UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **PRODUCTIVITY IMPROVEMENT USING INDUSTRIAL ENGINEERING TOOLS**

SESI PENGAJIAN: **2010/2011**

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PRODUCTIVITY IMPROVEMENT
USING INDUSTRIAL ENGINEERING TOOLS

HOW SHENG BOON

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2010

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "Productivity Improvement using Industrial Engineering Tools" is written by How Sheng Boon. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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DEDICATION

Special dedication to my family members and that always inspire, love and stand beside me, my supervisor, and ex-supervisor, my beloved friends, my fellow colleagues, all Faculty of Mechanical lecturers and members.

Thank you so much for your love, care, support and believes in me.

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Finally I want to thank all the direct and indirect supports helped me completing my Final Year Project in time.

ABSTRACT

The aim of this study is to study the implementation of industrial engineering tools in selected manufacturing company to identify the highest defects occurred at the company production lines and propose new methods to the selected manufacturing company for defects reduction and thus improve the productivity of the company. The chosen company is NamHwa Paper Industries (M) SDN. BHD. and the product being analyzed is 1040mm paper. The study mainly focuses on 7 Quality Control. In order to achieve the objective of the study, firstly, the flow of process to produce 1040mm paper was observed. From the observation, there are total of 8 workstations at the company. The workstations are Slitter, Print, Slotter, Glue, Stitching, Partition, Die Cut and Tie workstation. Then, each frequency of defects at the workstation was collected by using check sheets. The data was then arranged according to the highest to lowest frequency in cumulative table and Pareto chart was build base on the cumulative table. Defect with the highest frequency can be identified and was chosen to be analyzed. The workstation chosen for analyzed was Glue workstation. Initially, the original methods imply at glue workstation has very much defects and did not achieve the targeted output. Hence, brainstorming needs to be done to build the cause and effect diagram as detailed as possible causes in each of the broad areas where the causes will be 4M which is Methods, Machines, Manpower and Materials. Based on the cause and effect diagram, solutions were generated. There are few suggestions that can suite the company and improve the productivity of NamHwa Paper Industries (M) SDN. BHD. The solutions are divided the glue paper box into few group before stacking up, use electric fan or airy place for glue workstation, and use table lamp or hair dryer. Cost reduction for each solution was calculated and the solution with highest cost reduction is chosen to increase the productivity of the company.

ABSTRAK

Tujuan utama kajian ini dijalankan adalah untuk melaksanakan teknik industri di syarikat perkilangan yang dipilih untuk mencari kecacatan tertinggi yang berlaku di pemprosesan di kilang tersebut dan mencadangkan kaedah baru untuk mengurangkan kecacatan yang akan berlaku di syarikat perkilangan yang dipilih sehingga meningkatkan produktiviti syarikat. Syarikat yang dipilih untuk menjalankan kajian ini ialah NamHwa Paper Industries (M) SDN. BHD. dan model sampel yang digunakan ialah kertas 1040mm. Penyelidikan ini tertumpu pada "7 Quality Control Tools". Mula-mula, cara untuk memproses di kilang tersebut haruslah difahami dengan teliti. Menerusi pandangan kasar, adalah dimaklumkan bahawa kilang ini terdiri daripada 8 tempat kerja yang utama. Tempat kerja tersebut terdiri daripada Slitter, Print, Slotter, Glue, Stitching, Partition, Die Cut and Tie. Kemudian, setiap frekuensi kecacatan di setiap tempat kerja direkodkan ke dalam check sheets yang disediakan. Seterusnya, data-data yang direkodkan itu disusun mengikuti quantity frekuensi kecacatan yang paling tinggi ke paling rendah dalam ruang kumulatif yang disediakan dan pareto chart dapat dilukis. Dengan secara langsung, kecacatan yang paling banyak berlaku dapat dikenali dan dipilih untuk menjalankan analisis yang lebih mendalam. Tempat kerja gam memiliki frekuensi kecacatan yang tertinggi dan tempat kerja tersebut dipilih untuk dianalisis. Sebelum ini, kaedah yang digunakan di tempat kerja gamempunyai kecacatan yang sangat banyak dan tidak mencapai target. Maka, cause and effect diagram untuk kecacatan semasa gam perlu dilakarkan dan sebab-sebab berlakunya kecacatan harus dicatatkan melalui 4M iaitu "Methods", "Machines", "Manpower" dan "Materials". Melalui cause and effect diagram ini, kaedah yang baru harus dicadangkan untuk NamHwa Paper Industries (M) SDN. BHD. Cadanagan yang dicadangkan termasuklah membahagikan kertas yang baru digam itu ke beberapa tempat sebelum diletakkan sekali menggunakan kipas angin elektrik atau tempat lapang untuk tempat kerja gam, dan gunakan lampu meja atau pengering rambut. Pengurangan kos untuk setiap penyelesaian dikira dan penyelesaian dengan pengurangan kos tertinggi yang dipilih untuk meningkatkan produktiviti syarikat.

TABLE OF CONTENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

mm	Milimeter
RM	Ringgit Malaysia
w	Watt
kwh	Kilo watt hour

LIST OF ABBREVIATIONS

7QC	Seven Quality Control
LED	Light Emitting Diode
UCL	Upper Control Limit
LCL	Lower Control Limit
PCB	Printed Circuit Board
SPC	Statistical Process Control
TQM	Total Quality Management
DOE	Design of Experiment
SME	Small Medium Enterprises
JIT	Just In Time
FYP	Final Year Project
TNB	Tenaga Nasional Berhad
FKM	Faculty of Mechanical Engineering

CHAPTER 1

INTRODUCTION

1.1 Overview of the Project

In this modern and competitive world, manufacturing industry is one of the sectors which can takes turns under all types of economic systems such as free market economy and collectivist economy. All of the products generated is competing to gain demand and satisfactory from customers. Dealing with continuous competition, company not only needs to produce quality products but excellence production systems and management also plays an important roles.

The aim of study is to improve the productivity of an assembly line in industry manufacturing production. The objective is to identify the defect of the company and create a better solution to improve the production line performance. Various industrial engineering technique and tools is implementing in this study in order to investigate and solve the problem that occurs in the production. However, 7 Quality Control tools are the main tools that will be applied to this study.

Data for the selected assembly line factory are collected, studied and analyzed. The defect with the highest frequency will be the main target to be improved. Various causes of the defect will be analyzed and various solving method will be present. The best solving method will be chosen and propose to the company and compare to the previous result or production. However, the implementation of the solving methods is depending on the company whether they wanted to apply or not.

1.2 Problem Statement

Nowadays, for manufacturing company, the most important goals for almost all manufacturing company is to increase the productivity, which reflect to get a better production line efficiency. There are many methods exist by which productivity could be analyzed and improved.

Simulation software such as Quest, ProModel, and WITNESS allow users to build several layout of the company and identify the problems faced and hence improve the productivity of the company. 7 Quality Control tools also can be used to identify the defects at the workstation. However, the analysis of problems consume of longer time compare with the simulation software.

This study tries to identify the defects occurs at each workstation and hence overcome and reduce the defect that occurred during the productivity process. Last but not least, is to increase the production rate hence to cope up the demand from customer.

1.3 Objectives

Basically, the main purposes in accomplishing this study are shown below:

1) To implement industrial engineering tools in selected manufacturing company.
2) To identify the highest frequency of defects occurs at the workstations.
3) To propose new methods to the selected manufacturing company.
4) To improve the productivity of the company

1.4 Scopes

The scope of this study is mainly focusing on the criteria shown below:

a) The study mainly focuses on 7 Quality Control tools but only selected Quality Control tools are applied. They are check sheet, Pareto chart, and cause and effect diagram.
b) The industry that will be select is limited to company with production or machining lines.
c) Only defects with highest frequency will be analyzed.
d) Propose new methods to increase the productivity of the company but depends on company whether implement the new method or not.
e) Compare between the existing and proposed productivity.
f) Sample model being analysis is 1040 mm paper.

1.5 Summary

Productivity improvement is wide, vague, and open to different interpretations. It's often troubling, undesirable, and less than productive to invest an endless amount of time and effort into trying to improve productivity. Yet, it is invariably important to be able and identify the organizational constraints which are preventing the organization from becoming more efficient and competitive. Utilizing engineering tools will map and identify the main non productive segments in productivity line and draft a plan to address and remedy the issues. One of the simplest yet efficient tools will be 7 Quality Control tools. From this study, 7 Quality Control tools will be performed via detailed implementation for the proposed of improving the productivity of the selected company/industrial.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discuss about literature review that would have to be done on engineering tools. One of the most common engineering tools which can be utilized for this purpose would be 7 Quality Control Tools as this method would often be simple, but yet efficient. The reviews on journal, article and book has to be done. Of course the data collection from the industrial also will be the main source to improve the productivity of the selected industrial.

2.2 Introduction to Productivity

Productivity usually defined as a ratio between output and input. It is a fundamental concept considering this efficient and effective use of resources. Productivity improvement is seen as a critical success factor and the foundation of profitability (Kapyla et al., 2009).

Besides that, productivity can be regarded as a synonym for competitiveness since it expresses the ability to provide goods and services at prices which are regarded as “good value” and therefore competitive. Productivity measurement is a long-term measure. Some changes in “productive potential” only show in growth figures over a long period (Heap, 2006).

Furthermore, productivity means different things to different people and so different or even conflicting definitions and perceptions of productivity exist.

Productivity has been approaches as an umbrella concept including utilization, efficiency, effectiveness, quality, predictability and other performance dimensions, as well as a narrower concept reflecting only production efficiency. Productivity is the ratio of what is produced by an operation of process to what is required to produce it, or put simply the ratio of actual output to input over a period of time. Inputs might include transforming and transformed resources such as materials, equipment, customers and staff and the outputs are good and services (Johnston and Peter, 2004).

As a conclusion, productivity can be known as ratio of output and input. The greater the output, the better is the productivity and vice versa. Good productivity provides goods and services at good prices.

2.3 Introduction to Industrial Engineering

Industrial Engineering is an approach with a strong tradition of, and a significant effect on productivity measurement and improvement (Masin and Vytlacil, 2001).

According to Lo and Sculli, 1995, Industrial Engineering is concerned with the design, improvement, and installation of the integrated system of men, materials, and equipment. It draws upon specialized knowledge and skills in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design, to specify, predict and evaluate the result to be obtained from such a system.

Besides that, Industrial Engineering is a discipline that has been around in a number of forms and under a number of titles for the last 50 years. It has primarily been concerned with the pursuit of organizational efficiency through methods improvement and resource-saving. Besides, it also is a organizational reform through business, market and technology development (Mohanty, 1998).

As a conclusion, Industrial Engineering is inter-related with the improvement where knowledge and skills are applied in order to evaluate and obtain a result. Its underlying concepts overlap considerably with certain business-oriented disciplines

such as operations management, but the engineering side tends to emphasize extensive mathematical proficiency and usage of quantitative methods.

2.4 Quality and Productivity Improvement

Today highly competitive world, quality plays vital role as it leads to an improvement in productivity. Productivity, quality, and cost of operation relatively depended to each other. The relation of productivity, quality and cost are shown in Figure 2.1. By improving the productivity, the quality also must be improved and hence lower the reject rates or defects (Jafri and Chan, 2001).

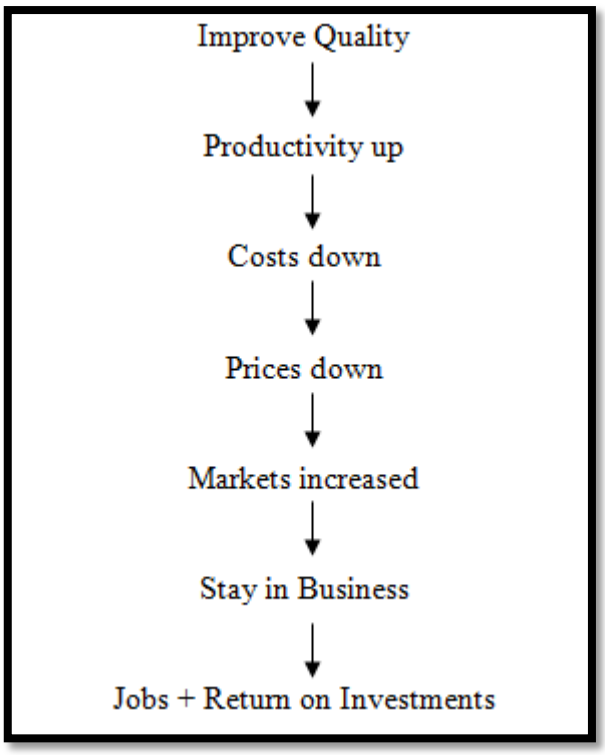

Figure 2.1: Relation between productivity, quality and cost

Source: Mohamed (2005)

2.5 Seven Quality Control Tools

When facing with quality problems, it similar to be lost as you doesn't know where you are. In productivity improvement or quality improvement process, solvers need to know what the main problem is, the causes of the problems before they propose the solutions. However, logical and systematic method should be applied to make the job easier by locating and eliminating the root or real cause of the problem. There are many techniques (Reed, 1992) available in problem solving, ranging from simple and easy to use methods to relatively complicate and advance statistical tools. (Winco, 1996). The 7 QC Tools are easier to apply and understand and yet proven scientific management tools. 7 QC tools can be used in all process phases, starting from the beginning of a product development up to management of a process, on day to day basis, and in systematic manner (Paliska et al., 2007). They form the fundamental foundation for all problem solving and quality control activities.

ISHIKAWA KAORU, Professor Emeritus, University of Tokyo has stated that "The term "7 tools for QC" is named after the 7 tools of the famous warrior, Benkei. Benkei owned 7 weapons, which he used to win all his battles. Similarly, from my own experience, you will find that you will be able to solve 95% of the problems around you if you wisely use the 7 tools of QC."

Basically, the 7 QC tools are check sheet, Pareto chart, flowchart, cause and effect diagram, histogram, scatter diagram and control chart (Ishikawa, 1985. and Pimblott., 1990). These 7 QC tools also known as Total Quality Management (TQM) tools (Jay and Barry, 2008).

2.6 Check Sheets

Check sheets also known as data collection sheets and tally charts (Ishikawa, 1982). Check sheets are used to collect data that will be used towards solving the problem selected. Data represent inputs which will be used to provide information that will enable the right decisions to be made. Check sheets are important as it provides the facts and present information in an efficient, graphical format. This may be accomplished with a simple listing of items.

The data that should be collect is the process data which is under investigation. The design of the check sheet has to allow valuable information to be obtained. It is important to keep the check sheet as simple as possible so that the entire investigation effort is put towards collecting the right type of information. The sheet should also be designed so that data is collected over a certain time scale. The analysis of information will only become meaningful if enough data has been collected. Check sheets should not be designed until the process has been properly understood and the problem clearly identified (Mohamed, 2005).

2.6.1 Who Should Collect The Data

The person who collects the data must fully understand the process, perhaps those who are responsible for the problem, are asked to collect the information. The data collected must be precisely attributing to the right cause so that the analysis gives accurate outcomes (Mohamed, 2005).

