to find ways to improve the process. Analyzing the multiple activity chart can uncover ways to divide work among employees, reduce time required for certain activities, or rearrange activities to shorten a job's overall time. It helps managers decide how to utilize people, workstations, or machines more effectively. Managers frequently use multiple activity charts to find ways to minimize idle time. The result can be significant productivity improvements. Such is the case for dentistry, which is a much different business than it used to be. The dental profession stands out in the health-care industry as a leader in productivity improvement. These substantial gains are being studied carefully by the rest of the health-care industry as a leader in productivity improvement. These substantial gains are being studied carefully by the rest of the health-care industry.

2.4 PERT/CPM Network

PERT and CPM are two commonly used approaches for managing projects. The network approaches provided by these techniques enhance management's ability to plan schedule and monitor complex projects. By identifying the project duration through the critical path, managers separate the important few from the trivial many and focus their attention on the most important activities.

2.4.1 Definition of PERT/CPM

Johnson, Newell, and Vergin (1972) defined PERT (Program Evaluation and Review Technique) as a technique of network analysis that presents a model of the activities which are necessary to complete a particular program. The PERT technique is based on the concept in any program there are three significant variables: time, resources (personnel, facilities, funds) and performance specifications.

Gaither (1996) supported that PERT is almost identical to CPM in regard to its functions, network diagrams, internal calculations, and resulting project management reports.

Critical Path Method (CPM) is an approach to planning and coordinating large projects by directing managerial focus to the project's most critical aspects and providing an estimate of its duration (Muhlemmann, Oakland, and Looker 1998).

It is developed in 1957 by J. E. Kelly of Remington Rand and M. R. Walker of Du Pont to help schedule maintenance projects in chemical plants. CPM is designed for projects with many activities where on time completion is imperative (Gaither 1996).

Once all activities and immediate predecessors have been identified, we can construct a graphical representation of the project called a project network or PERT/CPM Network. A project network consists of numbered circles connected by arrows. The circles represent events and are called nodes. The straight and curved arrows connecting the nodes called branches or arcs at a node, and thus a project network portrays the predecessor relationships among the activities. An example of a simple project network diagram is shown in Figure 2.4.

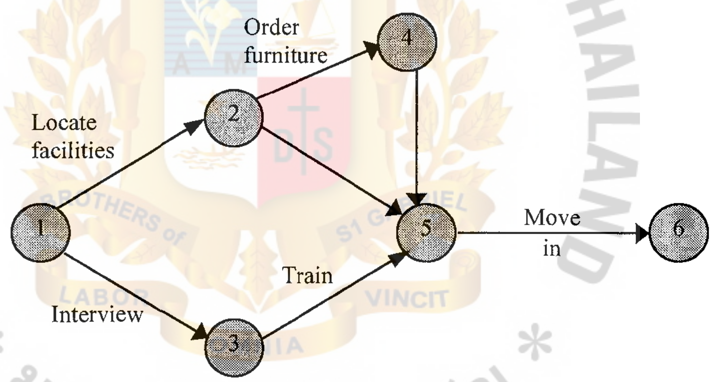

Figure 2.4. A Simple Project Network Diagram (Stevenson 1999).

2.4.2 Benefits and Limitations of PERT/CPM

PERT/CPM offer a number of benefits to project managers. However, they also have limitations.

The benefits of network planning models for large, complex projects are as follows:

(1) Considering projects as networks forces managers to organize the required data and identify the interrelationships between activities. This process also identifies the data to be gathered and provides a forum for managers of different functions to discuss the nature of the various activities and their requirements.

(2) PERT/CPM computer packages provide graphic displays of the project diagram and progress reports.

(3) Networks enable managers to estimate the completion time of the project, which can be useful in planning other events or in contractual negotiations with customers.

(4) Reports highlight the activities that are crucial to completing the project on schedule. These reports can be updated periodically over the life of the project.

(5) Reports also highlight the activities that have slack, thereby indicating resources that may be reallocated to more urgent activities. Networks enable managers to analyze cost-time trade-offs.

Finch and Luebbe (1995) supported that PERT and CPM networks offer managers an opportunity to better understand and manage projects. They give managers the ability to identify the specific activities and relationships within a project and estimate the time required to complete each activity. This helps them view the whole project rather than just small pieces. By identifying the critical path, PERT/CPM provides management a focus as the project is being monitored. Additionally, the networks provide a graphic model of the project and its key activities.

However, PERT/CPM has some limitations as follows:

(1) Network Diagrams. The methods used in PERT/CPM are based on the assumption that project activities have clear beginning and ending points, that they are independent of each other, and that the activity sequence relations can be specified in a network diagram. In reality, two activities any overlap, or the outcome of one activity may determine the time and resources required for another activity. Also, a network diagram developed at the start of a project may later limit the project manager's flexibility to handle changing situations. At times, actual precedence relationships cannot be specified beforehand because of some dependencies between activities.

(2) Control. A second underlying assumption in PERT/CPM methods is that managers should focus only on the activities along the critical path. However, managers also must pay attention to near critical paths, which could become critical if the schedules of one or more of the activities slip. Project managers who overlook near-critical paths may find their project's completion date slipping.

(3) Time Estimates. A third assumption that uncertain activity times follow the beta distribution-has brought a variety of criticism. First, the formulas used to calculate the mean and variance of the beta distribution are only approximations and are subject to errors of up to 10 percent for the mean and 5 percent for the variance. These errors could give incorrect critical paths. Second, arriving at accurate time estimated for activities that have never been performed before is extremely difficult. Many project managers prefer to use a single time estimate arguing that pessimistic time estimate than do the optimistic time estimates. Inflated pessimistic time estimates build a cushion of slack into the schedule. Finally, the choice of the beta

distribution is somewhat arbitrary, and the use of another distribution would result in a different expected time and variance foe each activity.

(4) Resource Limitations. A fourth assumption of PERT/CPM is that sufficient resources will be available when needed to complete all project activities on schedule. However, managers should consider the load placed on resources to ensure efficient resource use and avoid project delays caused by exceeding capacity. Network diagrams don't show the implications of resource limitations for a schedule of activities.

One weakness with networks is that they do not allow for the possibility that some activities may not be completed at all, throwing the time projection for the project into disarray. Some structured processes for developing contingency plans can minimize the impact of such occurrences (Stevenson 1999).

PERT/CPM can consider uncertainty in activity completion time but not uncertainty about whether actual completion will occur. Risk of completion exists in such activities as research and development and in the reengineering of processes, where some attempts will not be successful. Risk of completion time means the duration may be longer or shorter than expected, but it will be completed.

Although PERT/CPM has shortcomings, its skillful application to project management can significantly aid project managers in their work.

2.4.3 Other Aspects of the PERT/CPM Network

In addition to the PERT/CPM network, the process decision program chart (PDPC process) can be incorporated into the project planning process. This starts as a macro-level flow chart of the project's activities. For each activity there may be more than one approach leading to completion. Each of these approaches may have more than one possible out come, depending on problems encountered environmental issues, or other difficult-to-predict influences. Some of the possible outcomes may be undesirable and lead to a failure of completion.

For each possible outcome, a contingency plan is defined for one of two possible states. First, we might choose to allow the outcome to occur and define ways to recover or might choose to prevent the outcome because its impact would be so severe.

Options, possible outcome, and potential contingency plans are studied thoroughly before each activity is undertaken. Once the activities and relationships have been defined using PERT/CPM and the range of possible outcomes and contingency plans have been developed through PDPC, the potential for unexpected outcomes leading to risk of completion is reduced.

A model, however, is only as good as the data that have served as input. Activities are sometimes sequences improperly, time estimates may be inaccurate, and activities may be omitted entirely. Managers must recognize that time estimates are forecasts, and forecasts are frequently wrong. The most costly errors are typically not clerical errors but those that occur because the project wasn't understood completely. Computer software designed for project management is often necessary for complex projects. Even software cannot help management identify, before the fact, all activities that must be completed on a project that has never before been attempted. This can only come from managerial expertise and foresight. The success of the project planning effort can be increased by integrating the PERT/CPM techniques discussed here with other known successful approaches to managing tasks, such as the TQM tools (Finch and Luebbe 1995).

III. PRODUCTION PROBLEMS PRIORITIZATION

This chapter will describe background of the company, the prioritization of company's problems, and an analysis of sales volume through the application of Pareto diagram.

3.1 Background of the Company

Wood Mart Co., Ltd. is an export company that has been in business since 1989. The main product we produce is wood furniture which are made of rubber wood such as party wagon, dining sets, shelves, cabinets and small furniture trolleys. Our main customers are often the companies that have contacted us since our company started a business. The production will be conducted through make-to- order from customers and we have to order raw materials (rubber wood) from suppliers.

Due to this process, we have found many problems in various aspects such as late delivery of raw materials, mistake of production schedule. These problems cause late production and finally it leads to the delay of product shipments. Sometimes, the production is done urgently, thus the finished products do not meet the standard and are unqualified. As a result, the products are claimed and the customers are not satisfied with such events. Eventually the number of customers gradually decreases.

3.2 Problem Prioritization

The company has tried to solve such problems. Therefore, we do a survey by interviewing five employees in the management level. We also consider statistics as a tool for simply and effectively communicating information to this group. Since Elmore and Woehlke (1997) said that the statistics is important to learn the best way to present quantitative or qualitative information to the target group. Therefore, we start from setting the problems within the company. We generally first organize data by making a table and then by creating graphics. We create informative tables that convey the data set information as clearly as possible. For example, suppose we had found the company's problems and rank them in order. The sample form for ranking problems is shown in Table 3.1.

Table 3.1. The Sample Form for Ranking Problems.

No.	Problem	Rank
1	Fluctuating costs of raw materials	
2	Low quality raw materials.	
3	Late delivery of raw materials	
4	Old and out-of-dated machines.	
5	Cash flow shortage.	
6	Low performance workers.	
7	Workers shortage.	
8	Uneven order volume.	
9	Order for varieties of model.	
10	Price bargaining.	
11	Delayed Production.	
12	Low quality products.	
13	Claimed Products.	
14	Variation of packaging and fitting costs.	

We could prepare a tabular summary of the problem scores. To help organize such summary, we might first prepare a table of a summary of scores of each person in which we place the problem in order. We use the measures of central tendency techniques because it is appropriate with the interval and ratio variables. Elmore and Woehlhe

(1997) also wrote that there are three commonly used measures of central tendency: the mode, median and mean. The three measures of central tendency use different definition of central scores or typical value in a distribution. Each of the three measures of central tendency provides one number or index that is representative of all the numbers, values or scores in a distribution. We select the mean method to measure central tendency because it is the only measure of central tendency dependent on the value of every number in the distribution. Since the mean depends on the value of every number in the distribution, the mean is affected by extreme score. The mean is arithmetic average, that is, the sum of the observations divided by the number of observations. It is often referred to as the balance point in a distribution. The symbol used to represent the mean is $\bar{x}$. The formula for the mean is:

$$\bar{X} = \frac{\Sigma Xi}{N}$$

To consider the problem scores the mean is calculated by adding the scores from all five persons together and dividing by five. Therefore, the mean is 6.2. The mean of all problems is shown in Table 3.2.

Table 3.2. The Evaluation of Problems.

Problems	M.D	M1	M2	M3	M4	Total	Mean
1. Fluctuating costs of raw materials.	3	9	9	2	8	31	6.2
2. Low quality raw materials.	5	12	5	7	5	34	6.8
3. Late delivery of raw materials.	2	8	6	3	7	26	5.2
4. Old and outdated machines.	4	3	7	8	4	26	5.2
5. Cash flow shortage.	1	6	1	1	1	10	2
6. Low performance workers.	7	4	2	4	6	23	4.6
7. Workers shortage.	11	14	14	14	11	64	12.8
8. Uneven order volume.	6	10	10	5	2	33	6.6
9. Order for varieties of model.	10	7	13	9	3	42	8.4
10. Price bargaining.	8	5	8	6	9	36	7.2
11. Delayed Production.	13	1	4	10	10	38	7.6
12. Low quality products	12	2	3	11	12	40	8
13. Claimed Products.	9	11	12	12	13	57	11.4
14. Variation of packaging and fitting costs.	14	13	11	13	14	65	13

Afterwards, we got the mean of problem's person. We can examine it for the lowest score then the next-to-lowest score until we have reached the score with the highest value. We also rank again for the most important problem.

Therefore, problems are identified and prioritized in terms of severity through a Pareto Diagram. This method is a very useful visual aid for focusing on major quality problems. Pareto Diagram is a simple bar chart that is used after data have been collected to identify and rank problems. It is a vertical bar graph showing problems in a prioritized order, so it can be determined which problems should be tackled first or last. The graph of company's problems is shown in Figure 3.1.

. From the survey, we have found that the most severe problem is cash flow shortage. Any organization needs cash to run business. If they don't have enough cash flow, they cannot pay for raw materials to suppliers and this affects the production and the delivery. If the payment is still unpaid, it can cause discredit to suppliers and customers.

Second problem is that our company has low performance workers. They just do a job temporarily and most of them are people who live in the Northeast of Thailand. When they go back home, they mostly don't come back to work for the company. For these reasons, we have to employ new workers and waste time to train them to do a job. If new workers are not properly trained, they may perform jobs inefficiently and low quality products are produced. When low quality or defective products are claimed, it causes a great loss to the company.

For the third one, there are two equally severe problems: late delivery of raw material and old and outdated machines. If the supplier delivers the raw material late, we need to hire workers to do overtime jobs in order to manufacture the products on time. Late delivery of raw materials causes late production and finally it causes late delivery of finished products to customers. This also dissatisfies customers. For old and outdated machines, we have to take more time to produce products than the new one since it is less efficient. Therefore, finished products may have more defects than those products that are produced by new and sophisticated machines. Furthermore, we also need to pay more for maintenance cost.

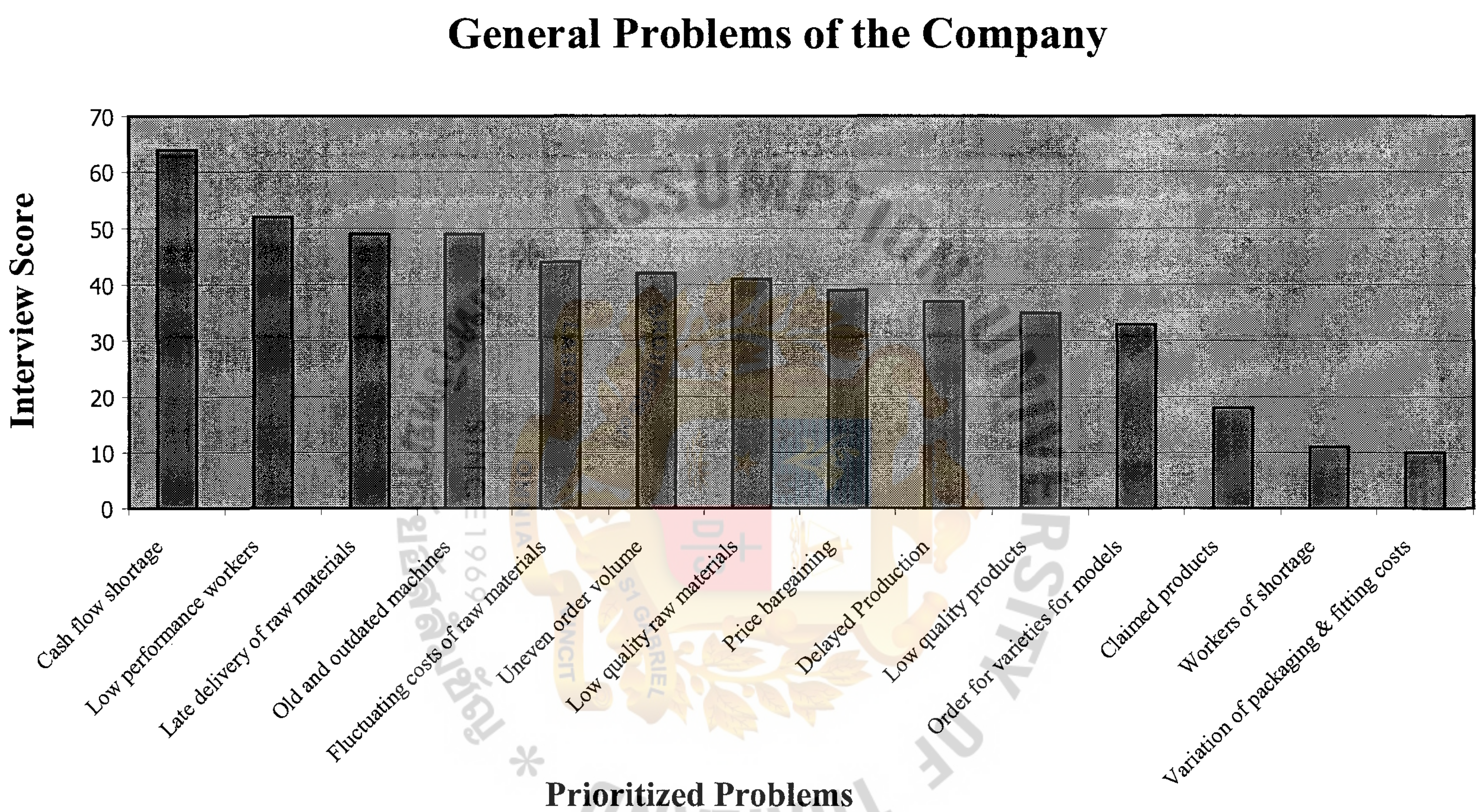

Figure 3.1. The General Problems of the Company.

Next problem is the fluctuating costs of raw materials. This is one problem that we cannot control. If the cost is not constant, we cannot estimate the price of products. Or if the cost is too high while the selling price of products is constant, we will get less profit. Sometimes, we may lose if we do not know how much exactly the cost is.

The next problem we have found is uneven order volume. For this problem, we cannot prepare the production in advance. If the order is low, we may not have cash flow for business. The marketing and production sections should work together to develop a well-planned production schedule.

Another problem is the quality of raw materials is not good enough. The purchasing section should select the best quality and cost of raw material. This problem causes customers to claim the defective products and the company has to spend a lot of money for this claim. Finally, our company's image will be jeopardized.

The eighth problem is customers always bargain. If we sell at a low price, we may get a loss, especially when we have to pay the high cost of raw materials, so we should update the price every 6 months.

The next problem is delayed production. Due to problem of shortage cash flow, we need to wait for opening L/C or the deposit in advance from customers. We sometimes receive the money late. When we receive the raw material late, we also set the production line late. The production process depends on the delivery of raw material.

The tenth problem is the production is lower than standard. One reason is worker's lack of working skill. We should have enough training for new workers and the supervisors should work closely with them. The second reason is the old machine may cause more defects.

Another problem is that each customer order has many kinds of models (products). As a result, we have shorter time to produce each kind of products for that order since we have to change the production line which is difficult and it wastes time to set the new production line.

The next problem is customers sometimes claim the products. If the workers lack working skill and the supervisor doesn't control them closely, then the image of the company may be tarnished. This wastes time and money and we may also lose our customers. So we should inspect every product before shipping or we should control the production process closely.

The thirteenth problem, is we do not have enough workers. Most workers are uneducated and poor. When they go back home, they do not come back to work. During long holidays, we should always hire new workers.

The last problem is the cost of packaging or fitting is not standard/constant. If the cost is increased, we will get lower profit, so we should make prices a little bit higher to protect the damage.

3.3 Sales Volume Analysis

Sales Volume is another issue that should be taken into consideration in analyzing the best-sold product in 1999 and it will be selected as an example in order to improve the production process which will be discussed in the next chapter. The products to be analyzed are those products that are often produced. These products consist of totally 8 items which will be discussed as follows.

From the analysis, Party Wagon is the best sold product in 1999. The target market of this product is in Europe and America and the sales volume of party wagon is approximately 272,836.64 bahts.

The second top sale in the last year is cutting board. Since its production process is not complex and it is also small, it can be produced in a large volume. Thus, its sales volume is 137,132 bahts.

The trolley is the next product that is the third top sale with the sales volume of 115,775.50 baht. It is so complex to produce because it can be utilized in the kitchen. However, this product is often claimed due to its various utilization. The dining chair and coffee table are the fourth and fifth sales volume which are easily assembled by customers. The sales volume are 110,150 bahts and 72,980 bahts respectively.

The sixth sales volume is end table. End table is the furniture placed in the bed room near the top of the bed. The sales volume is about 70,585 bahts. The next sales volume is dining table. Customers can select from a variety of models. Its sales volume is about 62,580 bahts. The last product is magazine rack. Its sales volume is approximately 57,900 bahts. The overview of the top eight sales volume is shown in Figure 3.2.

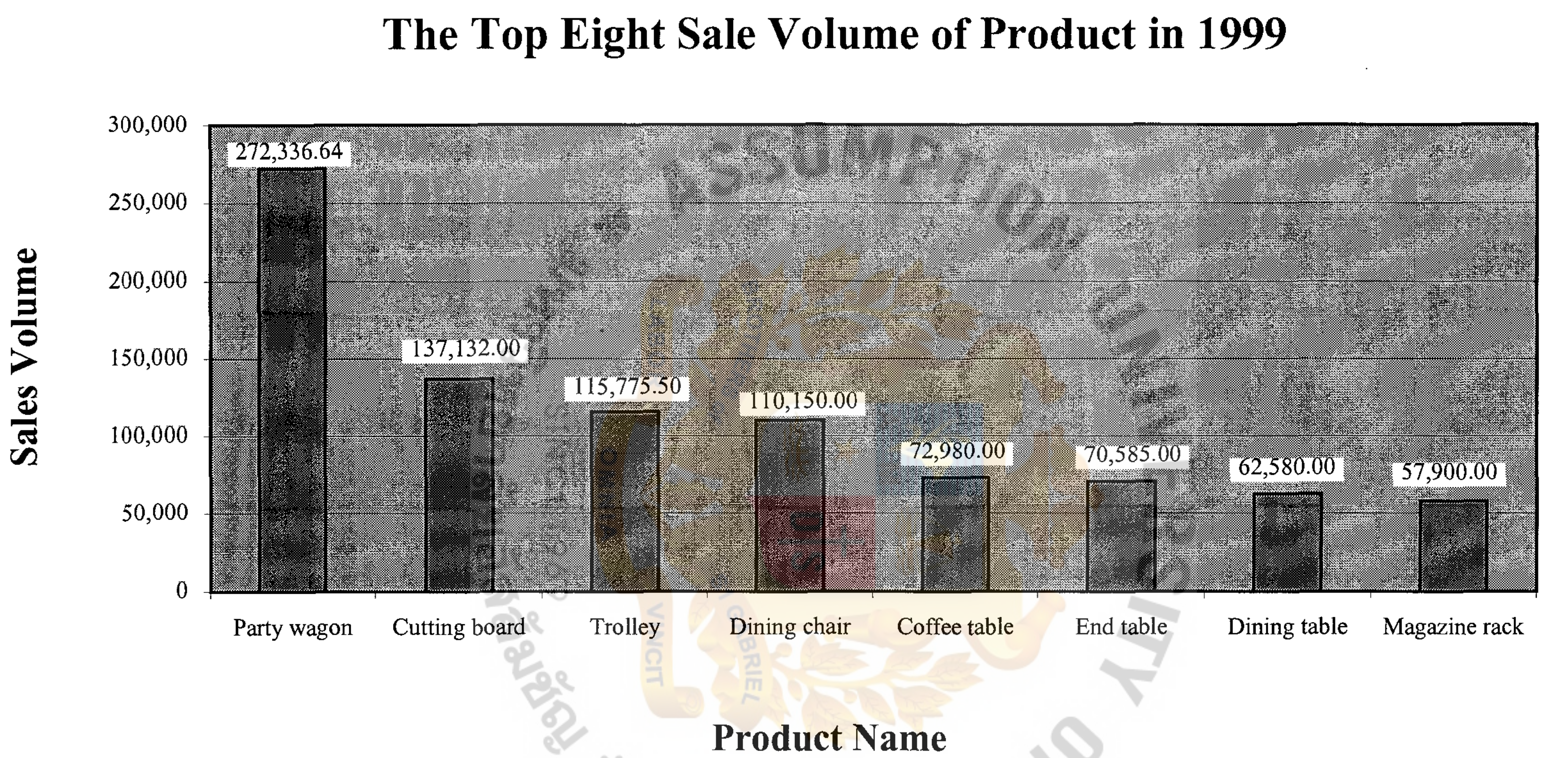

Figure 3.2. The Top Eight Sales Volume of Products in 1999.