2.6.2 Check Sheets Procedure

Nancy, (2004) stated that, first, decide what event or problem will be observed and develop operational definitions. After that, decide when data will be collected and the period of the data that will be collected. Next, design the form so that data can be recorded simply by making check marks or tick or similar symbols and so that data do not have to be recopied for analysis. Label all spaces on the form. Test the check sheet for a short trial period to be sure it collect the appropriate data and is easy to use. Lastly, each time the targeted event or problem occurs, record the data on the check sheet.

	Hour							
Defect	1	2	3	4	5	6	7	8
A	///	/		/	/	/	///	/
B	//	/	/	/			//	///
C	/	//					//	////

Figure 2.2: Example of Check Sheets

Source: Mohamed (2005)

Figure 2.2 shows that the check sheet is recorded for 8 hours period and concentrate on 3 types of defects which are A, B and C. Defect A is recorded with highest frequency of defect, 11 units than follow by defect B with 10 units and defect C with 9 units. Hence, the further study needs to concentrate on “Defect A”.

2.7 Pareto Chart

Pareto Chart also known as Pareto Diagram or Pareto Analysis. Pareto Chart are important tools in quality improvement process. They were created by Kaoru Ishikawa, who pioneered quality management processes in the Kawasaki shipyards (Durkee, 2007). Alfredo Pareto, an Italian economist (1848-1923) found that 80% of the property in Italy was owned by 20% of the population. (Durkee, 2007). This observation had leaded him to formulate the Pareto Principles. Pareto Principle supports the 80/20 rule, which states that 80% of problems (nonconformities or defects) are created by 20% of causes (Amitava, 2008).

Pareto Chart is a bar graph. It also graphically summarizes and clearly show the differences between groups of data-often those provided within check sheet. By drawing out the Pareto Chart, the frequency of the problem can clearly stated and focused to achieve improvement. Besides, 80% problem and 20% of the causes also can be identified. Normally, the graph will be arranged in order of longest bars on the left and the shortest to the right. By this arrangement, the chart visually depicts which situations are more significant and helps prioritize the problems by arranging them in decreasing order of importance. In environment with limited resources, these diagrams will help the companies decide on the order in which they should address problems (Amitava, 2008).

2.7.1 When to use Pareto Charts

Pareto Chart normally being produce when there are too many problems and causes appeared and the most significant need to be focusing (Nancy, 2004). It also can be use to analyze data about the frequency of problems and the causes that appeared in a process. It also very useful and easy to be interpreted the data to others.

2.7.2 Pareto Charts Procedure

According to Nancy, (2004) first, decide what categories that will use to group items than decide what measurement is appropriate. Those common measurements are frequency, quantity, cost and time. Next, decide what period of time the Pareto chart will cover, either one work cycle, 1 day or 1 week. After that, collect the data, recording the category each time or assemble data that already exist. Subtotal the measurements for each category and determine the appropriate scale for the measurements that have been collected. Mark the scale on the left side of the chart and make sure to construct and label bars for each category. Place the tallest at the far left, then the next tallest to its right and so on. If there are many categories with small measurements, they can be grouped as “other.”

Calculate the percentage for each category where the subtotal for that category divided by the total for all categories. Draw a right vertical axis and label it with percentages. Be sure the two scales match. Calculate and draw cumulative sums. Add the subtotals for the first and second categories, and place a dot above the second bar indicating that sum. To that sum add the subtotal for the third category, and place a dot above the third bar for that new sum. Continue the process for all the bars. Connect the dots, starting at the top of the first bar. The last dot should reach 100 percent on the right scale.

Table 2.1: Reasons for airline customer dissatisfaction

Reasons	Count
Lost baggage	15
Delay in arrival	40
Quality of meals	20
Attitude of attendant	25

Source: Amitava (2008)

Table 2.1 shows customer dissatisfaction for one airline company. Delays in arrival is the major reason, as indicated by 40% of customer. Thus, this is the problem that airlines company should address first. Figure 2.3 is the Pareto diagram generates from the results of Table 2.1.

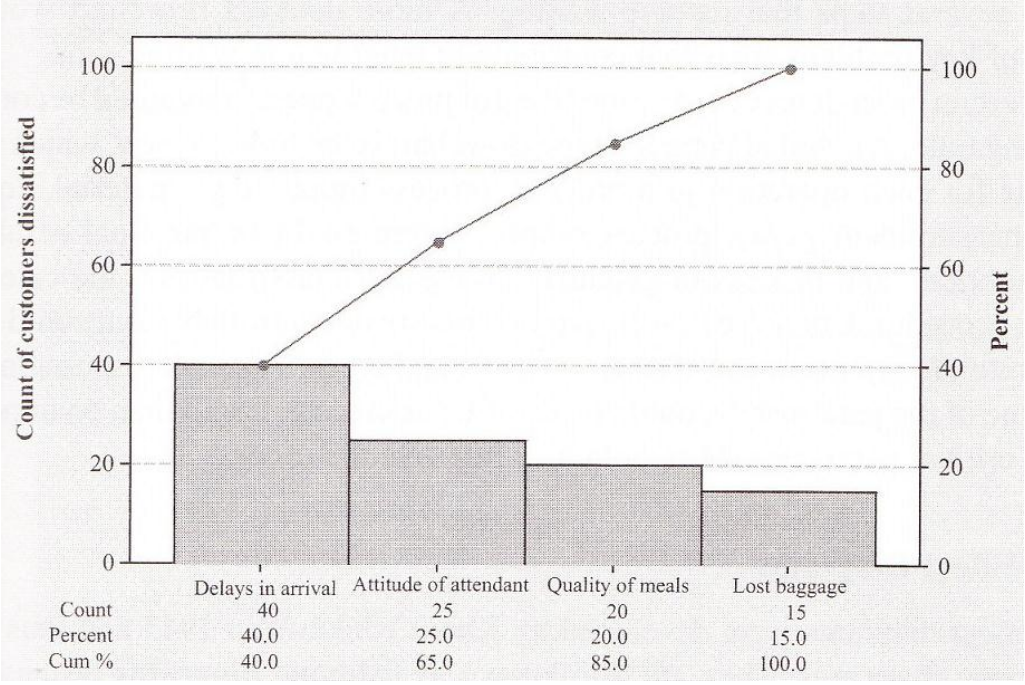

Figure 2.3: Example of Pareto Diagrams generates by Table 2.1

Source: Amitava (2008)

Figure 2.3 stated that the major reason of airline customer dissatisfaction is delay in arrival where 40 persons complain about it and stands for 40% of total complain. Attitude of attendant has second high in frequency which is 25 persons (20%) follow with quality of meals 20 persons (20%) and lost baggage for 15 persons (15%). The airline get 100 respondent of complain just because of 4 types of resons. Hence 80% problems and 20% causes can be clearly identified.

2.8 Flowcharts

Flowcharts shows the sequences of event in a process which are used for manufacturing and service option (Amitava, 2008). It is not statistical, but is used to piece together how the real process is run. Seeing it visually makes identifying both inefficiencies and potential improvements easier.

A series of shapes are used to depict every step of the process; mental decisions are captured as well as physical actions and activities. Arrows depict the movement through the process. Flowcharts vary in complexity, but when used properly can prove useful for identifying bottlenecks, redundant steps, and non-value-added activities. A relistic flowchart can be consturcted by using the knowledge of the person who carried out or incharge the particular process (Amitava, 2008).

2.8.1 Flowchart Procedures

First, familiarize the participants with the flow chart symbols. After that, draw the process flow chart and fill it out in detail about each element. Analyze the flow chart. Next, determine which steps can be combined, simplified, or eliminated. Lastly, finalize the flow chart. (Foster, 2001)

2.8.2 Flowchart Symbols

Flowcharts usually built by using six symbols which shown in Figure 2.4. The symbols can lead to an accurate and up to date representation of the process being considered and are the best means by which complex aspects can be simplified and communicate.

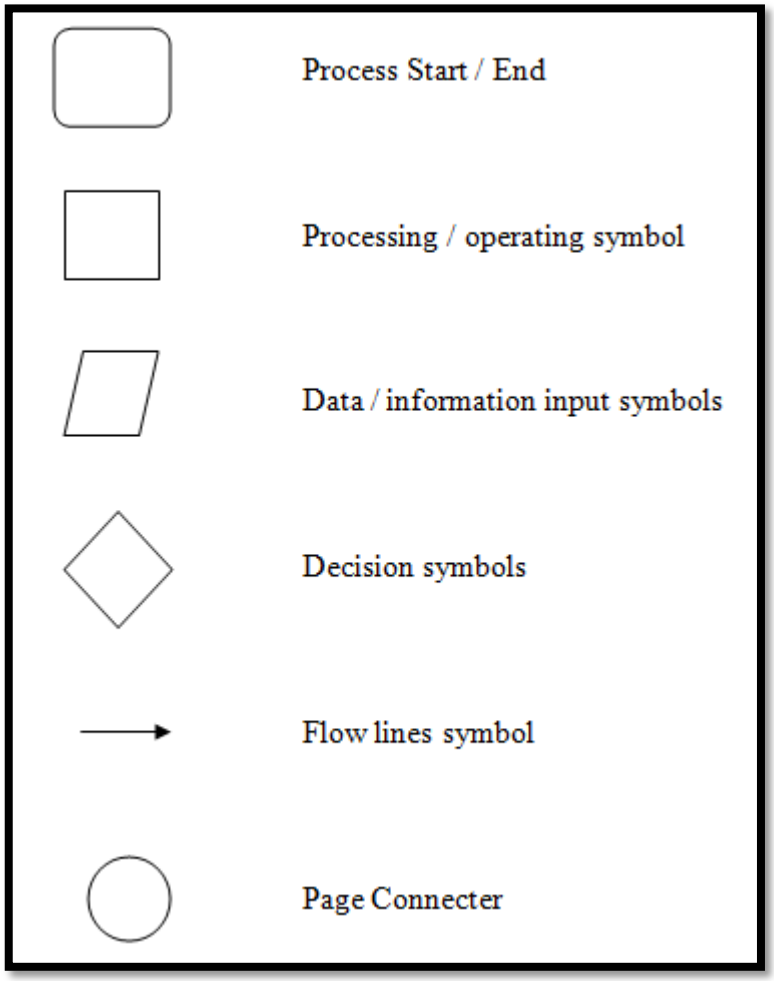

Figure 2.4: Flowcharts symbols

Source: Mohamed (2005)

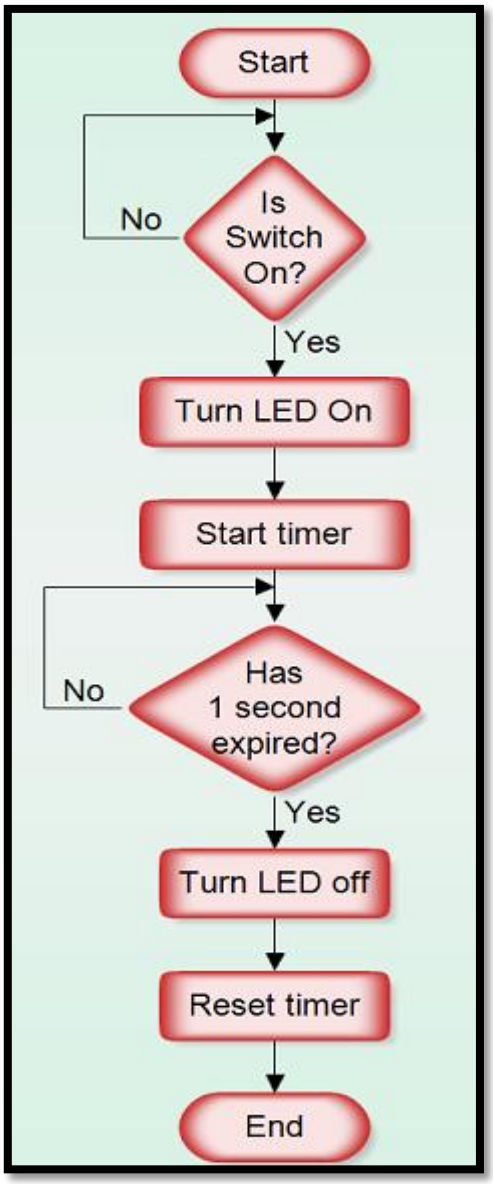

Figure 2.5: Example of flowcharts of a one second respond to a switch

Source: www.google.com/images (20 March 2010)

From Figure 2.5, when a switch is off, it will remain off. But when the switch been switching on, the LED will turn on and in the same time, the timer start. The timer detector will detect whether the LED had turn on for 1s. If the detector detects the time is less than 1s, than the LED will keep on lighting. If the detector detects the time reached 1s, The LED will turn off automatically. Hence the timer will be reset.

2.9 Cause and Effect Diagram

Cause and effect diagrams were developed by Kaoru Ishikawa in 1943 (Amitava, 2008). Hence, the diagram also called an Ishikawa diagram or fish bone diagram which is used to associate multiple possible causes with a single effect (Nitin and Santosh, 2009). These diagram help to determine which of several causes has the greatest effect. This diagram also can aid in identifying the reasons why a process goes wrong. If the process is stable, these diagrams can help mangement to decide which causes or defect to be investigate and make improvement (Amitava, 2008.).

2.9.1 When to use Cause and Effect Diagram

Cause and effect diagrams used to detect the problem of incorrect deliveries. When a production team is about to launch a new product, the factors that will affect the final product must be recognized. The diagram can depict problems before they have a chance to begin. It is also very usefull when a team's thinking tends to fall into ruts. (Nancy, 2004)

2.9.2 Cause and Effect Diagram Procedure

Nancy, (2004) stated that clearly identify and define the problem or effect for which the causes must be identified at the very first. Then, place the problem or effect at the right or the head of the diagram and identify all the broad areas of the problem. Write in all the detailed possible causes in each of the broad areas. Normally, the causes will be 4M (Reed, 1992) which is Methods, Machines, Manpower and Materials. Each cause identified should be looked upon for further more specific causes. Next, view the diagram and evaluate the main causes. Set the goals and take action on the main causes. When the group runs out of ideas, focus attention to places on the chart where ideas are few.

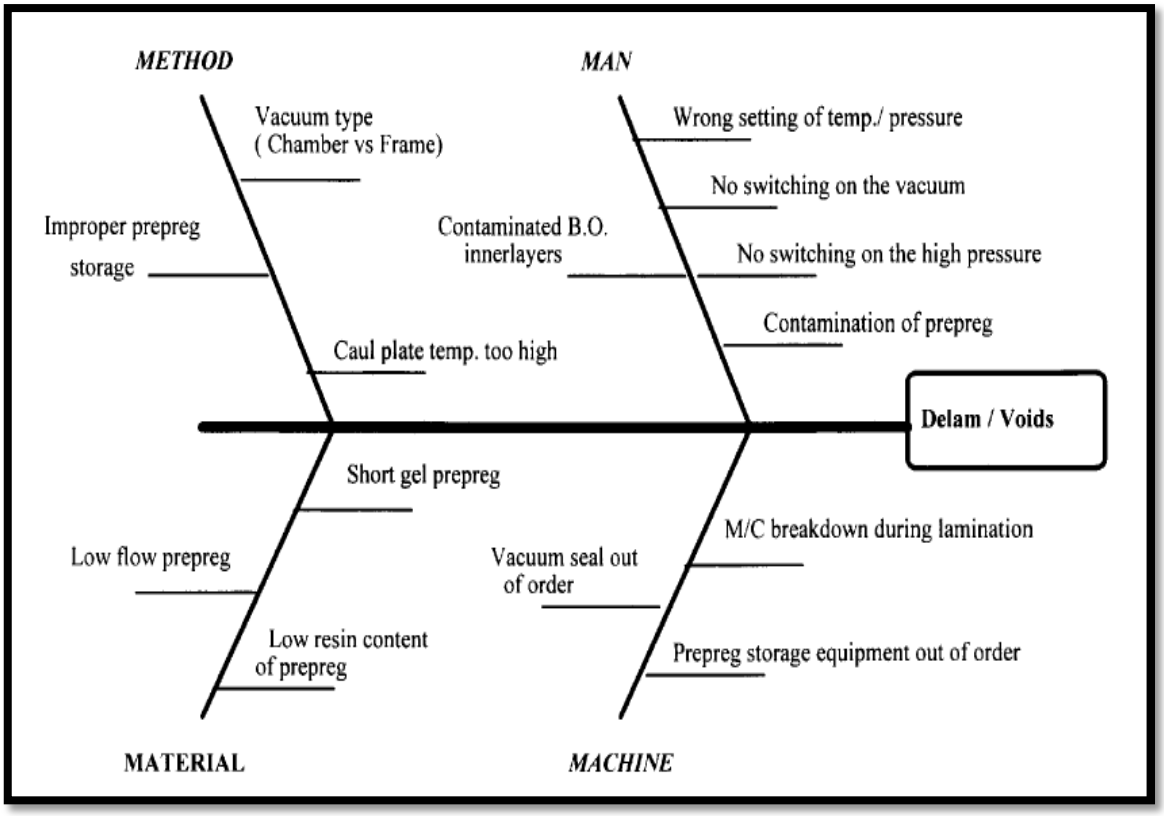

Figure 2.6: Cause and Effect Diagram of delamination / voids

Source: Winco (1996)

From Figure 2.6, the effect is the delamination or voids and the causes of voids is the 4M which are Method, Man, Material and Machine. There are 3 causes from Method which is improper prepreg storage, vacuum type and high temperature of caul plate. Causes that cause by Man is the error of setting of temperature or pressure, didn't switch on the vacuum and the high pressure when using the machine, contaminated B.O. innerlayers and contamination of prepreg. Material which cause voids are short gel prepreg, low flow or prepreg and low resin contect of prepreg. Last but not least, the causes that made by Machine are vacuum seal out of order, machine breakdown during lamination and prepreg storage equipment out of order.

2.10 Histogram

The development of the histogram is attributed to a French statistician, Guerry in 1833 (Amitava, 2008). Histogram is a bar graph that show frequency data. Histograms provide a simple, graphical view of accumulated data (Nitin and Santosh, 2009).

2.10.1 When to use Histogram

Histogram can be used when the data are numerical. Histogram can clearly show the shape of the data's distribution, especially when determining whether the output of a process is distributed approximately normally. It also can be use for analyzing whether a process can meet the customer's requirements or what the output from a supplier's process looks like. (Foster, 2001)

Histogram also can be applied to observe whether a process change has occurred from one time period to another and determine whether the outputs of two or more processes are different. Lastly, histogram can easily, quickly and effectivly communicate the distribution of data to others.

2.10.2 Histogram Procedure

First, collect data and sort it into categories. Then label the data as the independent set or the dependent set. The characteristic that been grouped would be the independent variable while frequency of that set would be the dependent variable. Make sure each mark on either axis should be in equal increments. For each category, find the related frequency and make the horizontal marks to show that frequency. (Nancy, 2004)

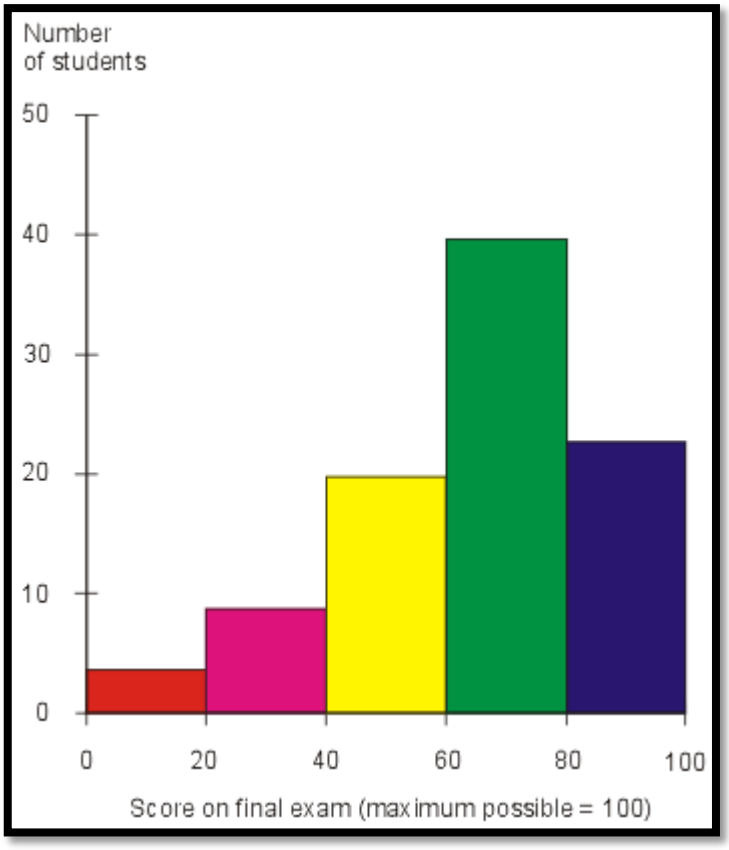

Figure 2.7: Example of Histogram

Source: www.google.com/images (20 March 2010)

Figure 2.7 shows that just a few students fail their final exam. There are 3 and 9 students respectively who score between 0 to 20 and 20 to 40 marks. There are20 persons score 40 to 60 marks and 21 persons score 80 to 100 marks. Most off the student score between 60 to 80 marks for their final exam. Hence we can conclude that average of the students can score during their final exam.

2.11 Scatter Diagram

Scatter diagram also know as scatter plot, X-Y diagram (Nancy, 2004), or correlation diagram which aims to establish relations between two variables. It is an investigation tools which works backward by plotting the effect against experimentally controlled changes in the causes in the process. (Amitava, 2008). The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. It is used to display the change of one variable when another changes. From a scatter diagram, mathematical equation that relates to the variables can be find. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line.

2.11.1 When to use Scatter Diagram

Scatter diagram can be use when there are paired numerical data or dependent variable may have multiple values for each value of independent variable. It also can be use to determine whether the two variables are related. Through scatter diagram, the potential root causes of problems can be identified too. Normally scatter diagram is apply after brainstorming causes and effects using a fishbone diagram, to determine objectively whether a particular cause and effect are related. (Foster, 2001)

2.11.2 Scatter Diagram Procedure

First, collect two pieces of data and create a summary table of the data. Next, draw a diagram labeling the horizontal and vertical axes. By convention the “cause” or “explanatory” or “independent variable is on the X axis and the “effect” or “response” or “dependent” variable is on the Y axis. Plot the data pairs on the diagram than interpret the scatter diagram. (Nancy, 2004)

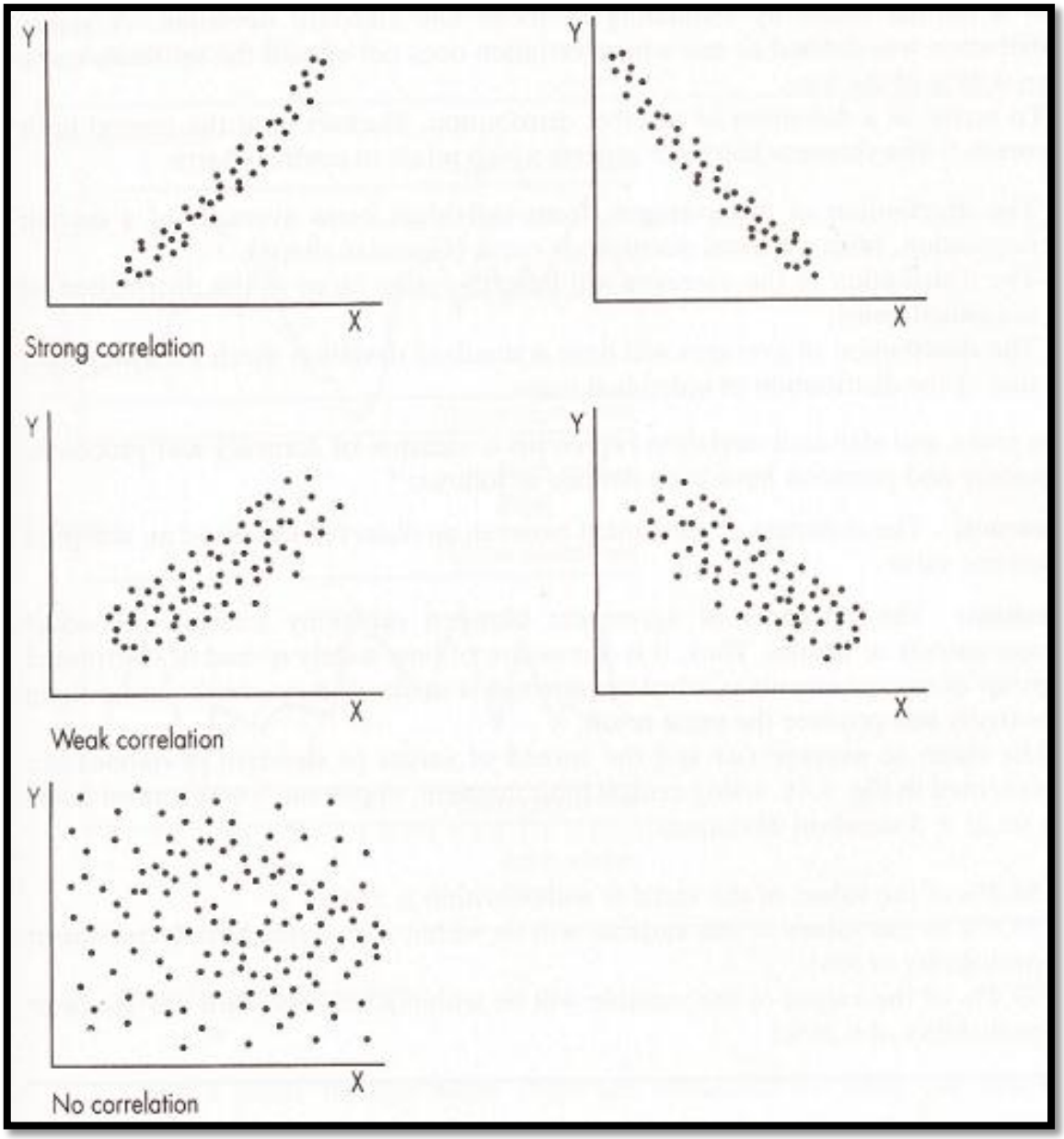

Figure 2.8: Correlation of Scatter Diagram

Source: Amitava (2008)

Figure 2.8 stated that strong correlation for variable X and variable Y will showed pack scatter plot. When the scatter plot is further away from each other, the correlation between two variables will become weaker.

2.12 Control Charts

Control charts were introduced in 1926 by Walter Shewart who concluded that a distribution can be transformed into a normal shape by estimating its mean and standard deviation (Amitava, 2008). Control chart is perhaps the most widely used of the "seven basic quality control tools" (Jafri and Chan, 2001). It is the key tool because it displays process behavior graphically and it is used to monitor and control processes within the specified control limits (Bisgaard, 1993). Control charts also can help improve data quality, which add values to a data base. This approach can also help to assure that a data base does not have major inadequacies in data quality (Carl and Jyoti, 1999).

Basically, control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By analyze the data, conclusion can be made whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation). (Nancy, 2004)

2.12.1 When to use Control Chart

Basically, control chart is use for controlling ongoing processes by finding and correcting problems as they occur. However, it also can be use for predicting the expected range of outcomes from a process. Besides that, it can determine whether a process is stable (in statistical control). By applying control chart, patterns of process variation from special causes (non-routine events) or common causes (built into the process) can be analyzed. The last and the most important of control chart are to determine whether the quality improvement project should aim to prevent specific problems or to make fundamental changes to the process. (Foster, 2001)

2.12.2 Control Chart Procedure

First, choose the appropriate control chart for the related data. Determine the appropriate time period for collecting and plotting data. Collect data and construct the chart and analyze the data.

Look for "out-of-control signals" on the control chart. When one is identified, mark it on the chart and investigate the cause. Document how you investigated, what you learned, the cause and how it was corrected.

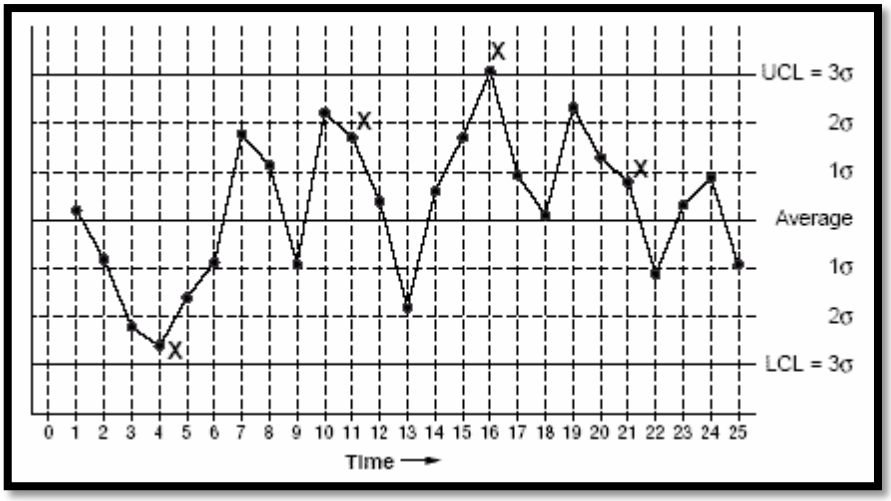

Figure 2.9: Example of Control Chart and Out of control signal

Source: Nancy (2004)

From Figure 2.9, it is clearly stated that point sixteen (16) is above the UCL (upper control limit). 4 point is between 2 σ and 1 σ and 8 points are above 1 σ but below 2 σ. There are 12 points is inside the average area.