IV. PROBLEM RECTIFICATION PLAN

According to problems found in the previous section, this chapter proposes problems that are grouped due to similarity or relatedness. Each problem in each group is discussed and solved by different ways. Furthermore, it also provides an example of the production process of party wagon which is the best sold product and the solutions to the existing problems through the application of process chart, PERT, and job analysis method.

4.1 Groups of Problems

Due to the interview of five top managers, the problems can be arranged into 14 cases. These 14 problems can also be grouped, according to its congruence, in to three categories:

(1) Order and Delivery Problems.

(2) Production Problems.

(3) Other Problems.

4.1.1 Order and Delivery Problems

For this group, there are totally five problems each of which is related to each other. The problems are:

(1) Late delivery of raw material.

(2) Uneven order volume.

(3) Order for varieties of model.

(4) Fluctuating cost of raw materials.

(5) Low quality raw materials

Late delivery of raw material is the first problem and it has an effect on the production process. If raw materials are delivered late, the production schedule has to be changed and this also affects other processes.

There are various causes of late delivery. One cause is rain. Since rain causes much humidity, wood becomes wet and it takes time to dry. This is very important because only dry wood is used in the production process. Another cause is each supplier has different ability of transportation. Some suppliers can deliver raw materials early since their location is not far from our company while others may deliver materials late since their place is far.

Another cause of late delivery is payment. If our company pays for raw materials late, the supplier may also deliver raw materials late.

Therefore, the first thing we have to do to solve this problem is to specify a delivery schedule from suppliers for each raw material, so that we can estimate the time of production and we can deliver finished products to customers on time . Thus, the material delivery schedule on time can be done in two ways.

In case raw materials (wood) are available, we have to force suppliers to deliver materials on time, otherwise, they will be penalized for late delivery such as they have to be charged or they have to reduce costs of raw materials.

If raw materials are scarce, especially in rainy season, we have to order materials in advance (around 2 months before the production) so that we will have raw materials available at the time of production.

Other problems are uneven order volume and various kinds of orders. When we produce them in a production line, the production line can be easily changed, when that happens, time as well as money are wasted. Production manager who is responsible for the production line will manage the assembly line according to the ordered forms.

Another solution is we have specified the minimum quantity of each product in each lot size. If customers order inconstant volume (for example, less than the minimum of the lot size, we may waste the remaining of raw materials in that lot size and we can waste cost. Therefore, we should inform the customers of the minimum order of each product, it will help save production time and cost. The other way to solve this problem is to survey the old record of production in the last year, so that we will know or can prepare the production line roughly in this year. Also, when we receive the purchase order from customer, we have to check the production line and calculate the time spent in the production process. If the present production line has the same or similar ordered product, we can conduct parallel processes.

Another problem is fluctuating cost of raw material. Since we can not control the cost of raw material, we, sometimes estimate the price of products to be sold more than standard. Also, we should inform the supplier to update the cost of raw material every month so that we can calculate the price of products correctly.

The last problem of this group is low quality raw materials. To solve this problem is the purchasing department must inspect the quality and check products price strictly. When the supplier delivery the raw materials, the receiver must inspect the raw material closely. If the quality of raw materials is not good enough, the quality of products will not be good either.

4.1.2 Production Problems

This group of problems concerns many aspects of workers and machine, which can be divided into four problems. They include:

(1) Low performance workers.

(2) Delayed production.

(3) Low quality products.

(4) Claimed products.

All of these problems are related to each other and the details of these problems that apply flowchart are illustrated in Figure 4.1.

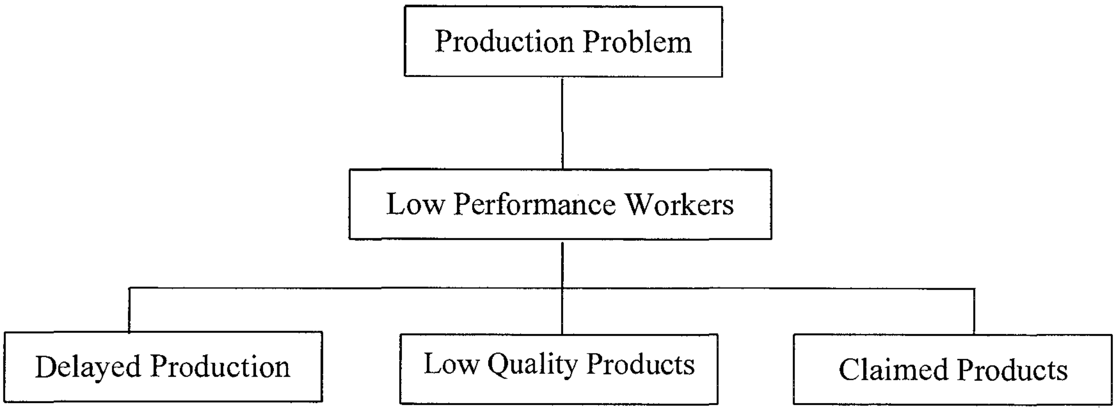

Figure 4.1. Production Problem Classification.

The first problem of production is low performance worker. Some workers have low capability which results in work error. The supervisor needs to be more careful with these low performance workers. We should have a training program for the new workers. We should also order them to work with senior workers in order to learn from them. Further, we should provide good working activity in order to create good relationships among workers such as skill competition and promotion for higher position worker or award giving.

If workers have worked for some periods of times, they will have more skill and experiences. Due to their skill, the problem of unconfirmed products could be reduced. Two problems can occur not only because of shortage of workers or underqualified workers, but also because of other causes.

This problem can be solved by providing workers with a training course from which they can learn some necessary skills. This keeps in lowering working error as will as being able to solve problems by themselves.

Delayed production is related directly with low performance worker. This problem is quite important. There are many causes of delayed production. The first cause occurs from the error of production line management. We should set or control the production line well, for example setting a schedule of producing/working of each department, rearranging the some steps of production line. We can work a parallel line in the same products.

The second cause is late delivery of raw material which has already been solved as mentioned above.

The other cause is uneven order volume. Customers' order volume depends on season and competition. We can solve the problem by creating a good relationship. If we can contact customers closely, we can analyze their needs. We can also collect the order list to mange the production plan.

The last cause is cash flow. If we do not have money to buy the raw material, we cannot produce the products. We should negotiate with supplier about payment such as they have to pay cash one month after receiving the raw material. If the suppliers purchase raw material on credit, we have more cash in our company. Another way, we should negotiate with the customer to pay about 50% deposit in advance of purchase order. It depends on the acceptance of customers. If the customer can deposit the order, we have cash flow within our company.

The next problem is the low quality products. Unqualified workers, old & outdated machine, defective raw materials and error production line, cause this problem. We should have well trained workers in order to prevent some error at work. Since we do not have well-trained worker, the production line is low in standard. The other cause is outdated machine. We should spend on maintenance cost. If we keep the machines in good condition, we can prevent some defective products. The low quality products also depend on the raw material, the finished products are also defective. The supervisor should control closely from the first step of selecting the raw material. The next step in the production line, we may set the standard of each product or apply some standard in the world such as ISO9001, ISO9002 or ISO14001. Each product should have skillful workers in the production line. All of them must work with senior workers or get a training course before starting the job. Quality products are made from all the above mentioned.

The last one is claimed product problem. When the customers receive the defective products, we get the claimed products. The causes of product claim are unstandard products, error in production line, and inefficient inspection. We should take care of every step closely and control production line strictly. We will utilize skilled worker in each step and we will adopt quality control concept to separate defective goods from all goods. We will keep database system to save the history of all products in every step. From this concept we know which part causes more defective goods. We can solve this problem by tending or taking care of that line.

4.1.3 Other Problems

This group is not related to order and delivery problem or production problem. There are four problems as below:

(1) Cash flow shortage

(2) Old and out-of-dated machine

(3) Price bargaining

(4) Workers shortage

(5) Variation of packaging and fitting cost

The first problem is shortage of cash flow. Since it is beyond the scope of this project, we will not discuss this matter. However, the finance department can solve this problem. If the company cannot run the cash flow smoothly, it will have to face many bad problems such as late delivery of raw material. There are many ways to solve this problem such as paying credit to customer for raw material or customers advancing the deposit of order. The solutions have already been solved as mentioned above. If some organizations always have shortage of cash flow, the business must be closed. This problem is very severe because it affects every problem.

If we have more old and outdated machines, it takes time in maintenance and repairing job. Thus, we should keep all equipments in good condition at all time. Proper selection of processes and equipment as well as proper selection and training of employees helps ensure technical feasibility. We should manage the skilled worker to work with old machines or assign someone to work at a routine basis with this machine.

Another problem is price bargaining. Customers always try to negotiate the best price. Prices depend on total cost plus margin. It can be variable with season. When the wood is scare, the price goes higher. The sales and marketing department should confirm the price after 30 days of quotation date. We should update the price every 6 months and inform the customers of that.

Next problem, we sometimes do not have enough workers. There are many causes of shortage of workers such as environment, internal psychology. Before the workers go back home, during farming or harvesting season, the company should prepare spare workers to work at that time. Also, the company should create a good atmosphere which motivates the workers to work while they are working in the normal time. Therefore, if we know that there will be a shortage of workers, we should recruit new employees.

The last problem is variation of packaging and fitting cost. It is difficult to reduce this cost, the supplier should update the cost of packaging and fitting cost every month. If the cost is increased, we should calculate or revise the price again. The purchasing department should also compare the cost with the cost of many suppliers to reduce this problem.

4.2 The Detailed Rectification Plan for Production Problem

We can apply the technique of cause-and-effect diagram to solve the production problems. Since Waters (1996) said that a cause-and-effect diagram is a way of presenting the possible causes of a defect in a simple diagram. When the possible causes of faults have been laid out in this form, managers can know all causes, thus they can find the problem and rectify it. Stevenson (1990) supported that cause-and effect diagram, is also known as fishbone diagram because of their shape or Ishikawa diagrams (after Japanese Professor Kaoru Ishikawa, who developed the approach to help workers who were overwhelmed in problem solving by the number of factors that need to be examined). It offers a structured approach to problem solving. In fishbone analysis, the team works backwards from the target for improvement on the spine bone, identifying causes down through the "bone structure." The lowest level of detail (finest bones) may reveal root causes, which are worthy targets for further problem solving. (Schonberger and Knod 1997).