Hence, obvious consistent or persistent patterns of the control charts show that something unusual about the data and the process. (Nancy, 2004)

2.13 Previous Case Study

Paliska et al., (2007) and his friends in journal titled *Quality tools – Systematic use in Process Industry***.** This paper dealing with one segment of broader research of universality systematic in application of 7 basic quality tools (7 QC tools). This research has shown that there is possibility of systematic application of the entire 7 QC tools in the frame of companies overall quality management system. The research has also shown that 7 QC tools are not so wide spread as expected, although they are quite simple for application and easy to interpret. Further investigation should be carried out in order to find reason for such condition, and, in accordance, to define appropriate corrective actions to eliminate or minimize the problem.

Winco, (1996) in journal titled *An Integrated Model for Manufacturing Process Improvement* presents a case study in which a local Printed Circuit Board (PCB) fabrication company employs very simple techniques such as Statistical Process Control (SPC) and seven basic tools to significantly improve both product and process quality and productivity. At the same time, it verified the intimate relationship between SPC, 7 basic tools, KAIZEN and Total Quality Management (TQM) principles should be integrated in practice.

Pierchala and Jyoti Surti, (1999) in a technical report titled *Control Charts as a Tool in Data Quality Improvement* discuss about control charts can usefully be applied to data quality. Besides, it is a tool to identify data elements that appear to need investigation in terms of the possible existence of data quality problem. Control charts helps to identify "just don't look right" data elements. In conclusion, control charts were found useful as an aid in the improvement and quality assurance.

Jafri and Chan, (2001) in a journal titled *Improving Quality with Basic Statistical Process Control (SPC) Tools: A Case Study* presents a case study in which a local plastic injection molding company deployed some part of the 7 basic QC Tools to significantly improve the monthly defect quality from 13.49% to 7.4%. Only check sheets, pareto chart, cause and effect diagram and control chart were used in this study

to meet the objectives of the study. In summary, 7 basic QC tools provide a very valuable and cost effective way to improve quality.

Shaik et al., (2004) and friends in a journal titled *A Plastic Injection Molding Process Characterization using experimental design technique: A Case Study* illustrates an application of design of experimental (DOE) approach in an industrial setting for identifying the critical factors affecting a plastic injection molding process of a certain component for air-conditional assembly. Analysis of variance (ANOVA), regression analysis, histogram, pareto chart and cause and effect diagram, MINITAB were used in this study to meet the objective of the study.

Naser, (2007) in journal titled *Application of quality tools by the Saudi food industry* examine the application of the quality tools in the production setups of this industry and to explore signs of Total Quality Management (TQM) to evaluate its competitiveness. Histogram, scatter plot and pie chart were the only tools use to investigate in order to meet the objective of the study.

Gunasekaran et al., (2000) and friends in journal titled *Improving operations performance in a small company: a case study* mainly study on small and medium enterprises (SME). Continuous improvement and a related conceptual model are discussed to highlight how productivity can be improved with limited sources. Most of the SME Company applied JIT or KANBAN and TQM tools for their productivity improvement. Flowchart, cause and effect diagram, and pareto analysis were used to determine why operators cannot reach the targets set after measuring the cycle time.

Eldin, (2009) in journal titled *Monitoring and controlling design process using control charts and process sigma*. This paper is to establish a means to control the design process in engineering organization that produce engineering deliverables for construction projects. The intended control is to deliver construction packages on time and within budget while controlling productivity of engineers and support staff involved in the design process. Control chart have been used to monitor design progress and for auditing business processes, process adjustments and to alert for action to rectify a schedule risk. Project six-sigma has also improved as project progress advances; from

0.92 to 10% project phase to 1.74 at 90% project completion. As conclusion, control charts helps in auditing business process, rectify a schedule or overrun risk.

Weller, (2000) in journal titled *School attendance problems:using the TQM tools to identify root causes* presents a model for principles to apply to provide quality outcomes, and applying the problem-solving tools and techniques of TQM to identify root problem causes, principals can identify realistic solutions which yield positive results and reduce costs in academic and nonacademic areas. Taguchi's, brainstorming, cause and effect diagrams, pareto charts, graph and check sheet were use to achieve the objective of the study.

Vassilakis and Besseris., (2009) in journal titled *Methodology and Theory: An application of TQM tools at a maintenance division of a large aerospace company* devoted to a description and evaluation of a selected maintenance process (assembly) at the aero-engines maintenance unit of a large aerospace company by implementation of TQM tools. Statistical process control (SPC) and cause and effect diagram is the main tools that implied in this studied.

Table 2.2: Summary of previous case study

Author(s) / Years	Descriptions	Conclusion
G. Paliska, D. Pavletic, and M. Sokovic. (2007)	Research of universality systematic in application of seven basic quality tools (7 QC tools).	7 QC tools are not so wide spread as expected. It is quite simple for application and easy to interpret.
Winco, K. C. Y. (1996)	Improve both product and process quality and productivity at local Printed Circuit Board (PCB) fabrication company.	Statistical Process Control (SPC) and seven basic tools to significantly improve both product and process quality and productivity. At the same time, it verified the intimate relationship between SPC, 7 basic tools, KAIZEN and Total Quality Management (TQM) principles should be integrated in practice.
Carl E. Pierchala, and Jyoti Surti, B.S. (1999)	Identify data elements that appear to need investigation in terms of the possible existence of data quality problem.	Control charts were found useful as an aid in the improvement and quality assurance.
Jafri, M. R., and Chan, K. T. (2001)	Local plastic injection molding company deployed some part of the 7 basic QC Tools to significantly improve the monthly defect quality.	Check sheets, pareto chart, cause and effect diagram and control chart were used in this study to meet the objectives of the study. 7 basic QC tools provide a very valuable and cost effective way to improve quality.
Shaik M. M. Y., Jafri M.R., W. Harun W. H, and Edly R.. (2004)	Application of design of experimental (DOE) approach in an industrial setting for identifying the critical factors affecting a plastic injection molding process of a certain component for air-conditional assembly.	Analysis of variance (ANOVA), regression analysis, histogram, pareto chart and cause and effect diagram, MINITAP were used in this study to meet the objective of the study.

Table 2.2: Continued

Author(s) / Years	Descriptions	Conclusion
Naser A.A. (2007)	Examine the application of the quality tools in the production setups of this industry and explore signs of Total Quality Management (TQM) to evaluate its competitiveness.	Histogram, scatter plot and pie chart were the only tools use to investigate in order to meet the objective of the study.
A. Gunasekaran, L. Forker, and B. Kobu. (2000)	Study on small and medium enterprises (SME). Continuous improvement and a related conceptual model are discussed to highlight how productivity can be improved with limited sources.	Most of the SME Company applied JIT or KANBAN and TQM tools for their productivity improvement. Flowchart, ishikawa diagram, and pareto analysis were used to determine why operators cannot reach the targets set after measuring the cycle time.
S. Eldin A. H. (2009)	Establish a means to control the design process in engineering organization that produce engineering deliverables for construction projects.	As conclusion, control charts helps in auditing business process, rectify a schedule or overrun risk.
L. D. Weller. (2000)	Model for principles to apply to provide quality outcomes, and applying the problem-solving tools and techniques of TQM to identify root problem causes, principals can identify realistic solutions which yield positive results and reduce costs in academic and nonacademic areas.	Taguchi's, brainstorming, cause and effect diagrams, pareto charts, graph and check sheet were use to achieve the objective of the study.
E. Vassilakis and G. Besseris. (2009)	Evaluation of a selected maintenance process (assembly) at the aero-engines maintenance unit of a large aerospace company by implementation of TQM tools.	Statistical process control (SPC) and cause and effect diagram is the main tools that implied in this studied.

2.14 Summary

This chapter discussed each of 7QC tools. Each tool is clearly defined with definitions, a step-by step process and how the tool can be used. Although these tools are rather simple, however they are effective for analyzing many quality problems.

7QC tools can be used in all process phases, from the beginning of a product development up to management of a process, on day to day basis, in systematic manner. In modern production processes it is necessary to implement integrated quality management system that involves quality management, responsible environmental performance and safe working environment. In the frame of integrated management system quality tools can be much wider applied with certain success. Furthermore, systematic application of 7QC tools will enable successful quality improvement process. 7QC tools has important place in data collecting, analyzing, visualizing and making sound base for data founded decision making.

CHAPTER 3

COMPANY BACKGROUND

3.1 Company Profile

Namhwa Paper Industries (M) Sdn Bhd was incorporated in April 1993. It is a company in Boxes-Paper business. The company operates in Malaysia. Its registered address is No. 16, Jln Jaya Gading 2, Kaw MIEL Jaya Gading, 26070 Kuantan, Pahang. It is one of the most successful boxes-paper companies in Malaysia.

Figure 3.1: Logo of Namhwa Paper Industries (M) Sdn Bhd

3.2 Company Objectives

NamHwa Paper Industries (M) SDN. BHD. is committed to achieve and sustain a reputation for quality in the domestic and export markets. The company shall strive to satisfy the needs of its customer by supplying products of high quality consistently, to meet customer's requirements at competitive prices, and highly efficient after-sales services.

3.3 Company Policy

To ensure prompt delivery to reach customer's door step in accordance to their Schedule Advice as well as further service on the back-up checking on their requirement after delivery.

JIT (Just In Time) system is to build up company's business image in looking forward to s long-term business relationship with clients.

3.4 Quality Policy

NamHwa Paper Industries (M) SDN. BHD. dedicated to exceeding the expectations of internal and external customers with uncompromising integrity, committed to market and manufacture products and services at the highest standard of integrity and professionalism in the industry through Total Customer Satisfaction, provision of value added services to our esteem customer, building a strong organization team to meet or exceed customer's expectations, and continual improve and maintain the effectiveness of Quality Management System.

3.5 Company Working Hour Schedule

Table 3.1: NamHwa Paper Industries (M) SDN. BHD. Working Hour

Working Hour	Break/ Rest Time
8:00 A.M. – 5:30 P.M.	10:00 A.M. – 10:15 A.M. 1:00 P.M. – 2:00 P.M. 3:45 P.M. – 4:00 P.M.

Source: NamHwa Paper Industries (M) SDN. BHD.

NamHwa Paper Industries (M) SDN. BHD. operates from Monday to Saturday. Only Sunday is closed for resting. There are only 8 days of Public Holiday that will be closed in a year.

3.6 Company Products

Namhwa Paper Industries (M) Sdn Bhd specialized in manufactured corrugated paper carton, laminated carton, die cut boxes, display boxes, paper skid, partition, paper pallet, product of Aluminium foil paper, layer pad, and others paper-related products. Figure 3.2 showed the example of the company products.

Figure 3.2: Products of Namhwa Paper Industries (M) Sdn Bhd

Source: NamHwa Paper Industries (M) SDN. BHD.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter provides a review of the methodology in conducting this study for two semesters. Starting with the design of the study, where the methodology in performing this study was reviewed. Framework of the study in the other hand reviewed the planning suggested in conducting the study.

4.2 Design of the Study

The first step in this study was confirmation of the title. After confirmed case study titles, a discussion with supervisor for consultation time was made. This case study proceeds with identifying the problem statement and objectives of the study followed by identified scope of study.

Before the project is conducted, a preliminary research on previous existing cases which is similar and related to this study should be done. All information's were gathered, so that it will give a clear view in order to understand the basic concept regarding to the title. All the related and useful information gained through reading journals, books and so on will be used in the future for the analysis part. Generally, there were about ten journals were discussed. This study mainly focused on 7 Quality Tools, which included Pareto Diagram, Cause and Effect Diagram, Check Sheets, Flow Chart, Scatter Diagram, Histogram and Control Charts.

The most important source for this study is the industrial or company. The industry that will be select is limited to company with production or machining lines. Any industrial in Malaysia with production or machining line will be targeted but the priority will be industrial that situated around Kuantan. Apply letter for visiting the targeted industrial was collected from the faculty before visit the company. The company that had been chosen for this project is Namhwa Paper Industries (M) Sdn Bhd.

Then, this study proceeded with the methodology of the study. In this section, the design of the study and methodology of data collection for this study was reviewed and discussed generally. After that, the data were collected from the selected company and conclusion for the whole first semester and planning for the second semester of the study were made.

For second semester, solutions and cost consumptions were generated in order to improve the productivity of the company. Best solution was chosen and suggests to the company but depend on the company whether they wanted to apply or not.

The next steps of this study were writing abstract and construct table contents, list of tables, references and appendices. The reports were than edited according to the format given. Lastly, conclusion and recommendation were made base on the objective of the study.

4.3 Design of the Study Flow Chart

In order to accomplish the objectives of this project, a design of the study flowchart has been created as shown in Figure 4.1. The flowchart is a guideline to make sure that the project run in schedule and successfully. Below is the combination flowchart for both Final Year Project (FYP) 1 and 2. FYP 1 was conducted from the beginning until analysis data while FYP 2 was conducted started from generate solution until the conclusion was made.

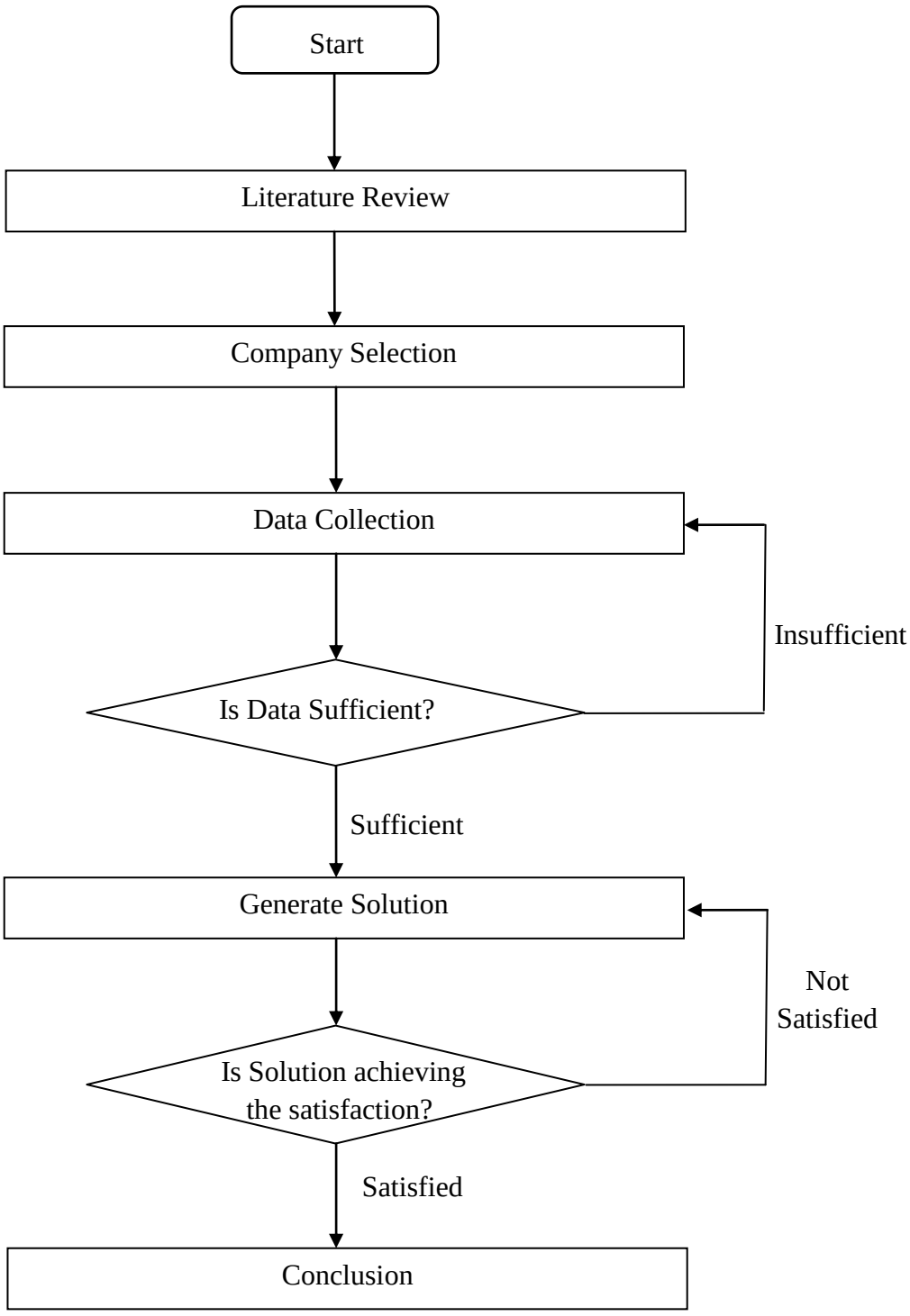

Figure 4.1: Flow Chart of Final Year Project (FYP)

4.4 Methodology of Data Collection

Before proceed to data collection at NamHwa Paper Industries (M) SDN. BHD., the production flow for the company and workstation at the company were clearly understand and identified by doing some interview with the supervisor and the workers of the company. Besides, observation of the company also need to take to account in order to know more about the product of the company and also the production flow lines of the company.