In this project, the only production problem is analyzed with an application of cause-and-effect diagram. Therefore, causes of production problems are shown in Figure 4.2.

In this diagram, there are 4 major causes of the production problem as follows:

(1) Low performance worker

(2) Delayed production

(3) Low quality products

(4) Claimed products

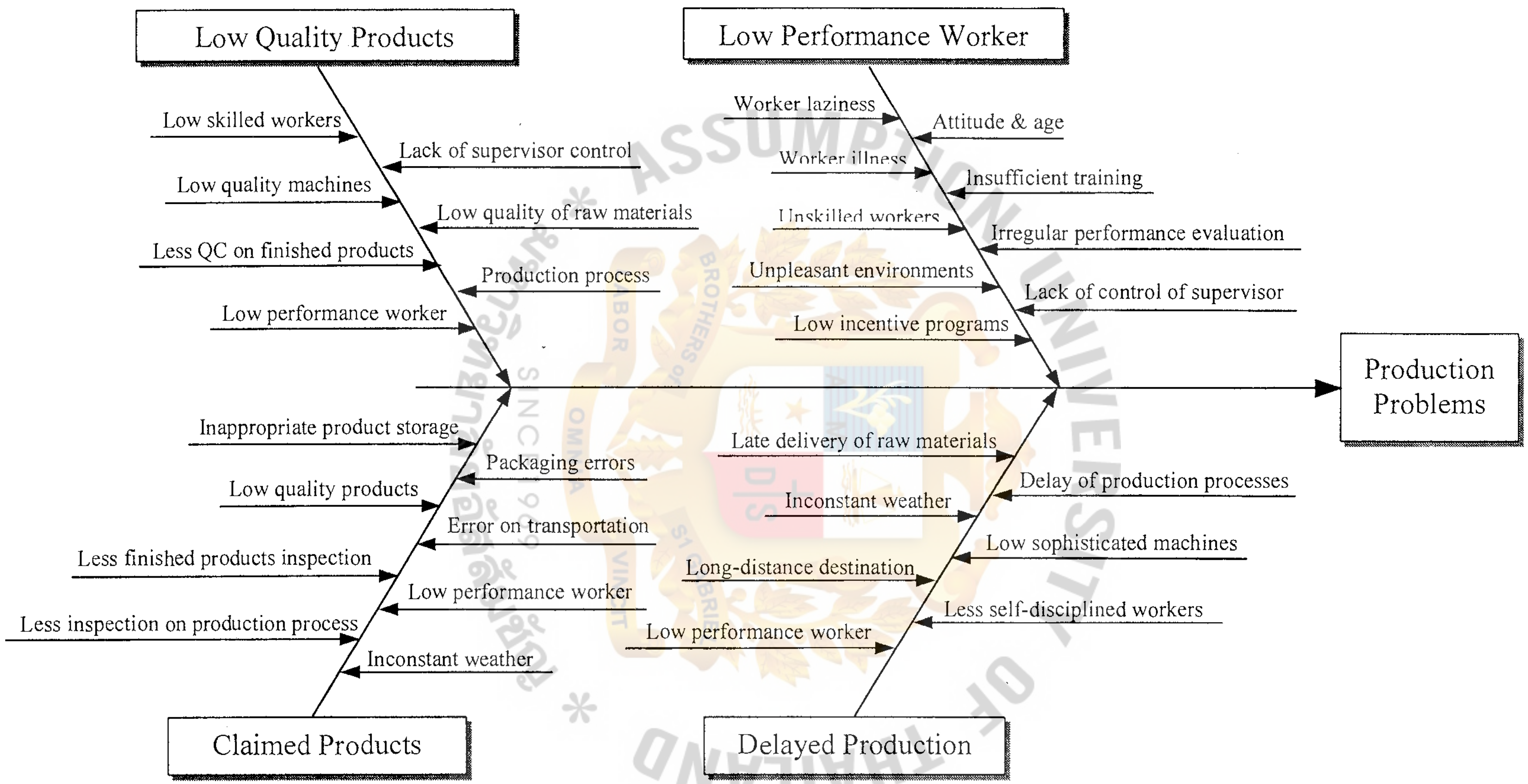

Figure 4.2. The Cause-and-Effect Diagram.

Problems with the low performance worker are caused by worker's laziness, attitude & age, illness, insufficient training, being unskilled, irregular performance evaluation, unpleasant environment, low incentive programs and lack of control supervisors.

The second main cause of production process is late shipments. There are many sub causes of late shipments. The late delivery of raw materials, delays of production processes are the sub causes of late shipments. The last sub causes are long distance destination and less self-disciplined workers. These are sub causes of late shipment, which is not good for the company.

The third main cause is low quality products. If we have low skilled workers and low quality machine, it will cause low quality products. Another causes are lack of control of supervisors, low quality of raw materials, less quality control, finished products and production process.

The claimed products are the last main causes of production problem. We have packaging errors, inappropriate product storage, low quality products, errors on transportation, less finished products inspection, less inspection on production process and inconstant weather.

4.3 Process Charting

According to problems we have found in the previous section, this part is the solutions to the problems concerned with the production process. In this section, we provide the example of the production process of one product called "Party Wagon" by using process chart and PERT to help us analyze the process in order to reduce unnecessary processes. This part also compares the existing production process with the improved production process.

4.3.1 The Existing Process Chart

Party Wagon is one product that consists of several parts. It includes 2 top panels, a bottom panel, 3 legs and 3 sided- panels. Each part can be produced simultaneously, but some take long, some take short. Thus, each part will be finished in different times.

For the top panel, it begins with cutting the rubber wood roughly. This process takes 0.49 minutes with 7 workers. Next, the rough cut wood is planned for 4 sided within 0.43 minutes and it takes 2 workers to complete this process Then the wood is sanded and laminated. To do this 5 workers are involved within 0.72 minutes. After sanding and laminating, it is planned for only 2 sided. This process takes 0.36 minutes per 2 workers. Next, 3 workers will band saw within 0.72 minutes. Further, the wood is sharper. This process takes only 0.36 minutes with 2 workers. After that it takes 0.96 minutes to router the wood. This process requires 3 workers to complete. Then a hole is drilled. Drilling process takes 0.72 minutes with only one person. After that the panel is brought to sand curve within 0.216 minutes per 6 workers. Then the hole of the panel is filled. For this, only one worker is needed since it is not a complex process. Next process is sanding that takes 0.36 minutes and 2 workers to complete. After sanding, the panel is checked for completeness. Repair will be done to any defect found. For this, 8 workers are involved and it takes 0.36 minutes to complete. After that, it is sprayed with sealer. It takes 0.45 minutes and 3 workers for this process. Then, the sealed panel is polished for 0.45 minutes by 3 workers. The final process of this part is to spray lacquer to the panel. The process also takes times the same as the earlier process, that is 0.45 minutes and 3 workers. All of these processes take totally 7.41 minutes.

For the bottom panel, it has similar procedures as the process of the top panel. The first line procedures are the same but they take different times. For the rough cut process, it takes 0.012 minutes with 4 workers. The next process is 4 sided planner, it takes 0.007 minutes per 2 workers. For the process of sanding and laminating, it takes only 0.09 minutes by 4 workers. For 2 sided planner process, it takes 0.048 minutes by 2 workers and the next process of rip saw takes 0.18 minutes and it requires only 1 worker to complete. Among these 5 procedures, the bottom panel part takes less time than the top part. After that the wood is shappered within 0.072 minutes, requiring 1 worker. Then it is brought to be drilled for 0.24 minutes by one worker and sanded within 0.09 minutes by 2 workers. Moreover, it is sprayed sealer for 0.07 minutes. This process requires 2 workers. After that it is sealed within 0.06 minute by 2 workers. The final process of this part is to spray lacquer. This process takes 0.07 minutes done by 2 workers. For the bottom panel, it takes only 0.94 minutes for the whole process.

After finishing the top and bottom panel part, they are combined by assembling as the first process of combination. It takes 0.24 minutes requiring 2 workers. After that the combined panel is checked for completion and packed. This process takes only 0.18 minutes by 6 workers and the final process of this part is packing. It takes 0.12 minutes by 7 workers to complete this part. For the combination process of top and bottom panel, it totally takes only 0.54 minutes.

For leg production, there are as many procedures as for the panel, but it produces 3 legs rather than one or two as the panel. The procedure begins with rough cutting rubber wood. This process takes 0.09 minutes by 4 workers. After that rough cut wood is planned for 4 sides within 0.25 minutes. The planning requires 2 workers to do this task. Next, the planed wood is to be round polished by 2 workers within 0.8 minutes. Then, it is drilled in order to join with the side panel. This process takes 0.72 minutes and requires 2 workers to do. After that the legs are sanded delicately within 0.29 minutes by 4 workers. Then they are sprayed by sealer. This process takes only 0.11 minutes. The final process is to polish within 0.4 minutes by 2 workers. The completed legs are kept for a while in order to combine with the side panel. For the process of leg production, it takes totally 3.09 minutes.

For side panel, it has totally 3 pieces. Side panel production consists of the least processes when compared with other parts production, but it doesn't take the least time. For the first process, rubber wood is roughly cut. This process takes 0.02 minutes by 4 workers. After that it is brought into circle planner within 0.11 minutes by 2 workers. Then it is round polished by 2 workers within 0.48 minutes. Also it is cut to make proper shape within 0.36 minutes. This process requires only 1 worker. After that, it is sprayed with sealer within 0.08 minutes by 2 worker and finally it is brought to sealer and take 0.18 minutes to complete by 2 workers. The process of side panel production takes totally 1.22 minutes.

After legs and side panels are completely done, they are assembled by gluing. This is considered as the first process of assembly and it takes 1 minute by 6 workers. After that, the glued parts are slot router within 0.18 minutes by 1 worker. Then it is drilled by router for 0.24 minutes by 1 worker. Next is to drill a hole at the top 2 bottoms. This also takes 0.24 minutes by 1 worker. Then 4 workers screw it within 0.24 minutes. After that it is brought to be polished for 0.36 minutes by 2 workers. After joining these 2 parts the completed part is checked to ensure that there is no defects. This process takes only 0.14 minutes and requires 6 workers to do the task. Then it is sprayed by lacquer within 0.29 minutes by 3 workers. The final process is assembly and packaging for 0.24 minutes by 7 workers. This process of assembly takes totally 2.53 minutes.

Finally, the top and bottom panel are combined and assembled with legs and side panels to produce the finished product. The existing process chart is shown in Figure 4.3.

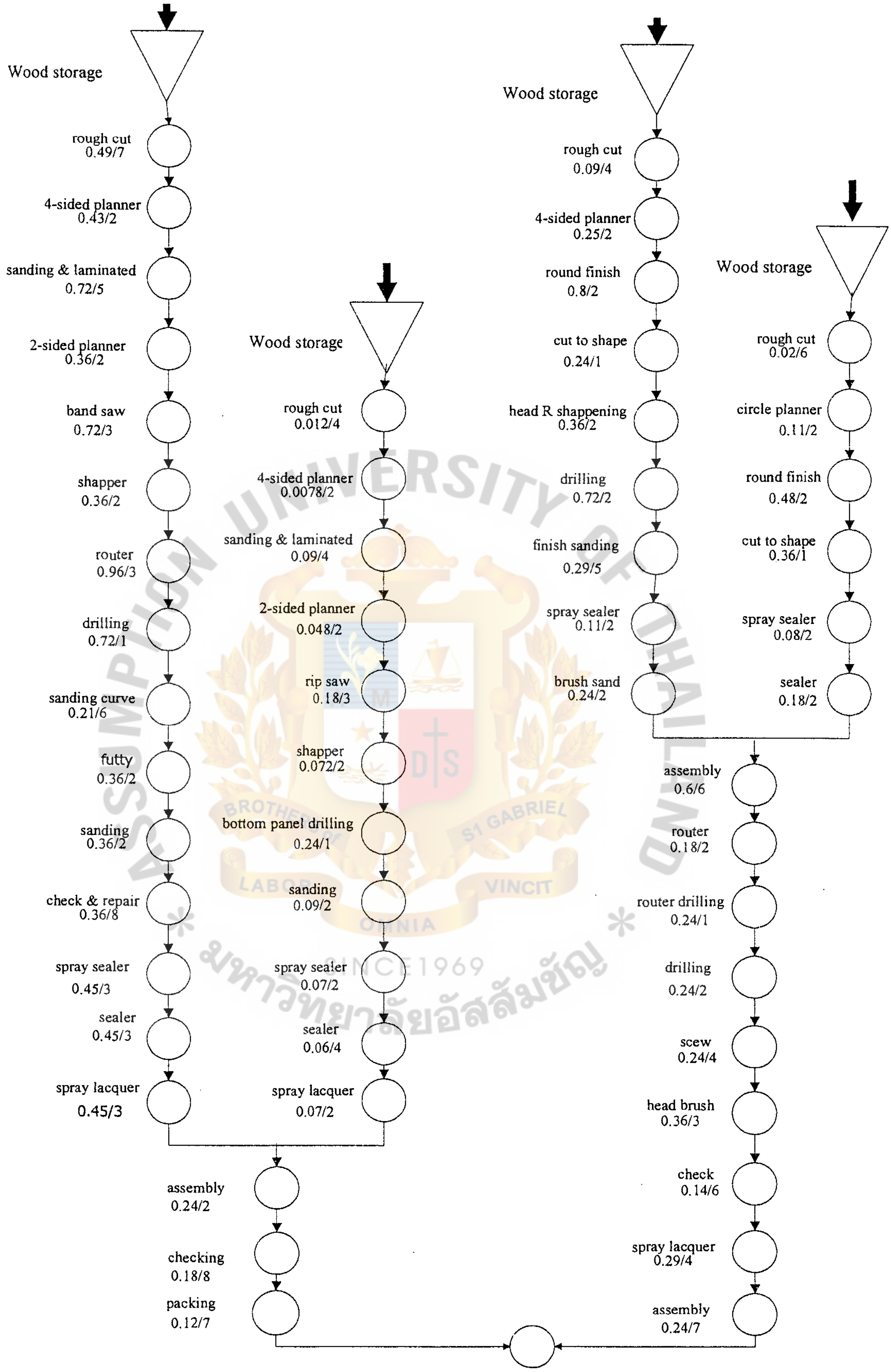

Figure 4.3. The Existing Process Chart.

4.3.2 The Proposed Process Chart

From the original process we can reengineer some complexity process into one process. The original process shows that woods for top panel and bottom panel have been cut separately. But in the new process, we customize those two steps into one step by adding the process of wood selection before sending to rough cut process. The wood selection process generates the three advantages over the old process, which are cost reduction, process time reduction, and numbers of workers reduction. In the new process, we also design the new working-method that matches with the practical raw material. The original process used two sizes of wood input into the separated rough cut process we used three size of wood but it had low cost and less numbers of workers. By combining the process, we can reduce the no. of workers from 13 to 5 persons in the new process and time reduces from total 0.84 minutes to 0.50 minutes. In the new process the wood size 1.10 x 4" and 1.0 x 2" were separated to input the rough cut process. The wood 1.10m x 4" is cut roughly with 2 workers by 0.141 minutes. Another size of wood (10m x 2") and 10m x 4" is cut roughly by 2 workers within 0.004 minutes. After cutting the wood roughly, the worker collects them according to their size in 0.143 min. Next, 5 workers will sand and laminate the wood within 0.45 minutes. After the wood is sanded and laminate, the next process is 2 sided planner and band saw. The 2-sided planner takes 2 workers with 0.204 minutes and the band saw takes 4 workers within 0.6 minutes. The worker will separate the main panel with the supporting panel. For the main panel, there are 3 steps before sanding to finishing sanding. The first sub step is copying sharper within 0.36 minutes by 2 workers. The second step is bowl router by 4 workers within 1.28 minutes. The last step for the main panel is curve sanding which takes 0.36 minutes by 6 workers.

For the supporting panel, these are 2 sub steps. The first sub step is copy sharper. It takes 0.036 minutes by 1 worker. The next step is curve sanding. It takes 0.09 minutes by 2 workers. After the wood is curved sanding, the worker will finish sanding again. This process takes 0.34 minutes by 3 workers. Then it is checked and repaired. The check and repair process takes 0.135 minutes by 3 workers. The next step is spray sealer and sealer sanding. The spray sealer process takes 0.43 minutes by 5 persons. And for the sealer sanding, it takes 0.25 minutes by 4 workers. Then it is finished with lacquer. It takes 0.35 minutes by 4 workers. Then, the top panel and supporting panel are assembled within 0.36 minutes by 3 persons.

For leg production, it also has to be combined with the side panel. In this new process, the worker who receives the cut wood will be enforced to increase his operation by adding the function of wood size selection, the receiver had to separated each size of wood to each pallet. The wood selection takes 0.07 minutes by one worker. The size of wood is separate 1.5" x 3" x 1.30 with 1" x 2" x 1. For the beginning step, 4 workers cut the wood roughly, it takes 0.05 minutes. Then, the wood is planned 4-sided within 0.25 minutes by 2 persons. And then 1 worker takes 0.24 min. to cut to size. The wood will be waiting for round sanding.

For the side panel, the size of wood is 1" x 1" cut roughly by 2 workers within 0.02 minutes. After that the wood is round shape sharper within 0.11 minutes by 2 workers. Then only 1 worker is cut to size within 0.36 minutes.

When the leg and side panel are cut to size, they are combined by round sanding by 2 workers within 0.145 minutes. All woods are sent to sharpening head R by 2 workers within 0.48 minutes. The leg and side panel is drilled by 2 workers within 0.24 minutes. After the wood has been drilled, it is sanding within 0.29 minutes by 4 workers.

All woods are sprayed with sealers by 3 workers within 0.14 minutes and sand brushed within 0.24 minutes by 2 workers. Next, the frame assembly takes 0.6 minutes by 2 workers. The wood is notch router by 2 workers within 0.18 minutes. The 2 workers bring the wood to router drilling within 0.48 minutes by 2 workers.

The next step is wheeling panel-drilling which takes 0.24 minutes by 2 workers. The leg and side panel are locked by 3 workers within 0.3 minutes. And 3 workers are head brushes within 0.36 minutes. When the work is complete, the wood is sprayed lacquer by 3 workers within 0.22 minutes. Before packing, 8 workers assemble the right and left frames within 0.27 minutes. The last step is workers pack the product. The proposed process chart is shown in Figure 4.4.

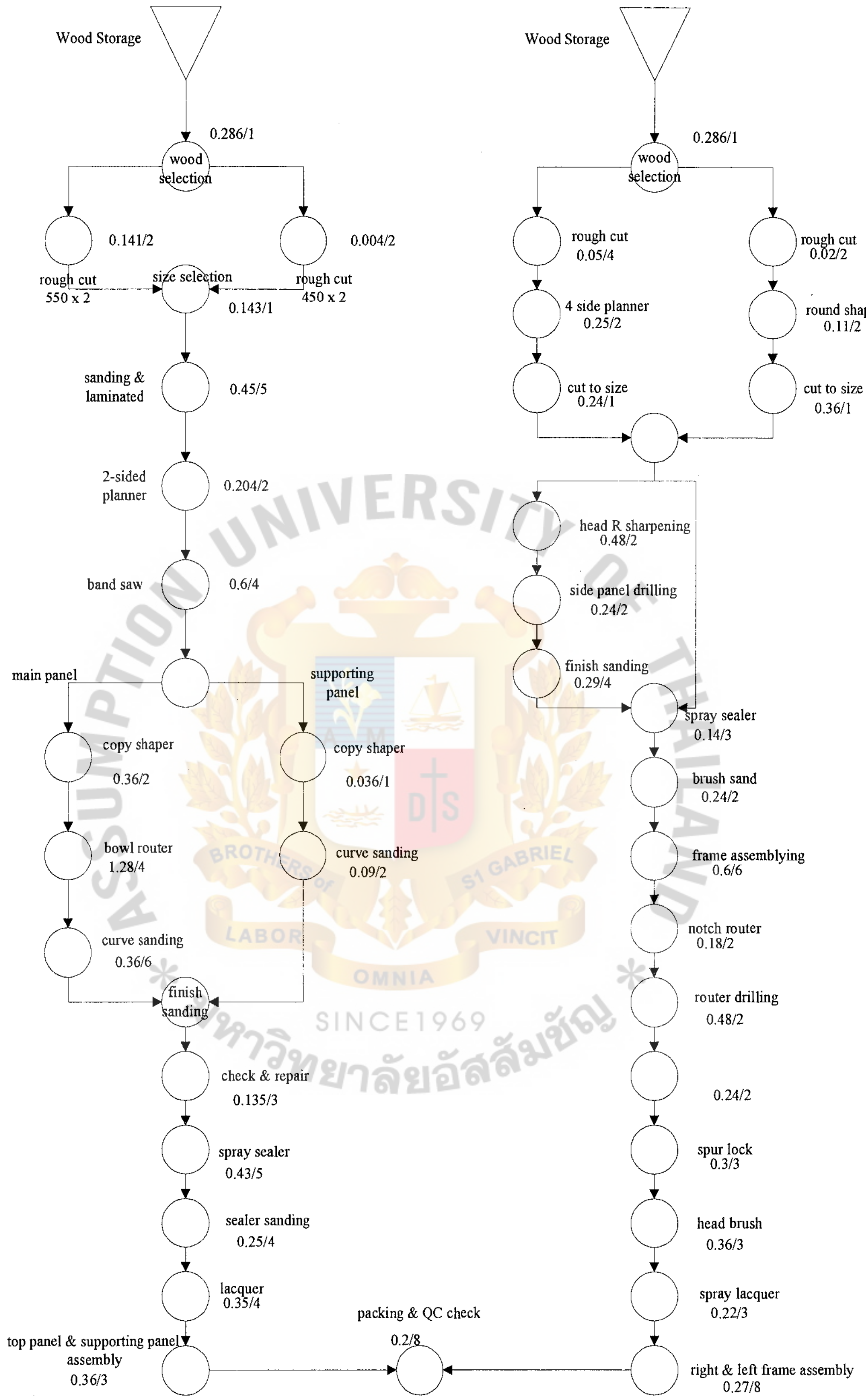

Figure 4.4. The Proposed Process Chart.

4.3.3 PERT Application toward the Existing and the Proposed Processes

PERT and CPM are the techniques for additional analysis in manufacturing process reconstruction. The longest process time is critical in calculating the base of process to process in a flow chart. As well as Process Flow Chart, the process station in PERT chart, which be called NODE, will have the step number the same as the process flow chart. Nevertheless, PERT chart will have a dummy to indicate the sequence of process. Over viewing to PERT chart, the dummy is the additional step used to reduce the process time. The PERT for new reconstructed process has two dummies, which help to reduce the process time from 7.946 in the existing process to 5.689 in the new process. Although dummy is the sequence to indicate the sequence of process, it has a role for the alternative route to reduce the critical time in process. There are 53 nodes in the existing process whereas in the new process they will be separated into 42. The number of node reduction may imply the performance of process whether it has stability or not. In this analysis, the existing process has more stability than the new process with the longest critical time. However, in this study the main concentration will be on the shortest critical path to reduce the production cost.