4.4.1 Workstation and Production Line

Basically, NamHwa Paper Industries (M) SDN. BHD. has 8 main workstations. The workstations are Slitter, Print, Slotter, Glue, Stitching, Partition, Die Cut and Tie. There are one machine each for Slitter, Print, Slotter and Die workstations, two machines for Stitching and three machines (2x 1040mm and 1x 1400mm) for Die Cut workstations. Only manual or hands on will be apply for partition and glue workstation.

The main products for this company are boxes. Various types of boxes can be produced to meet the customer demand. Different types of boxes will give different process flow but the flow is still the same, only for some product they might skip some of the workstations. Figure 4.2 shows the product process flow for Namhwa Paper Industries (M) Sdn Bhd.

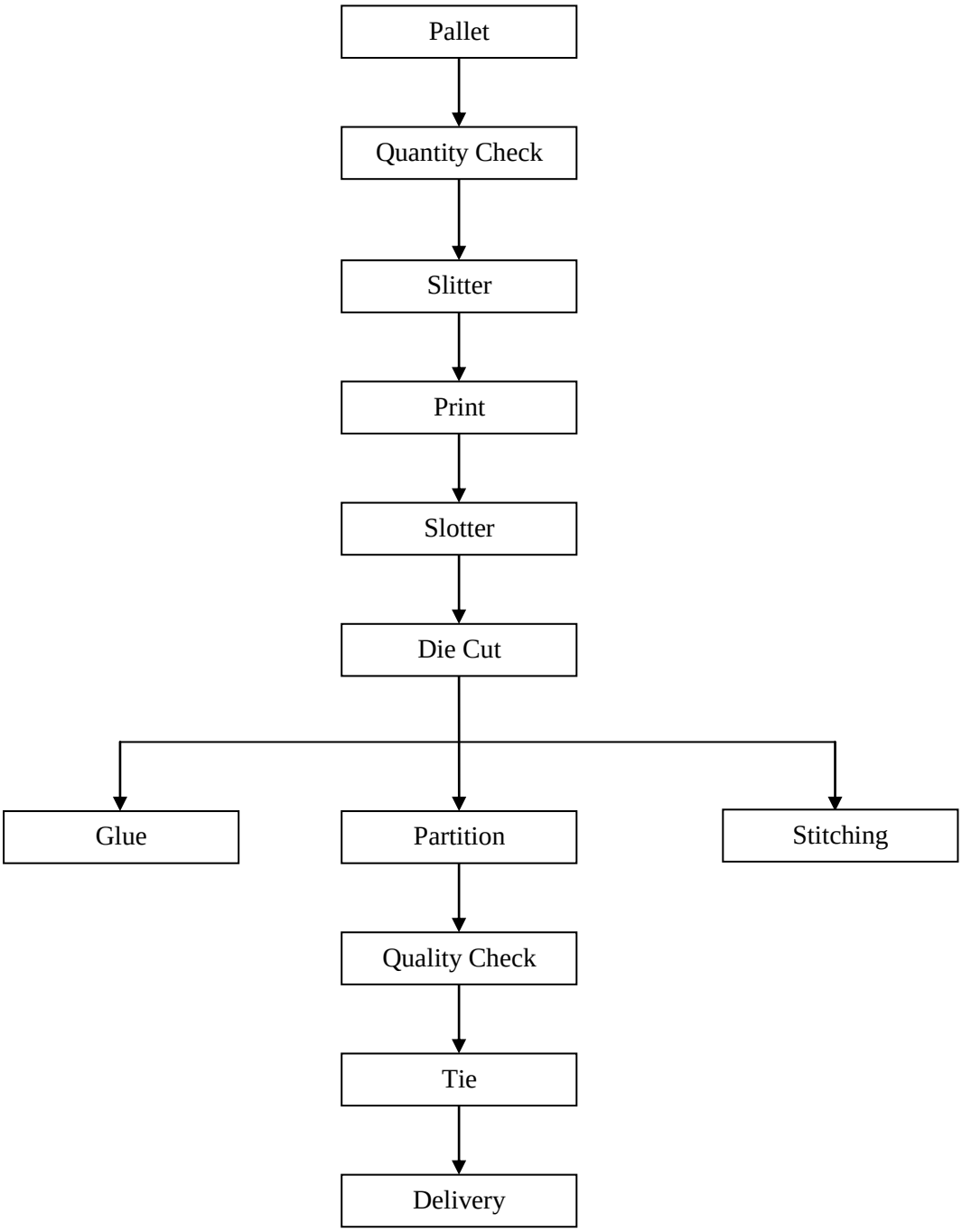

Figure 4.2: Product Process Flow

Source: Namhwa Paper Industries (M) Sdn Bhd

4.4.2 Data Collection

This is the most time consuming and most important of all the steps involved. Relevant information is gathered regarding to the system that is studied. There are various ways to collect data. Figure 4.3 shows the flow chart for data collection.

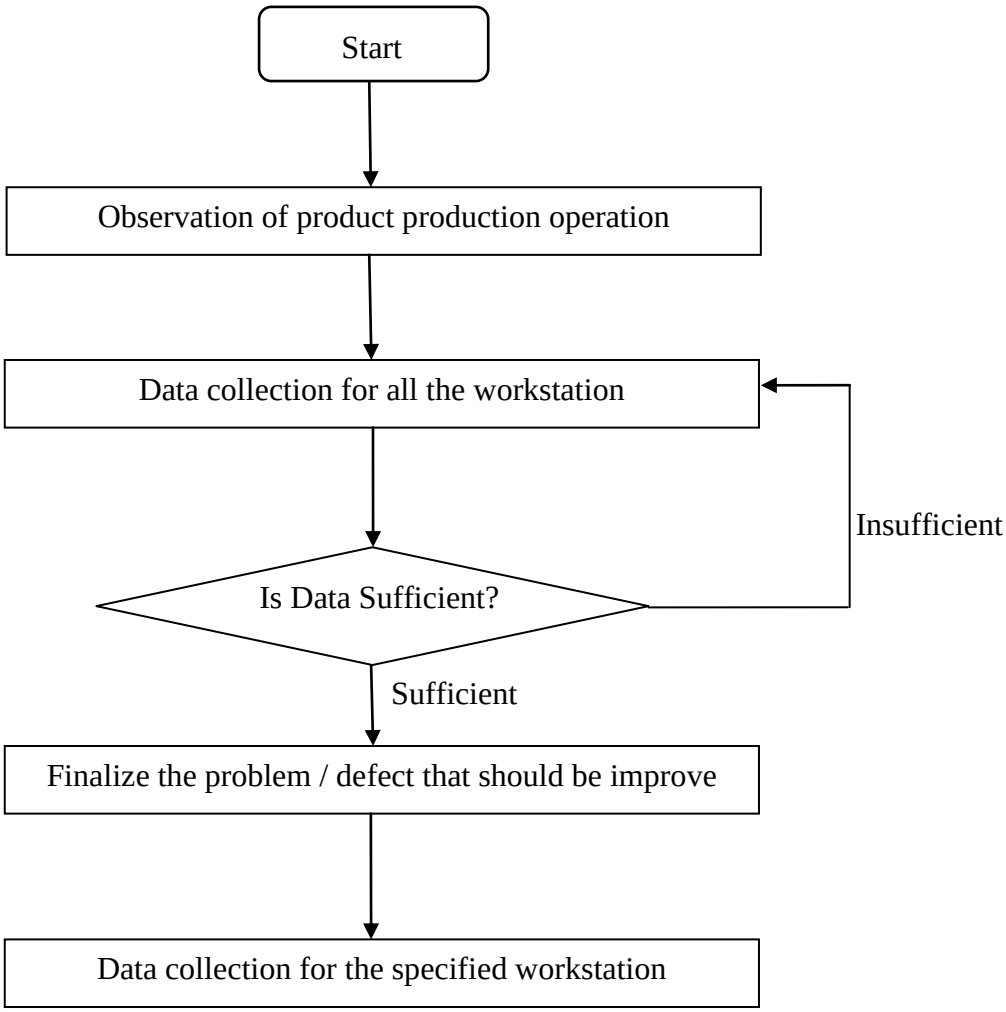

Figure 4.3: Flow chart for data collection

4.4.3 How to Collect Data

First of all, observations for the whole process of the production line for the selected industrial are done for the better understanding of the production process. Observation and interview with the workers and supervisor were carried out to get ideas which workstation has a lot of defects. Since the production line only consists of 8 workstations; hence data collection on every workstation can be made. The main tool for collecting data is Check Sheet. Once there are defect occurs, marking on the frequency need to be make. One check sheet is only use for collect defect that occurs in 5 pallets where 1 pallet is equal to 350 pieces. Figure 4.4 shows the example of check sheet that been use for collect defect frequency.

Defect	Pallet					Frequency
	1st	2nd	3rd	4th	5th	
Glue						
Partition						
Stitching						
Slitter						
Print						
Slotter						
Die Cut						
Tie						

Figure 4.4: Example Check Sheet for Determine Defect

4.4.4 Data Analysis

There are many ways to analyze data. The most common engineering tools which can be utilized for this purpose would be 7 Quality Control Tools as this method would often be simple, but yet efficient. The tools are check sheet, Pareto chart, flow chart, cause and effect diagram, histogram, scatter diagram and control charts. However, only four tools will be used for this project studied. They are check sheet, pareto chart, flow chart, and cause and effect diagram.

When the data needed are collect, it was than arrange from the highest to the lowest frequency in cumulative table as shown in Figure 4.5.

Causes	Frequency	Relative %	Cumulative Frequency	Cumulative Frequency %

Figure 4.5: Example of cumulative table

Based on the Pareto chart, defect with the highest frequency can be identified. Hence, brainstorming need to be done to build the cause and effect diagram as detailed as possible be causes in each of the broad areas where the causes are Methods, Machines, Manpower and Materials. Each cause identified should be looked upon for further more specific causes. View the cause and effect diagram and evaluate the main causes and generate solution base on the main causes. Any solution can be accepted as long as can improve the productivity of the industrial. The solution can be either own design ideas or any other related ideas from books, journal or research.

After generated solution, discussion and evaluation were made follow by the comparison between old and new productivity to prove the new ideas improved in term of productivity and efficiency. However, the implementation of the new idea is depending on the company/industrial whether they wanted to imply or not. Lastly, best solution was chosen and conclusion was made.

4.5 Summary

This chapter is a guideline to carry out the project so that the project can run in schedule and smoothly. Observation and interview with the workers and supervisor has been done. Frequency of defect occurs on every workstation had been collect into the specific check sheet too. From the check sheet, a Pareto chart can be build. Thus a defect with the highest frequency can clearly identify and further improvement on the particular workstation can be made and hence improve the productivity of the company.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 Introduction

The production line involved in this study is manually operated. Starting from a 1040 mm paper, it than being produce to become a paper box. This sample is the most common and simple model. This particular model is always running in daily operations alongside with other models. Thus improvement process base on this model and become the benchmark for others product.

Additionally, the 1040 mm paper has the highest demand from the company. Hence, it contributes more in determining the output volume of whole production in this company. Therefore by checking this model, the company productivity improve and indirectly bring effects to the company profit margins.

As mentioned in the objectives, this project must implement industrial engineering tools and propose new methods to improve company productivity. The chosen industrial engineering tool is 7 Quality Control tools and only relevant tools will be use. To make the project runs smoothly, data in each workstation will be collected and interpreted. Related tools were chosen for analyzed the defect and thus improve company production by using own knowledge and the reviews on journal, article and book.