Considering the table of PERT calculation, critical time and slack time of each process that implies an indicator of process situation and the trend of process time is shown in a table. The slack time in the new process shows some stage has exceeded the process expected time that means the manufacturing process requires further improvement. The improvement of each process will help the reduction of the total process time. In this regard, it is important to recognize that the activity slack times are based on the consumption that all of the activities on the same path will be started as early as possible and not exceed the expected time the improvement of slack time reduction may study in the advanced analysis. Perhaps the 53 activities may become one of the quality devices to reduce slack time.

Figure 4.5 and Figure 4.6 illustrate the graphic display of PERT and CPM which is an indicator to monitor the completion of process.

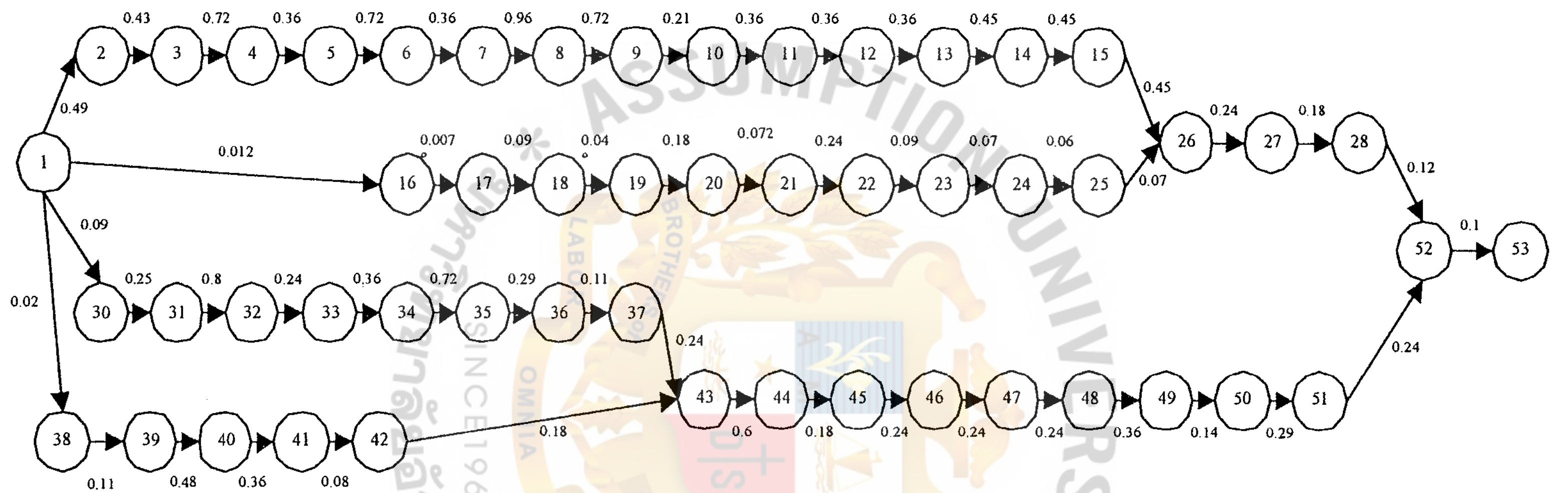

Figure 4.5. The Existing Process in PERT Diagram.

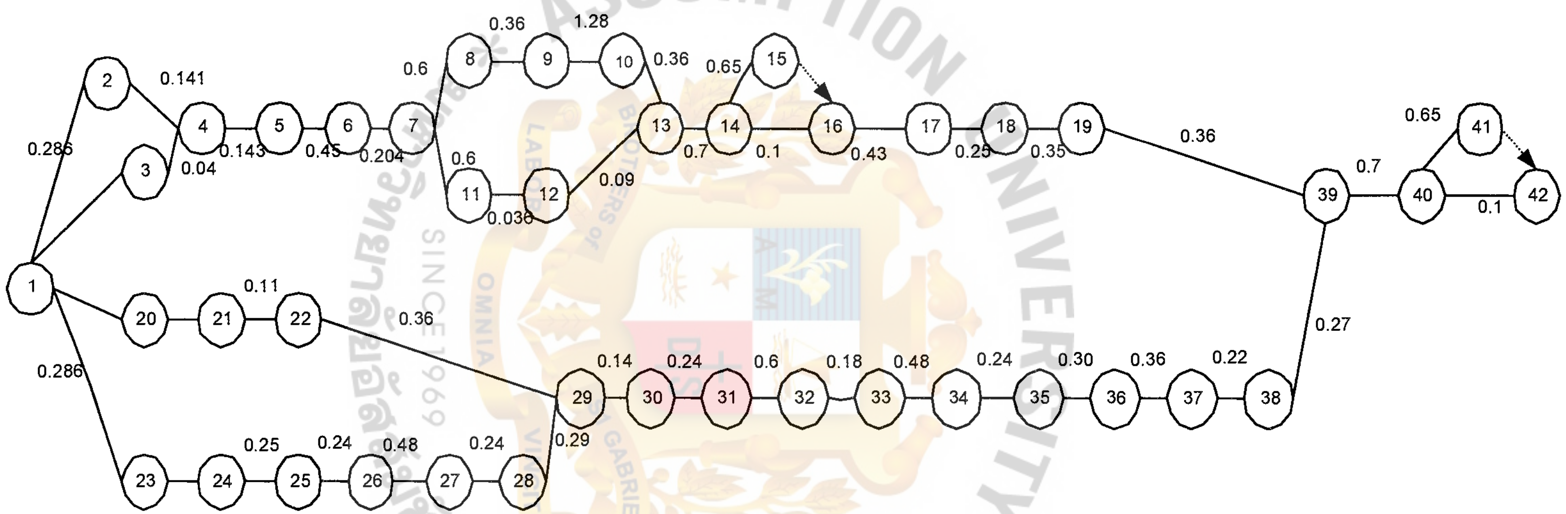

Figure 4.6. The Proposed Process in PERT Diagram.

Table 4.1. The Calculation of Critical Path of the Existing Process.

Activity	Duration	ES	EF	LS	LF	Slack
1-2	0.286	0	0.286	0	0.286	0
1-3	0.286	0	0.286	0.137	0.423	0.137
1-20	0.286	0	0.286	0.2758	3.044	2.758
1-23	0.286	0	0.286	1.698	1.984	1.698
2-4	0.286	0.286	0.427	0.286	0.427	0
3-4	0.004	0.286	0.29	0.423	0.427	0.137
4-5	0.143	0.427	0.57	0.427	0.57	0
5-6	0.45	0.57	1.02	0.57	1.02	0
6-7	0.204	1.02	1.224	1.02	1.224	0
7-8	0.6	1.224	1.824	1.224	1.824	0
7-11	0.6	1.224	1.824	3.098	3.698	1.874
8-9	0.36	1.824	2.184	1.824	2.184	0
9-10	1.28	2.184	3.464	2.184	3.464	0
10-13	0.36	3.464	3.824	3.464	3.824	0
11-12	0.036	1.824	1.86	3.698	3.734	1.874
12-13	0.09	1.86	1.95	3.734	3.824	1.874
13-14	0.7	3.824	4.524	3.824	4.524	0
14-15	0.65	4.524	5.174	4.524	5.174	0
14-16	0.1	4.524	4.624	5.074	5.174	0.55
16-17	0.43	5.174	5.604	5.174	5.604	0
17-18	0.25	5.604	5.854	5.604	5.854	0
18-19	0.35	5.854	6.204	5.854	6.204	0
19-39	0.36	6.204	6.564	6.204	6.564	0
20-21	0.02	0.286	0.306	3.044	3.064	2.758
21-22	0.11	0.306	0.416	3.064	3.174	2.758
22-29	0.36	0.416	1.836	3.174	3.534	1.698
23-24	0.05	0.286	0.336	1.984	2.034	1.698
24-25	0.25	0.336	0.586	2.034	2.284	1.698
25-26	0.24	0.586	0.826	2.284	2.524	1.698
26-27	0.48	0.826	1.306	2.524	3.004	1.698
27-28	0.24	1.306	1.546	3.004	3.244	1.698
28-29	0.29	1.546	1.836	3.244	3.534	1.698
29-30	0.14	1.836	1.976	3.534	3.674	1.698
30-31	0.24	1.976	2.216	3.694	3.914	1.698
31-32	0.6	2.216	2.816	3.914	4.514	1.698
32-33	0.18	2.816	2.996	4.514	4.694	1.698
33-34	0.48	2.996	3.476	4.694	5.174	1.698
34-35	0.24	3.476	3.716	5.174	5.414	1.698
35-36	0.3	3.716	4.016	5.414	5.714	1.698
36-37	0.36	4.016	4.376	5.714	6.024	1.648
37-38	0.22	4.376	4.596	6.094	6.294	1.698

Table 4.1. The Calculation of Critical Path of the Existing Process. (Continued)

Activity	Duration	ES	EF	LS	LF	Slack
38-39	0.27	4.596	4.866	6.294	6.564	1.698
39-40	0.7	6.564	7.264	6.564	7.264	0
40-41	0.65	7.264	7.914	7.264	7.914	0
40-42	0.1	7.264	7.364	7.814	7.914	0.55

Table 4.2. The Calculation of Critical Path of the Proposed Process.

Activity	Duration	ES	EF	LS	LF	Slack
1-2	0.49	0	0.49	0	0.49	0
1-16	0.012	0	0.012	6.46	6.47	6.46
1-30	0.09	0	0.09	2.31	2.4	2.31
1-38	0.02	0	0.02	3.13	3.15	3.13
2-3	0.43	0.49	0.92	0.49	0.92	0
3-4	0.72	0.92	1.64	0.92	1.64	0
4-5	0.36	1.64	2	1.64	2	0
5-6	0.72	2	2.72	2	2.72	0
6-7	0.36	2.72	3.08	2.72	3.08	0
7-8	0.96	3.08	4.04	3.08	4.04	0
8-9	0.72	4.04	4.76	4.04	4.76	0
9-10	0.21	4.76	4.97	4.76	4.97	0
10-11	0.36	7.97	5.33	4.97	5.33	0
11-12	0.36	5.33	5.69	5.33	5.69	0
12-13	0.36	5.69	6.05	5.69	6.05	0
13-14	0.45	6.05	6.5	6.05	6.5	0
14-15	0.45	6.5	6.95	6.5	6.95	0
15-26	0.45	6.95	7.4	6.95	7.4	0
16-17	0.0078	0.012	0.019	6.47	6.49	6.47
17-18	0.09	0.019	0.109	6.48	6.57	6.46
18-19	0.048	0.109	0.157	6.57	6.618	6.46
19-20	0.18	0.157	0.337	6.618	6.798	6.46
20-21	0.072	0.337	0.409	6.798	6.87	6.46
21-22	0.24	0.409	0.649	6.87	7.11	6.46
22-23	0.09	0.649	0.739	7.11	7.2	6.46
23-24	0.07	0.739	0.809	7.2	7.27	6.46
24-25	0.06	0.809	0.869	7.27	7.33	6.46
25-26	0.07	0.869	0.939	7.33	7.4	6.46
26-27	0.24	7.4	7.64	7.4	7.64	0
27-28	0.18	7.64	7.82	7.64	7.82	0
28-52	0.12	7.82	7.94	7.82	7.94	0
30-31	0.25	0.09	0.34	2.4	2.65	2.31
31-32	0.8	0.34	1.14	2.65	3.45	2.31

Table 4.2. The Calculation of Critical Path of the Proposed Process. (Continued)

Activity	Duration	ES	EF	LS	LF	Slack
32-33	0.24	1.14	1.38	3.45	3.69	2.31
33-34	0.36	1.38	1.74	3.69	4.05	2.31
34-35	0.72	1.74	2.46	4.05	4.77	2.31
35-36	0.29	2.46	2.75	4.77	5.06	2.31
36-37	0.11	2.75	2.86	5.06	5.17	2.31
37-43	0.24	2.86	3.1	5.17	5.41	2.31
38-39	0.11	0.02	0.13	3.15	3.26	3.13
39-40	0.48	0.13	0.61	3.26	3.74	3.13
40-41	0.36	0.61	0.97	3.74	4.1	3.13
41-42	0.08	0.97	1.05	4.1	4.18	3.13
42-43	0.18	1.05	1.23	4.18	4.36	3.13
43-44	0.6	3.1	3.7	5.41	6.01	2.31
44-45	0.18	3.7	3.88	6.01	6.19	2.31
45-46	0.24	3.88	4.12	6.19	6.43	2.31
46-47	0.24	4.12	4.36	6.43	6.67	2.31
47-48	0.24	4.36	4.6	6.67	6.91	2.31
49-50	0.14	4.96	5.1	7.27	7.41	2.31
50-51	0.29	5.1	5.39	7.41	7.7	2.31
51-52	0.24	5.39	5.63	7.7	7.94	2.31
52-53	0.1	7.94	8.04	7.94	8.04	0

V. PLAN EVALUATION

5.1 Process Chart Evaluation

The scenario of the new process capability will be evaluated in this chapter. The evaluation concentrates on the procedures of the new process chart module, job analysis and design module and technical methodology of process (PERT). However, the main interest is penetrating to the problems of production line that is analyzed and rectified in the previous chapter.

After the new process chart is analyzed, it results in the reduction of process time, cost of raw wood, and labor cost as well as the rearrangement of process procedures. Also, the new process helps the plant manager make decision easily on how to put the right man on the right job and the readjustment of the number of workers in each workstation or machine. Further, the new process chart provides the best solution to minimize the idle time of each workstation.

With the new flowchart, the total production time can be reduced from 7.946 minutes to 5.819 minutes, resulting in a 2.127 min. reduction. In addition, the rearrangement of workstations in the new flow chart can reduce the number of workers per station, some production process, and production cost.

In the new process chart module, we have found that the process efficiency increases by 39.66% when compared to the previous one. The new process chart can also result in faster production speed than the previous process for 1.3966 times.

In practical, working days of each month are fixed to 26 days; if the existing process is frozen, the existing process will use 30.19 days to produce one container. Therefore, the existing production line makes the real production time prolonged 4 days on the next month. In fact, the production line should be finished within one month, we have to expand the working hour (overtime) 1.5 hours for each day. Considering to the new process, the total production time generates only 21.62 days in each month, thus the new process can provide the production time to be finished within one month.

The schedule is represented as follows:

Table 5.1. The Comparison of Production Time between the Existing and the Proposed Process.

The existing process	**The new process**	**Diff.**
1 day = 480 minutes.	1 day = 480 minutes.	
1 piece = 7.946 minutes.	1 piece = 5.689 minutes.	2.257
Total q'ty per day = 60.407(480 /	Total q'ty per day= 84.37(480/	39.66
7.946)	5.689)	1.396
26 days = 1,570.58 (60.407 x 26)	26 days = 2,193.62 (84.37 x 26)	6
1 container = 1,824 pieces	1 container = 1,824 pieces	
Producing time per container =	Producing time per container =	8.57
30.19 days (1,824 x 26) / 1,570.58	21.62 days (1,824 x 26) / 2,193.62	

Practically, working days of each month are fixed to 26 days; if the existing process is frozen, the existing process will use 30.19 days to produce one container. Therefore, the existing production line makes the real production time takes 4 more days into the next month. In fact, the production line should be finished within one month, we have to expand the working hour (overtime) 1.5 hours to for each day. Considering the new process, the total production time generates only 21.62 days in each month, thus, the new process can provide the production time to be finished within one month.

For an existing process, the existing total cost of raw wood is calculated as 370.38 bahts per set of Party Wagon.

The expenses of a complete set are calculated from the factory constant factors and formula.

Raw wood cost x 7% of sealer x 15% of lacquer x 15% (miscellaneous cost) = total expanse per set.

Therefore, we can calculate as follows:

For the existing process = 261.74 x 7 % x 15 % x 15% = 370.38 bahts per set of Party Wagon.

For the new process = 236.8 x 7 % x 15 % x 15% = 335.08 bahts per set of Party Wagon.

So we can save production cost 35.30 bahts per set. We can also save the total production expense 64,387.27 bahts per container (1,824 sets x 35.30 bahts).

For the calculation of labor cost, the old process is represented as below:

Normal working time = 8 hrs a day (480 minutes) labor cost = 150 bahts per day per person.

Overtime = 1.5 hrs a day (90 minutes)

Therefore, labor cost for normal one hour equal 150 / 8 = 18.75 bahts per hour per person. For overtime = 18.75 x 1.5 = 28.125 per hour per person. But overtime has one and a half everyday.

Thus, overtime cost for each day = 28.125 + (28.125 / 2) = 42.1825 bahts per day per person.

Hence, one day working time = normal (480 min) + O.T. (90 min) = 570 min.

Labor cost = normal 150 bahts + O.T. 42.1875 bahts = 192.1875 bahts.

Average = 192.1875 / 570 = 0.33717 per minute per person.

The labor cost per workstation can be reduced from 0.3371 bahts in the existing process to 0.3125 bahts per day in the new process. If labor cost per set is calculated, it results in 6.53 bahts for the old process, while the new process is 9.73 bahts per set. So we can save 3.2 bahts per set (9.73-6.53) and we can save 5,836.80 bahts per container (1,824 x 3.2).

In this study, the process efficiency calculates is based on production per set, nevertheless, the total efficiency of quantity per container should be defined from the advance study. To clarify the effect from process reconstruction, the economized of raw wood is clearly sampled in this study. For example, in the old process, we used the wood sized 1 x 4" x 550 mm. 6 pieces to laminate the top or bottom panel but in the new process, we use the diversify of wood size to laminate the panel. Hence, the main reasons are to save material cost and timing cost. The difference of these two methods are shown as the following:

The older panel use 1" x 4" x .550 x 0.0228 x 250 x 6 = 75.24 bahts.

The new panel use 1" x 4" x .450 x 0.0228 x 250 x 2 = 0.08 bahts.

1" x 4" x .550 x 0.0228 x 250 x 2 = 0.10 bahts

1" x 2" x .450 x 0.0228 x 250 x 4 = 0.08 bahts

Total = 0.26 bahts.

Remark: 0.0028 is a constant factor used to change from cubic foot to cubic meter before calculating material cost.

The new process can save the raw material cost of 74.98 bahts per set. Thus, 1 container which has 1,824 sets can save 74.98 x 1,824 = 136,763.52 bahts.

From all calculation, it is found that if we apply the new process, we can obtain many benefits. We can reduce the production time since the production processes will be done more efficiently and the work redundancy is decreased. Since the number of workers in each workstation is reduced, labor cost is also reduced. Moreover, raw wood cost is also reduced due to decreased work redundancy. Therefore, we can improve the production processes and we can also save costs, so we can gain profits from doing the business if we apply this proposed process.

The total summary is represented as follows:

Table 5.2. Improvement Summary between the Existing and the Proposed Process.

	The existing process (Time)	The proposed process (Time)	Diff.
Production time	7.946	5.819	2.217
Total raw wood cost	370.38	335.08	35.30
Labor cost	9.73	6.53	3.2

5.2 Job Design Evaluation

Due to the existing theories of job design, many people such as Adam Smith, Frederick W. Taylor an so on had suggested the possible best approaches to design job for employees to perform their jobs so that both workers and the organization can obtain the benefits altogether.

From the research on job design, it is concluded that the determination of the best approach for job design from one method as a standard can not be absolutely done because the condition differs from one place to another, the limitations or supportive factors will also be different. Since each approach is proposed to solve some specific problems concerning doing a job, it provides advantages to workers and organization at some points. However, it results in various disadvantages as well.

Consequently, there is no best method of job design that fits all kinds of job. Also, improving the job design method does not mean that the newly revised approaches can be applied to all kinds of job in all organizations. Rather, the most acceptable way to improve job design method is to combine advantages of each approach and apply these good points to the redesigned method. First, we should solve the problem of low performance worker because it causes other problems. There are many causes of low performance worker. Furthermore, to make the job design approach most effective, several factors concerning jobs should be considered in order to design appropriate jobs for workers. These factors include workers themselves, job characteristics, working environment and compensation system.

In designing jobs for employees, several factors have to be considered since only one or two factors are insufficient and each factor is also equally important and dispensable. Thus, factors related to job design should be determined and considered on each importance for the effective job design. These factors involved people, job itself, compensation, and working environment.

People or workers in this case should be thought of as the first factor. Therefore, the way to consider the differences of the individual who has different needs and the reaction on different designed job is to consider the congruence between wants and rewards from work as one facet, and the ability and the need of the individual is the other facet. Consequently, the work behavior and individual feelings will result in the best way if nature of the job and nature of the individual are congruent very well.

A second set of factor to be considered when viewing the designing of job involves those factors relating to the attributes of an individual's job. The characteristics of job may vary depending on the kind of each job. Some jobs require workers to have various skills since each job has the variety of activities to be done as suggested by

Engelstad (1979). According to Hackman and Oldham (1980), they proposed types of job-related factors that have influenced employee motivation, satisfaction and performance toward work. Furthermore, Engelstad (1979) also proposed that some jobs may provide opportunity to learn on the job and give authority in decision-making to workers in doing jobs. Also, some jobs may offer socializing opportunity or increase solidarity or provide security feelings.

In addition to the characteristics of the job mentioned above, other characteristics are specialization. Some kinds of job are repetitive or routine and some workers may want to work on this kind of job since it is not complex and ambiguous, rather it is systematic so it is easy to perform and it requires lower skilled workers. Thus, this kind of worker prefers easy job to the complex one. However, some workers do not like repetitive or easy task since it is boring and monotonous. Rather, they prefer complexity and task that requires high knowledge and skill. If they can do this kind of job, they will feel proud of themselves and this reason may make them work harder because they are assigned challenging jobs.

Therefore, the company should analyze the characteristics of each worker in order to assign the right jobs to the right man so that they can experience the feeling of responsibility, achievement, growth and recognition by doing the job well. As a result, the company will obtain the benefits it needs from better worker performance and the workers will also be satisfied with the job they are doing.

Moreover, non-financial motivation techniques include quality of work life (QWL) which is defined as the degree to which employees are able to satisfy their important personal needs by working in the firm. The contributions of QWL consist of a fairly equitable and supportive treatment of employees; an opportunity for them to utilize their skills to the utmost; open and trusting communication between them;

opportunity for them to make decision on job; fair compensation; and safe and healthy environment.

In addition to QWL, other techniques are quality control (QC) which is to form small groups of employees and supervisor to work closely together. The members, then receive training in group problem solving, running meetings, and making presentations. This technique helps members receive praise, publicity, and satisfaction from their participation. They also gain a feeling of significance and personal growth from this activity. Improvement team is another technique similar to QC but formed on ad hoc basis.

Training and education can also compensate employees in such a way that they support employee empowerment that provides new knowledge and skill. It also includes job enrichment skills and job rotation that enhance their career opportunities. Non-financial compensation relates to motivation by providing QWL to satisfy higher-level needs. Levin et al (1972) also provided some examples of non-financial compensation such as company papers, athletic and social events, worker-of-the-week contests, suggestion boxes, and programs which involve the workers in environmental design. However, there are a lot of campaigns that help to foster an attitude of genuine concern for the quality of the employee's work.

As concluded, incentives or compensations, whether financial or non-financial, have been found to improve productivity, increase morale and increase job satisfaction of employees.