5.2 Company Layout

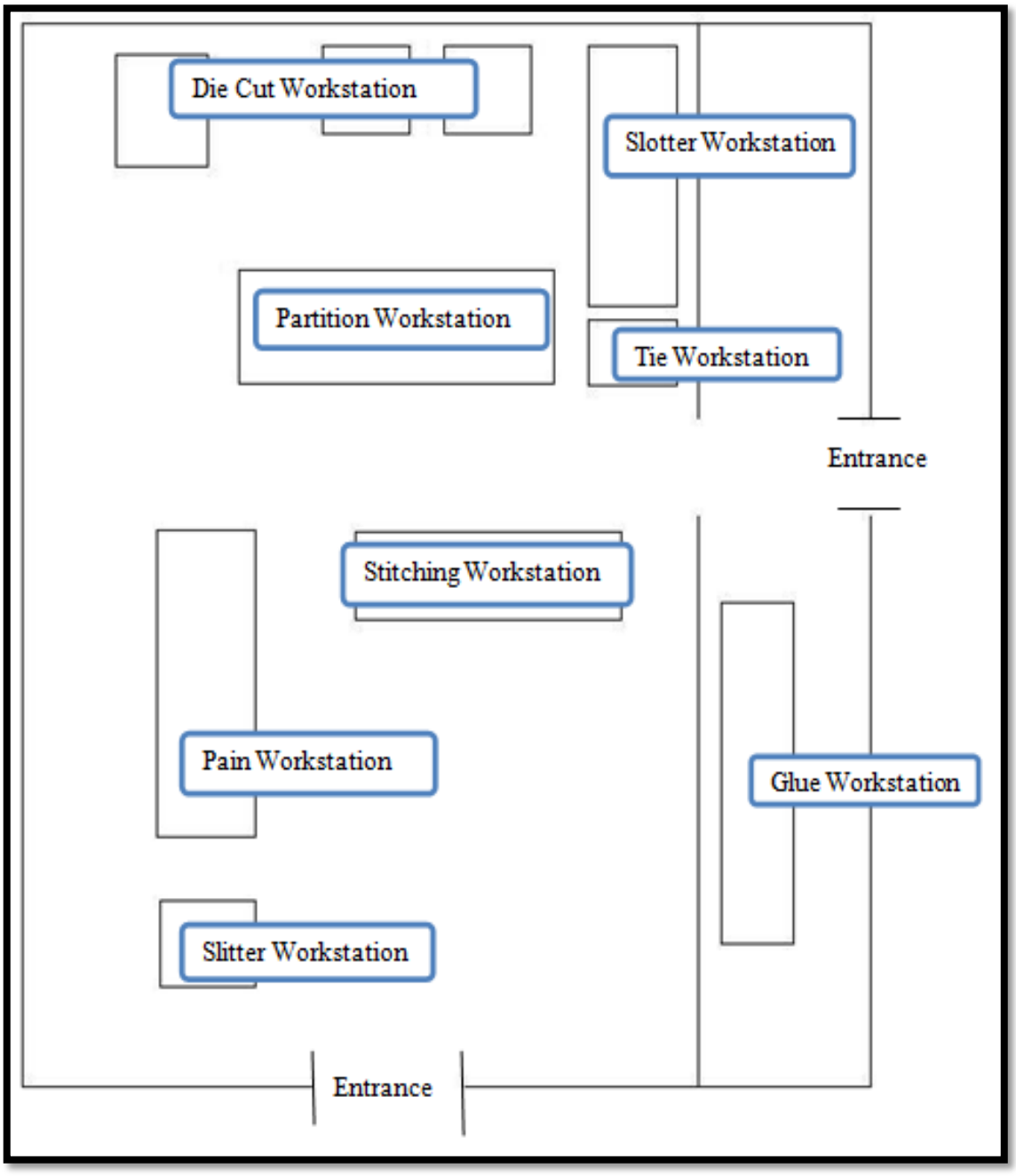

Figure 5.1: NamHwa Paper Industries (M) SDN. BHD. Factory Layout

From Figure 5.1, NamHwa Paper Industries (M) SDN. BHD. has 8 main workstations. The workstations are Slitter (bottom left of the company), Print (in front of the slitter workstation), Slotter (top right of the company), Glue (most right hand side), Stitching (at the middle of the company), Partition (beside tie workstation), Die Cut and Tie (bottom of the slotter workstation). There is only1 machine each for Slitter, Print, Slotter and Die workstations, 2 machines for Stitching and 3 machines (2x 1040mm and 1x 1400mm) for Die Cut workstations. The 1400mm is situated at the most left hand sided and another two 1040mm is situated in front of the partition workstations. As mentioned before, partition and glue workstations are manual workstation where the entire product will be produce by using man power.

There are no conveyer belts or robotic arms to transfer the product to each station. Products being transferred by using fort lift in a quantity of 1 pallet (350 pieces) for each time. Products have been processed kept around the workstation. Final products will be sealed by using polystyrene and kept in the most upper left of the company and also at the free space beside the partition workstation.

5.3 Company Machines

Figure 5.2 to Figure 5.9 shows the company machines at each workstation. Figure 5.10 is the Forklift that being used to transfer the products to each workstation.

Figure 5.2: Slitter Machine

Figure 5.3: Print Machine

Figure 5.4: Slotter Machine

Figure 5.5: Die Cut Machine

Figure 5.6: Stitching Machine

Figure 5.7: Tie Machine

Figure 5.8: Partition (Manual)

Figure 5.9: Glue (Manual)

Figure 5.10: Forklift

5.4 Problem Identification

Observation and data collection were done to identify problem that might occur. Table 5.1 shows the data collection at each workstation.

Table 5.1: Check sheet for data collection at each workstation for 5 pallets

Defect	Pallet					Frequency
	1st	2nd	3rd	4th	5th	
Glue	////	///	~~////~~	~~////~~	~~////~~ /	23
Partition	//		/	/	//	6
Stitching		//		/		3
Slitter		//	/		////	7
Print	/				/	2
Slotter				//		2
Die Cut	/		/		//	4
Tie		/	/		/	3

Table 5.1 shows that glue workstation has the highest frequency of defect which is 23 defect follow by slitter and partition workstations with 7 and 6 defects respectively. Die cut workstation has 4 defects while tie and stitching has 4 defects each. Print and slotter workstation has lowest defect with 2 defects each.

Based on the check sheet result, Pareto chart can be build. A new table is design to make the things easier for the construction of Pareto chart. Table 5.2 shows the data for Pareto chart and Figure 5.11 is the Pareto Chart for the defect that occurs in each workstation.

Table 5.2: Data for Pareto Chart

Causes	Frequency	Relative %	Cumulative Frequency	Cumulative Frequency %
Glue	23	46	23	46
Slitter	7	14	30	60
Partition	6	12	36	72
Die Cut	4	8	40	80
Stitching	3	6	43	86
Tie	3	6	46	92
Slotter	2	4	48	96
Print	2	4	50	100

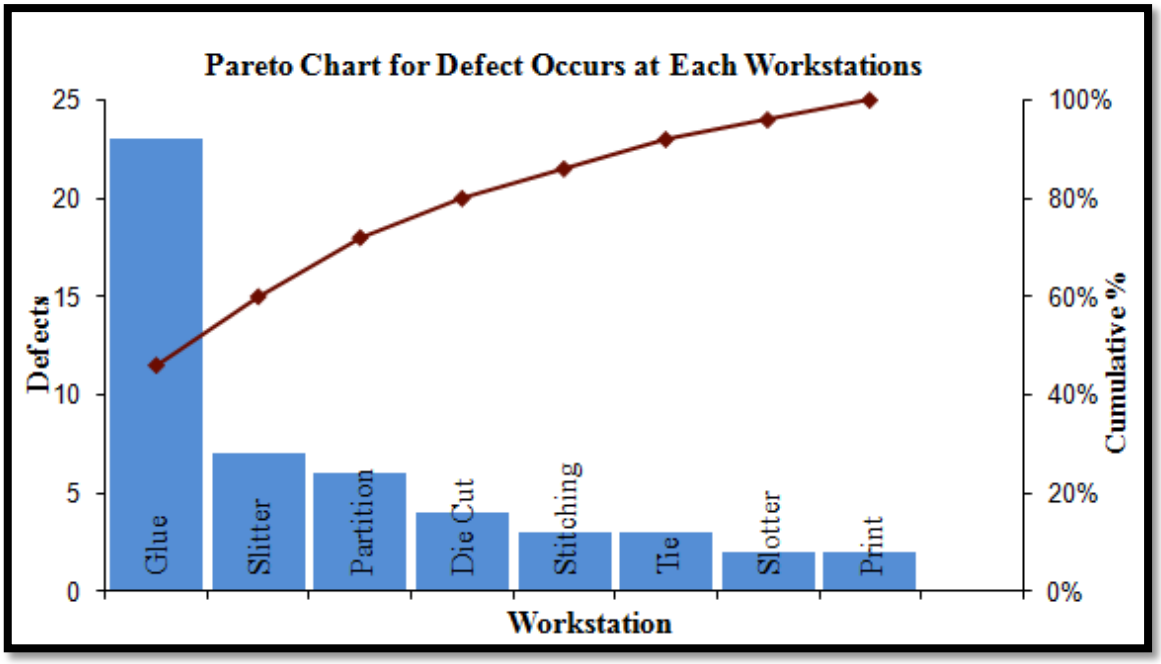

Figure 5.11: Pareto Chart for defect occurs at each workstation

From Table 5.2 and Figure 5.11, it showed that glue workstation has highest frequency of defect with 23 defects which stand 46% of the defects that occurs on the whole process. Slitter and partition workstation has 14% and 12% each while die cut has 8% of overall defect. Stitching and tie shared 6% each of defect. Slotter and print workstations has lowest defect which is 4% of defect respectively. It is obvious that glue workstation has the highest defect which can cause the company sometime can't

meet the demand of the customer. The company productivity drop due to the error occurs in glue workstation. Hence improvement should be done on glue workstation.

5.5 The Original Process at Glue Workstation

As mentioned earlier, glue workstation is workstations that operate manually which mean the glue workstation glue the paper box by the operator himself. There are none any machine involve in this machine. Operator used their own hands to glue the 1040 mm paper.

At glue workstation, completed 1040 mm paper is transferred to glue work station by fort lift and is divided to few pieces in a group as shown in Figure 5.12.

Figure 5.12: Example of ready 1040 mm paper before Glue

Glue is prepared and poured into the container as shown in Figure 5.13. Meanwhile, the ready 1040mm paper is then arranged in quantity of fifteen in a time. Big rounded brush is used to stick the glue onto the 1040mm paper and the 1040mm paper with glue is show in Figure 5.14.

Figure 5.13: Glue and the big rounded brush are ready in the container.

Figure 5.14: 1040mm paper stacked in 15 pieces and being glue

The 1040 mm paper is folded and glue to become a paper box. The paper box is then stacked up as shown in Figure 5.15. Lastly, the paper box is transferred to the tie workstation to tie it.

Figure 5.15: Ready paper box being stacked up

5.6 Problem / Defects at Glue Workstation

Based on the interview with the stuff and supervisor, problems that occurred at the glue workstation is after the paper box is glue and stacked together, the glue not in time to dry and this causes the paper box stacked together.

Another defect is due to the carelessness or lack of skill of operator during glue up the 1040 mm paper to become paper box and cause the paper box can’t get the correct dimension or shape that the customer need.

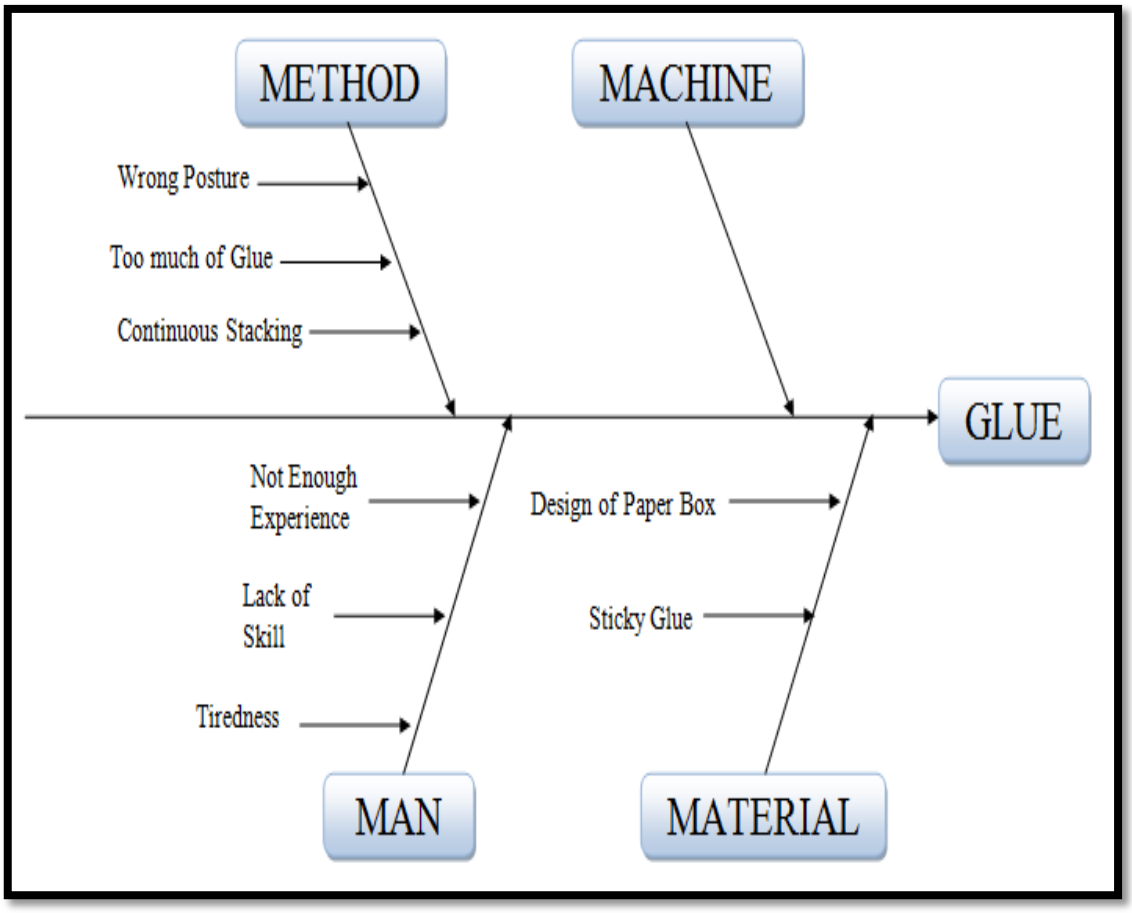

Figure 5.16: Cause and Effect Diagram of Glue Workstation

Figure 5.16 shows that the defect occurs at the glue workstation are only due to Method, Man and Material. There is no problem for machine due to the glue workstation didn't use any machine and only work by using human power. Wrong standing posture, too much of glue used and the continuous stacking are the wrong method that being used by the operator to cause the defect occurs. Some of the defect occurs at the glue workstation due to the new hired operator not enough experience or lack of skills and tiredness. Material used for glue workstation is glue and paper box. Both also caused the defect occurred. The design of the paper box is not so good while the glue that being used is too sticky.

5.7 Suggestion of Solutions

The solutions that being made is based on the defect occurred at the glue workstation. Instead of suggest opinions, the solution must improve the productivity of the company. The solutions also need to suit the company and the workers.

There are three suggestions that can suit the company and improve the productivity of NamHwa Paper Industries (M) SDN. BHD. They are divided the glue paper box into few group before stacking up, use electric fan or airy place for glue workstation, and use table lamp or hair dryer.

5.7.1 Divide the Glue Paper Box into Few Groups

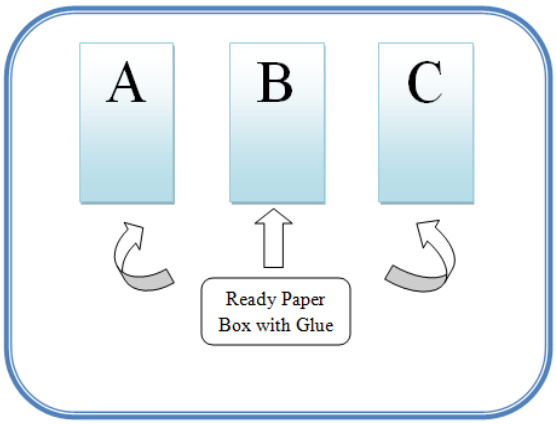

Figure 5.17: Solution concept for first solution

Previously, the defects occurs on glue workstation due to the glue linkage not in time to dry and the operator straight away stacked the paper box on top of it and cause the new paper box to paste together. Hence the alternative way to solve this problem is don't stacked the already glue paper box together but divide it into a few group as shown in Figure 5.17. For an example, when the paper box is glued, the 1st paper box put at the slot A while the 2nd paper box put at slot B and the 3rd paper box placed at the C slot. Hence, the paper box got more time to expose to the air and the possibility to dry is much higher than just place the paper box at a place in a time.