The final factor to be considered in job design is the working environment. Since it has an effect on the behavior of employees, their performance, and their feelings toward work. If they work in an unpleasant or uncomfortable area (in office or industry) or in the poor atmosphere; smelling or noisy, these things can distract them from work or even affect their health and then they cannot produce the outputs as well as they can.

Therefore, the management should provide environment for workers in order to facilitate them in working. Heizer and Render (1991) defined working environment as the physical environment under which employees' work affects their performance, safety, and quality of work life. Under working environment, it can be divided into two broad categories: those associated with physiological aspects and those associated with psychological aspects.

In addition, Bridger (1995) suggested some approaches to control noise. First is to eliminate the threat to hearing by redesigning the machine or using a less noisy machine. Second, personnel should be removed from the noisy environment. Finally, personnel have to be protected by using earplugs or earmuffs or by building an acoustic refuge.

Next factor of physiological aspects of working environment is work breaks. As suggested by Stevenson (1990), the frequency, length, and timing of work breaks can have a significant impact on both productivity and quality of output. Since this period of time can help workers take a rest in order to relieve fatigues, tiredness from working and refresh them to work further. If workers perform the job without any break, it may cause them stress and tired which will result in lower quality of work or output.

Therefore, work breaks are important to worker. If they are provided sufficient breaks, they can refresh themselves to work better than those who have no breaks. This also affects the quality and the amount of output they can produce.

Final physical condition of working environment is safety. Working safety is one of the most basic issues in job design since workers cannot work effectively if they feel they are in physical danger. Therefore, an effective program of safety and accidents control requires the cooperation of both workers and management. Workers must be trained in proper procedures and attitudes so that they can contribute to a reduction in hazards by pointing it out to management. Management must also enforce safety procedures and use of safety equipment to workers (Stevenson 1990).

In addition to the physical comfort and well-being of workers which is a fundamental concern in job design, the other aspect that affects work performance is psychological aspect. This concerns the quality of peer group interaction that includes supervisors, colleagues, and subordinates. All these people have influenced individual's working, though indirectly. Work performance will be in the good result if employee is supported correctly and treated properly. If they are encouraged and helped by employers and co-workers, they can work well and produce outputs as best as they can. On the other hand, if they are treated unfriendly or badly, this may lead to negative attitudes resulting in worse performance (both quality and quantity o output). Hawthorne studies (Roethlisberger and Dickson 1939) indicated that peer group can significantly influence an employee's effort since influence can occur at both ends of the productivity continuum. From this point of view, it can be said that work performance concerns morale because morale can influence employee's performance. Interactions among employees may be encouraged to improve morale, as a result their work performance will be better. Viteles (1953) defines morale as an attitude of satisfaction with a desire to continue in and a willingness to strive for the goals of a particular group or organization. Morale is a reflection of the summed motivation of group members to work together toward a common goal.

In the case of supervisor, Porter and Miles (1974) stated that supervisor or leadership style can influence effort and performance under certain circumstances. Immediate supervisors can play an important role in motivation because of their control over desired rewards (such as bonuses, raises, feedback) and because of their central role in the structuring of work activities. In other words, supervisors have considerable influence over the ability or freedom of employees to pursue their own personal goals on the job. In the case of work assignment, if employees are assigned to perform highly repetitive work, it can lead to worker dissatisfaction. This dissatisfaction often results in lower worker morale and increased problems in many areas. Low morale leads to labor grievances, which later affects the productivity and performance (Levin et al. 1972). Thus, the style of supervisors in any aspect (communication, duty designation or reward and punishment) can influence employees' decisions to produce on the job.

If we provide appropriate jobs, working environment, training and reward, workers will feel more comfortable to work and be happy to work in our company. As a result, their performance is better and this can also result in a better quality of products. However, we should also have a quality control for the production process to ensure that the finished products meet the standard. Thus, our company can reduce defective goods and claimed products, so it can result in customer satisfaction

Further, job design application can help the production process smoothly since well-trained workers can utilize materials and machine effectively, therefore the processes can be done as it is scheduled. As a result, the products can be finished on time and are also delivered to customers on time

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This project proposes the prioritization and rectification of production problems for a rubber wood furniture manufacturer. Such solutions need many approaches to be applied to the problems include job analysis and design, pareto analysis, process charting and PERT/CPM.

According to many theories, job design is the specification of the tasks, methods toward jobs in order to satisfy both the organizational and job holder's requirements. The objective of job design is to enable the jobholder to be technically capable of performing the assignment with the equipment and systems available. It is to help the organization keep costs at economic level and it is also to create a feeling of great worth and better behavior to employees.

Pareto analysis is a technique that classifies problem areas according to the degree of defect importance. Thus, it can help prioritize and focus causes or problems where they are most needed. It can also help measure the impact of an improvement between the existing and the new process. Pareto analysis can be illustrated in a Pareto chart, a diagram which is a vertical bar graph showing problems in a prioritized order, so it can determine which problems should be tackled first.

Process chart can also be applied to the problems since it is an organized way of recording all the activities performed by a worker, by a machine, at a workstation, or on materials. Its purpose is to provide an unambiguous, succinct record of a process so that it may be examined, analyzed and desirably improved. Five symbols used in the process chart include operation, transportation, inspection, delay, and storage.

Further, there are many other approaches that can be used to solve problems. This includes multiple activity charts, which is helpful for visualizing the portions of a work cycle during which an operator and equipment are busy and idle.

PERT and CPM are two common approaches for managing a project which enhances management's ability to plan schedule and monitor complex projects. By identifying the project duration through the critical path, managers separate the important few from the trivial many and focus their attention on the most important activities.

PERT and CPM provide a number of benefits to project managers since they give managers the ability to identify the specific activities and relationships within a project and estimate the time required to complete each activity. By identifying the critical path, they provide management a focus as the project is being monitored.

However, PERT and CPM can offer limitations since a network diagram developed at the start of a project may later limit the project manager's flexibility to handle changing situations. Also, they do not allow for the possibility that some activities may not be completed at all.

PERT /CPM can consider uncertainty in activity completion time but not uncertainty about whether actual completion will occur.

For the prioritization toward the production problem, a survey of company's problems conducted by interviewing five employees in the management level. Then, the result of the survey is analyzed to find out all possible problems. These problems are thus calculated to examine the higher scores, which is ranked as the most important problem and needed to be solved first. As a result, it is found that the problems are arranged orderly due to the severity include cash flow shortage, low performance workers, late delivery of raw material, old and outdated machines, fluctuating costs of raw materials, uneven order volume, low quality raw materials, price bargaining, delayed shipment, low quality products, order for varieties for models, claimed products, workers shortage, and variation of packaging and fitting costs respectively.

All these 14 problems are categorized, according to their similarity or relatedness, into three groups: order and delivery problems. Production problems, and other problems. For order and delivery problems, there are totally five sub problems: Late delivery of raw material, uneven order volume, order for varieties of model, fluctuating cost of raw materials, and low quality raw materials.

The production problems concern many aspects of workers and machines which include low performance workers, delayed production, low quality products, and claimed products. These problems are solved by applying job design methods such as holding training programs, providing appropriate compensation and recognition, and other methods such as quality control, quality assurance.

For the group of other problems, it included cash flow shortage, old and outdated machine, price bargaining, worker shortage and variation of packaging and fitting cost. All these problems are rectified by several solutions since each problem is not relatively related.

For more emphasis, the production problems are rectified in details by applying cause-and-effect or fishbone diagram to analyze the root causes of these problems which are caused by workers, machine or production process. All these root causes are solved by many theories such as job design, process charting, and PERT/CPM.

For process charting and PERT/ CPM, they are used to solve the existing production processes of Part Wagon which is the best sold products of the company. As a result, the time taken in each process is reduced, thus the total process time to produce this product is reduced.

In addition, job design method is also selected to solve the production problems since this technique can improve worker performance and create better environment. If the organization can solve the problem of worker, it can improve the other problems such as some production problems. For such production problem, we select the best selling product to rearrange the step of production process. Further, the processes of production are reduced by applying PERT technique, as a result, the new process has less procedures, thus it takes less time for the production. Less labor cost and less raw wood cost. This project is conducted in order to solve the existing problems or problems that may occur in the future by applying such methods. The organization can also achieve the goal of productivity and efficiency it needs to survive economically and it can improve the customer satisfaction as well.

6.2 Recommendations

This project toward an application of many approaches is likely to be useful for any organization that needs to improve and solve some existing problems about the production. Each part will be proposed the suitable technique which is systematically described and illustrated for a clearer understanding.

Although all theories are not integrated, several theories referred in this project are sufficient to be applied in the problems. However, other approaches available at some sources may be more useful for the application. Due to the limitation of the time frame, an implementation of process chart is not completely conducted to obtain the result of methods application. Therefore, this project will be implemented and studied further to verify that the performance outcome will practically follow the proposed model.

This project emphasized on the solutions for production problems since it seems to be the most important operation for general manufacturers, other problems that are the results of the survey, such as shortage of cash flow, are not mentioned. However, the production problems have an effect on such problems. For example, delayed production may result in late shipment of products to customers, as a result the payment of these products is beyond the due date. If this event occurs regularly, the company may face the shortage of cash flow and may not have enough money to keep running the business. Therefore, it is the priority to solve the production problems, so that other consequent problems can be solved as well.

For any approach used in this project, such as Pareto chart, it can be applied to other problems not only the production problems since this approach is to prioritize the most severe or important problem so that it is considered to be solved as soon as possible.

Further, there are many other approaches that can be applied to solve the production problems. Such approaches include MPR (Materials Resource Planning), QC (Quality Control), JIT (Just-In-Time), and so on. All these approaches are useful for any manufacturer since they propose the solutions to the different problems. Thus, the problem rectification toward these methods will be implemented further so that the company can improve the production processes and increase the quality of finished products which will result in customer satisfaction and for the company being accredited by ISO 9000.

Eventually, this project provides an approach as a step-by-step solution to the problems, thus those companies that want to tackle the problems but do not know how to deal with them can apply this approach in order to know which problem should be solved first. When the severe problem is solved, the company will not be severely affected by other problems.

However, the proposed solutions to the production problems will not be done effectively if the management and all employees do not incorporate with this matter.

BIBLIOGRAPHY

1. Dilworth, J. B. Production and Operation Management: Manufacturing and Nonmanufacturing, 2nd Edition. New York: McGraw-Hill, 1989.

2. Elmore, P. B. and P. L. Woehlke. Basic Statistics. London, England: Addison-Wesley Educational Publishers Inc., 1997.

3. Evans, J. R. Applied Production and Operation Management, 4th Edition. Singapore: Info Access and Distribution, 1994.

4. Finch, B. J. and R. L. Luebbe. Operations Management: Competitive in a Changing Environment. Fort Worth: Dryden Pr., 1995.

5. Krajewski, L. J. and L. P. Ritzman. Operation Management, 4th Edition. London, England: Addison-Wesley Publishing Company Inc., 1996.

6. Muhlemann, A., J. Oakland, and K. Lookeryer. Production and Operation Management, 6th Edition. London: Pitman Publishing, 1994.

7. Render, B. Production and Operation Management, 3rd Edition. Boston: Allyn and Bacon, 1993.

8. Russell, R. and B. W. Taylor III. Production and Operation Management: Focusing Quality and Competitiveness. London, England: Prentice Hall International, 1995.

9. Stevenson, W. J. Production and Operation Management, 6th Edition. Boston: Irwin / McGraw-Hill, 1999.

10. Vollmann, T. E., W. L. Berry, and D. C. Whybark. Manufacturing Planning and Control Systems, 4th Edition. New York: The McGraw-Hill Companies, 1997.

11. Waters, D. Operation Management: Production Goods and Services. London, England: Addison-Wesley Publishers Ltd., 1996.