5.7.2 Use Electric Fan or Airy Place

Standing fan can be used and put in front of the paper box after it is glue. By switching on the fan, the wind that blows to the paper box can let the glue dry. There are same concepts applied when the glue workstation is situated at an open air where the natural wind will blow and cause the glue dry. However, there is a concern where the wind that blows might be too strong and blow away the paper box. Hence, another weight need to place on top of the paper box to make sure it will not fly away. There are two types of fan that can be used whether table fan or the standing fan as shown in Figure 5.18.

Figure 5.18: Example of table fan (left) and standing fan (right)

5.7.3 Use Table Lamp or Hair Dryer

Small table lamp and hair dryer can be use to dry the extra glue too. The concept of heat transfer is applied where the heat of lamp or the hair dryer to the glue and make the extra glue on the paper box dry. Paper box can be place under the lamp or use hair dryer and blow it for around 30 second before stacked the paper box together. However, the table lamp that can be used is limited to the table lamp with long bulb. This is because the round bulb can only heat a small portion of the paper box while long bulb can heat longer portion of the paper box and safe the time of production. Figure 5.19 shows the example of table lamp and hair dryer.

Figure 5.19: Example of table lamp and hair dryer

5.8 Estimated Operation Cost

Costing Assumption:

$$Labor\ cost\ per\ month = RM700$$

$$Working\ day\ per\ week = 6\ days$$

$$Working\ hours\ per\ day = 8\ hours$$

$$Total\ working\ hour\ per\ month = 208\ hours$$

$$Average\ time\ usage\ at\ glue\ workstation\ for\ 15\ pieces = 45\ seconds$$

$$1\ pieces\ of\ paper\ bos\ time\ usage = \frac{45\ seconds}{15\ pieces}$$
$$= 3\frac{seconds}{piece}$$

$$1\ hour\ paper\ box\ production\ = \frac{\frac{60\ minutes}{1\ hour} \times \frac{60\ seconds}{1\ minute}}{\frac{3\ seconds}{1\ piece}}$$
$$= 1200\frac{pieces}{hour}$$

Table 5.3: Cost for original process at glue workstation

Cost Element	Rate per Month (RM)	Total Hours per Month	Cost per Hour (RM)
Operators	700	208	3.3653
Glue (10 little)	3 bottle	39.90 / bottle	0.5755
		TOTAL	**3.9408**

Based on Table 5.3, the total cost to produce paper box per hour is RM 3.9408. Brush is used in the glue workstation. However, the lifetime and usage of brush is very long and only being change twice a year, hence the cost of the brush can be neglected.

5.8.1 Example Calculation for Table 5.3

$$Labor\ cost\ per\ hour = \frac{RM\ 700}{208\ hours}$$
$$= RM\ 3.3653$$

$$Glue\ Cost\ per\ Hour = \frac{RM\ 39.90\ \times\ 3}{\frac{208\ hours}{1 month}}$$
$$= RM\ 0.5755$$

$$Total = RM\ 3.3653 + RM 0.5755$$
$$= RM\ 3.9408$$

Table 5.4: Additional cost for process at glue workstation

Cost Element	Rate per Month (RM)	Total Hours per Month	Cost per Hour (RM)
Table Lamp 2 Lamp (25watt)	2.7664	208	**0.0133**
Normal Fan (200 watt)	11.0656	208	**0.0532**
Standing Fan (250 watt)	13.8320	208	**0.0665**
Hair Dryer (1000 watt)	55.3280	208	**0.2660**

From Table 5.4, it show that table lamp will has the lowest additional charge to the glue station which is RM 0.0133 per hour follow by normal fan RM 0.0532 per hour and standing fan RM 0.0665 per hour. Highest additional cost will be hair dryer which cost RM 0.2660 per hour. The rate of cost per hour is controlled by the wattage of the items. The higher the wattage consumed, the more cost per hour will be.

5.8.2 Example Calculation for Table 5.4 (Normal Fan 200 watt)

$$Power\ rating\ for\ a\ normal\ fan\ =\ 200\ w \text{ or } 0.2\ kw$$

$$Days\ of\ a\ normal\ fan\ operation\ per\ week = 6\ days$$

$$Total\ hours\ of\ a\ normal\ fan\ operation\ per\ month = 208\ hours$$

$$Total\ power\ consumption\ of\ a\ normal\ fan\ per\ month = 41.6\ kwh$$

According to the pricing tariff for medium voltage general industry from Tenage Nasional Berhad (TNB), the rate is 26.6 cent/ kwh.

$$Total\ cost\ of\ a\ normal\ fan\ per\ month = 41.6\ kwh\ \times 26.6\frac{sen}{kwh}$$

$$= 1106.56\ sen$$

$$= RM\ 11.0656$$

For table lamp, the total coast per month need to times with the quantity of lamp operate simultaneously. Since the table lamp used two 25watt simultaneously, hence the total cost need to times by 2 (50 watt).

5.9 Comparison of New and Old Solutions

Table 5.5: Frequency and defects at glue workstation for old and new solutions

Method	Frequency (5 Pallets)	Frequency (per month)	Defects per Month (RM)
Original	23	2990	255.2982
3 Table Lamp	17	2210	188.6986
Normal Fan	20	2600	221.9984
Standing Fan	18	2340	199.7986
3 Hair Dryer	1	130	11.0992

From Table 5.5, it showed that all of the new solutions improved the productivity of the company. Obviously, by attached hair dryer to the glue workstation, the defects can be reduced the most followed by table lamp, normal fan and standing fan. Hence, all the solutions can be used in term of improving the productivity of the company.

5.9.1 Example Calculation for Table 5.5 (Original)

$$Frequency\ (per\ month) = \frac{Frequency}{5\ pallets} \times \frac{25\ pallet}{day} \times 26 \text{ working days}$$
$$= \frac{23}{5\ pallets} \times \frac{25\ pallet}{day} \times 26 \text{ working days}$$
$$= 2990\ defects$$

$$From\ estimated\ operation\ cost\ at\ page\ 50,$$
$$1200\ pieces\ of\ paper\ box\ are\ produced\ per\ hour.$$
$$There\ are\ 8\ hours\ of\ working\ hours\ per\ days.$$

$$Hence\ 1\ days = 1200 \times 8$$
$$= 9600\ pieces\ per\ day$$

$$Defects\ per\ Month\ (RM)$$
$$= \frac{Frequency\ (per\ month)}{9600} \times \frac{Original\ cost}{hour} \times \frac{working\ hours}{day} \times \frac{Working\ days}{month}$$
$$= \frac{2990}{9600} \times \frac{RM\ 3.9408}{1\ hour} \times \frac{8\ working\ hours}{day} \times \frac{26\ Working\ days}{1\ month}$$
$$= RM255.2982$$

For Table Lamp and Hair Dryer, the defects per month needs to times with the quantity of the table lamp and hair dryer apply. For this case, 3 table lamps and 3 hair dryers is used.

Table 5.6: Extra cost and cost reduction at glue workstation for old and new solution

Method	Extra Cost per Month (RM)	Total Cost (RM)	Cost Reduction (RM)
Original	0	255.2982	**0**
3 Table Lamp	8.2992	196.9978	**58.3004**
Normal Fan	11.0656	233.0640	**22.2342**
Standing Fan	13.832	213.6306	**41.6676**
3 Hair Dryer	165.984	177.0832	**78.2150**

Based on Table 5.6, it showed that there are cost reductions after imply the new solution for the glue workstation and in directly all the solution can be used. However, by using hair dryer, the cost reduction is much higher than other solutions. It can reduce around RM 78.2192 every month compared to the original workstation. Hence hair dryer is the most effective and best solutions.

5.9.2 Example Calculation for Table 5.6 (Normal Fan)

$$Extra\ Cost\ per\ Month\ (RM)$$
$$= \frac{RM\ 0.0532}{hours} \times \frac{8\ working\ hours}{day} \times \frac{26\ working\ days}{month}$$
$$= RM11.0656$$

$$Total\ Cost\ (RM) = Defects\ per\ Month\ (RM) + Extra\ Cost\ per\ Month\ (RM)$$
$$= RM221.9984 + RM11.0656$$
$$= RM233.0640$$

$$Cost\ Reduction\ (RM) = Total\ Cost\ (RM) for\ original - Total\ Cost\ (RM)$$
$$= RM255.2982 - RM233.0640$$
$$= RM\ 22.2342$$

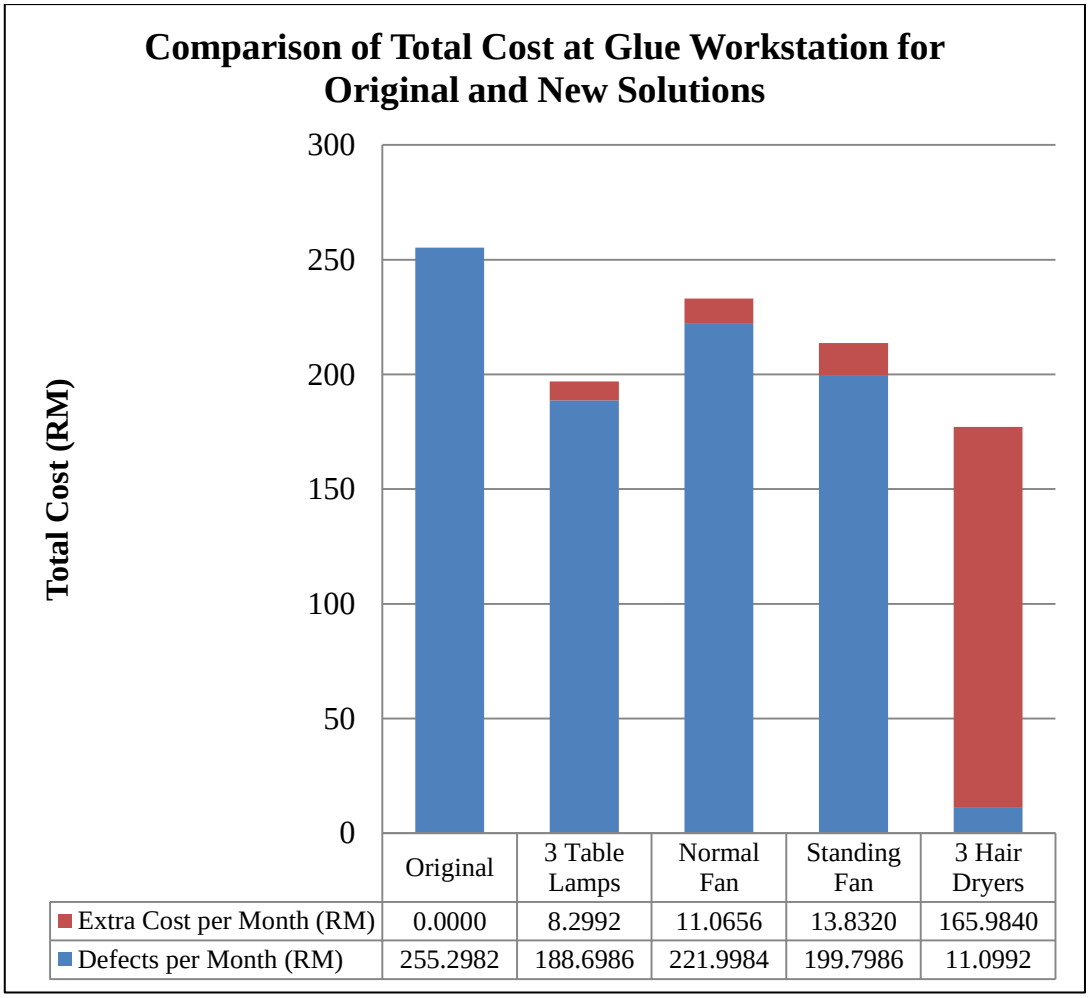

Figure 5.20: Comparison of total cost at glue workstation for original and new solutions

Based on Figure 5.20, it showed that each solution reduces the number of defects occur at the glue workstation and in-directly improved the productivity of the company (Blue). Hair dryer showed highest additional cost for glue workstation due to the high wattage and high electric consumption (Red). However, hair dryer almost reduced all defects that occurred at the glue workstation. The total height of the chart indicated the total cost that will be used at glue workstation. Hence, hair dryer is chosen to improve the productivity of the company.

5.10 Final Solution

Based on Table 5.5, Table 5.6 and Figure 5.20, hair dryer obviously improve the productivity and also has lowest additional cost. Since the first solution concept of divided the paper box into few groups before stacking up does not consume of any extra budget, hence the first concept of the solution and hair dryer were combine for the final solution. The final concept of the solution was shown as Figure 5.21 below.

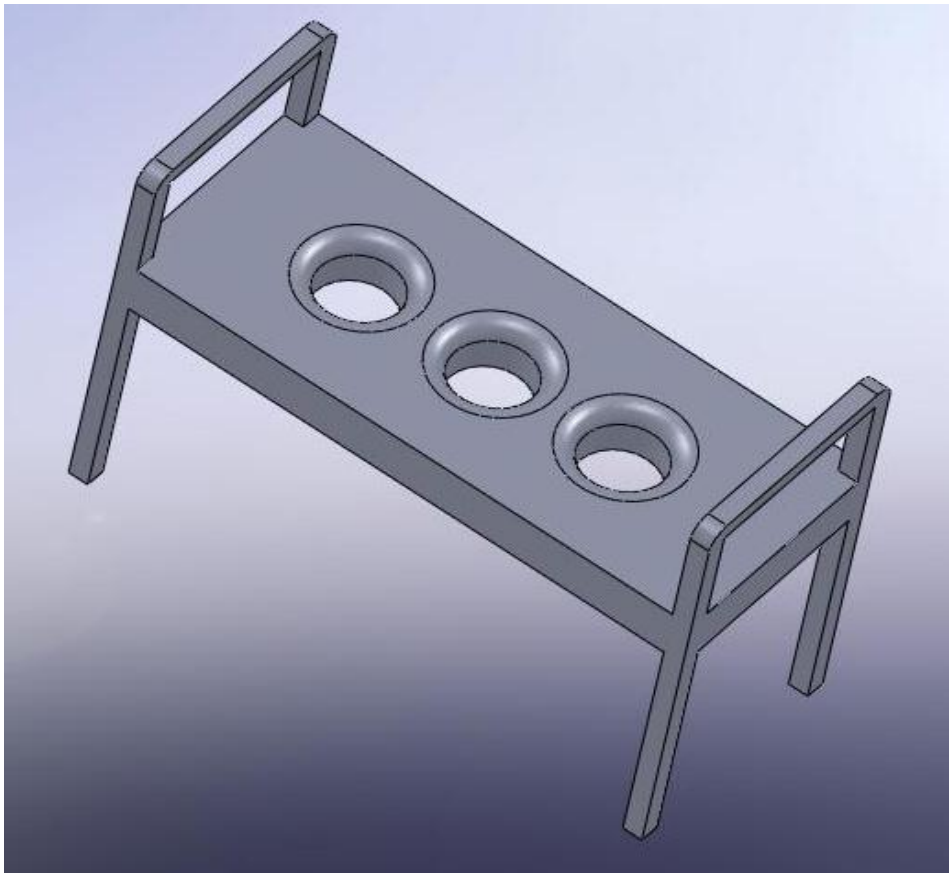

Figure 5.21: Final Solution Concept

The rack is designed in order to place the hair dryer at the holes provided. The paper can be placed under the hole with hair dryer and blow by the hot air. Time consumption for taking the hair dryer and blow the paper can be reduce and indirectly improve the productivity of the company.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study was carried out in order to solve the defect existed in NamHwa Paper Industries (M) SDN. BHD. It was identified that the glue workstation has the highest defects that contribute to low productivity and low efficiency of the company. So, further investigation and data collection was developed with aid of 7 quality control tools. However, only check sheet, pareto chart and fish-bone diagram were used to solve the problems occurred at glue workstation. 4 new alternative solutions have been suggested and discussed in order to solve the existing problem.

The main objectives of this project are successfully achieved where 7 quality control tools was implement in NamHwa Paper Industries (M) SDN. BHD. The defect with the highest frequency was determined at the glue workstation. New methods were produced to the selected manufacturing company thus improve the productivity of the company and meet the unpredictable customer demand.

The new method that was produced was the combinations of first and third solutions which are divide the paper box into 3 groups before stacking up and paper box was blow by the hot air of the hair dryer while waiting to be stacked up. As conclusion, a special rack was design in order to combine the both suggested solutions.

6.2 Recommendations

Based on the study carried out at NamHwa Paper Industries (M) SDN. BHD., there are several recommendations in order to improve the productivity in the future. Below are the recommendations for the future work:

a) Enhance the analysis by using WITNESS software because it significantly reduces the time spent experimenting, by automatically finding the optimum solution to satisfy chosen performance criteria which is fully customizable, by setting the parameters that are allowed to change and the optimizer will perform experiments intelligently to find the best solutions.

b) Use other software for simulation tools such as ARENA, PROMODEL, CIMFACTORY and others. Nowadays, there are varieties of microcomputer-based simulation packages on the market. This will help to produce better results in terms of other criteria which cannot be carried out by WITNESS software.

c) Implant robotic hands or conveyer belt on the factory. As we know, machine has the higher accuracy and effectiveness compare to human being. A robotic hand or machine can be use to produce paper box. However it will cause a lot of maintenance fees and need a lot of cost to imply a new machine. But by imply machine to the workstation, it will definitely increase the productivity quality and quantity.

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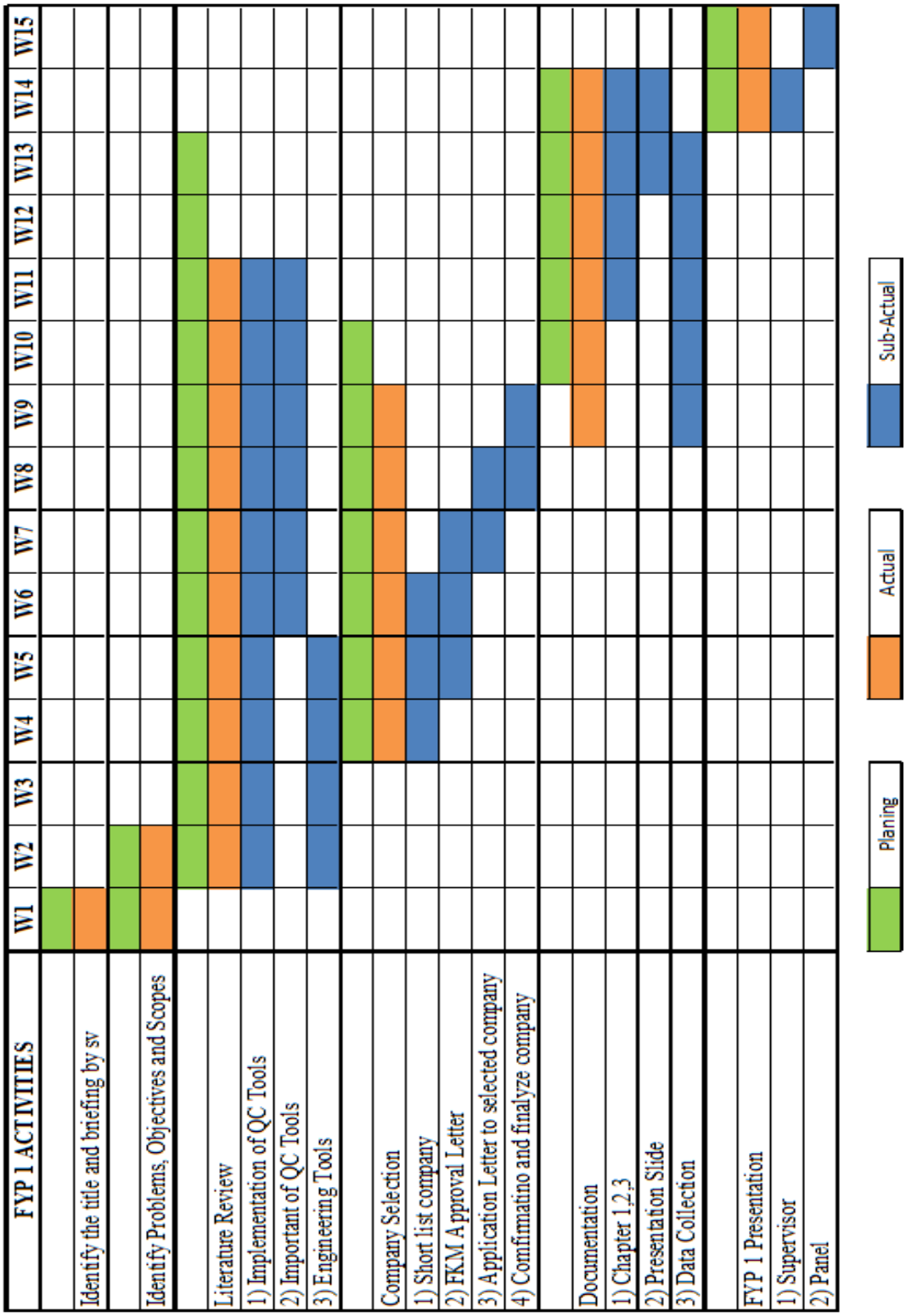
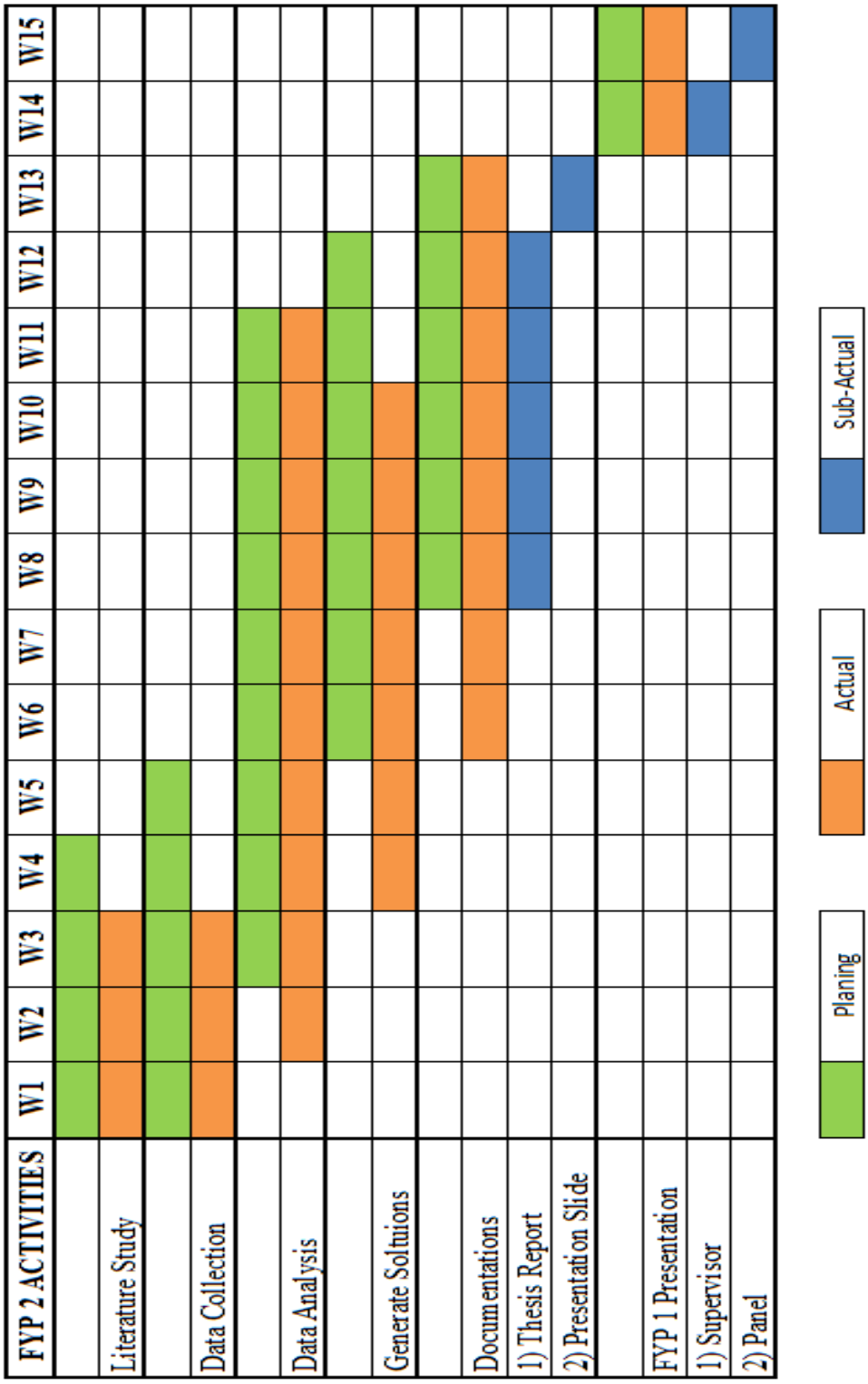
APPENDIX A1

GANTT CHART FOR FINAL YEAR PROJECT 1



APPENDIX A2

GANTT CHART FOR FINAL YEAR PROJECT 2



APPENDIX B1

CHECK SHEET FOR DETERMINE DEFECT

Defect	Pallet					Frequency
	1st	2nd	3rd	4th	5th	
Glue						
Partition						
Stitching						
Slitter						
Print						
Slotter						
Die Cut						
Tie						

* 1 pallet = 350 pieces

APPENDIX B2

TABLE FOR CONSTRUCT PARETO CHART

CAUSES	FREQUENCY	RELATIVE %	CUMULATIVE FREQUENCY	CUMULATIVE %

APPENDIX C1

TNB PRICING

Industrial

	TARIFF CATEGORY	UNIT	RATES
1.	**Tariff D - Low Voltage Industrial Tariff**		
	For Overall Monthly Consumption Between 0-200 kWh/month		
	For all kWh	sen/kWh	32.5
	The minimum monthly charge is RM7.20		
	For Overall Monthly Consumption More Than 200 kWh/month		
	For all kWh (From 1kWh onwards)	sen/kWh	34.8
	The minimum monthly charge is RM7.20		
	Tariff Ds – Special Industrial Tariff (for consumers who qualify only)		
	For all kWh	sen/kWh	32.7
	The minimum monthly charge is RM7.20		
2.	**Tariff E1 - Medium Voltage General Industrial Tariff**		
	For each kilowatt of maximum demand per month	RM/kW	23.40
	For all kWh	sen/kWh	26.6
	The minimum monthly charge is RM600.00		
	Tariff E1s – Special Industrial Tariff (for consumers who qualify only)		
	For each kilowatt of maximum demand per month	RM/kW	18.10
	For all kWh	sen/kWh	25.8
	The minimum monthly charge is RM600.00		

3.	**Tariff E2 - Medium Voltage Peak/Off-Peak Industrial Tariff**		
	For each kilowatt of maximum demand per month during the peak period	RM/kW	29.30
	For all kWh during the peak period	sen/kWh	28.1
	For all kWh during the off-peak period	sen/kWh	17.3
	The minimum monthly charge is RM600.00		
	Tariff E2s – Special Industrial Tariff (for consumers who qualify only)		
	For each kilowatt of maximum demand per month during the peak period	RM/kW	25.20
	For all kWh during the peak period	sen/kWh	25.8
	For all kWh during the off-peak period	sen/kWh	14.7
	The minimum monthly charge is RM600.00		
4.	**Tariff E3 - High Voltage Peak/Off-Peak Industrial Tariff**		
	For each kilowatt of maximum demand per month during the peak period	RM/kW	28.10
	For all kWh during the peak period	sen/kWh	26.6
	For all kWh during the off-peak period	sen/kWh	16.0
	The minimum monthly charge is RM600.00		
	Tariff E3s – Special Industrial Tariff (for consumers who qualify only)		
	For each kilowatt of maximum demand per month during the peak period	RM/kW	22.20
	For all kWh during the peak period	sen/kWh	24.3
	For all kWh during the off-peak period	sen/kWh	13.4
	The minimum monthly charge is RM600.00		

APPENDIX C2

FKM APPROVAL LETTER

Fakulti Kejuruteraan Mekanikal
Faculty of Mechanical Engineering

26600 Pekan, Pahang Darul Makmur
Tel : (+609) 424 2201
Faks/Fax : (+609) 424 2202
Web : www.ump.edu.my

Universiti Malaysia PAHANG

RUJ. KAMI *(OUR REF.)* : UMP.14.02/14.20 (99)
RUJ. TUAN *(YOUR REF.)* :

27 Januari 2010

SESIAPA YANG BERKENAAN

Tuan,

PENGESAHAN PELAJAR MENJALANI PROJEK SARJANA MUDA (PSM)
UNIVERSITI MALAYSIA PAHANG

NAMA	:	**HOW SHENG BOON**
NO MATRIK	:	**ME07034**
NO KAD PENGENALAN	:	**871225-03-5129**
PROGRAM	:	**SARJANA MUDA KEJURUTERAAN MEKANIKAL DENGAN KEJURUTERAAN PEMBUATAN**

2. Adalah dimaklumkan bahawa pelajar yang tersebut di atas merupakan pelajar Fakulti Kejuruteraan Mekanikal, Universiti Malaysia Pahang, Kuantan, Pahang.

3. Pelajar tersebut sedang menjalankan kajian 'Productivity Improvement Using Industrial Engineering Tools' untuk Projek Sarjana Muda. Segala informasi yang akan diberikan oleh pihak tuan hanya akan digunakan untuk tujuan PSM sahaja.

4. Kerjasama dan bantuan pihak tuan amat dihargai.

Sekian. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan tugas,

TN. HJ. AMIRRUDDIN BIN ABD KADIR
Timbalan Dekan (Akademik & Hal Ehwal Pelajar)
Tel : 09-424 2211