PRODUCTION PROCESS IMPROVEMENT: A CASE STUDY OF POLYESTER MANUFACTURER

By

PORNPISSANU THOME

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
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Martin de Tours School of Management and Economics
Assumption University
Bangkok, Thailand

August 2014

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Declaration of Authorship Form

I, Pornpissanu Thome, declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

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I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

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Date ______________________

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Pornpissanu Thome
Assumption University
August, 2014

ABSTRACT

Production is the most critical point in supply chain management because production is in the middle of the supply chain. The pathway from upstream to downstream, it starts from supplies delivered as raw material to the production plant for the conversion process then distributing finished product to customers. The quality of finished products is related with the production performance of a company. It involves managing the production lead time, process management and especially the quality of finished products. Moreover, the information and working flow of internal supply chain is a key point to the success in the company supply chain management. The implementation of improving production process lead to increase performance to achieve efficiency and effectiveness in competitive advantages is necessary.

To reduce the defective products from the production department of a company, Business Process Improvement (BPI) methodology is applied to improve the production process by data analysis for finding the root cause of the problems and improving the process to be more efficient in the working process. Therefore, this research attempts to answer the question ***"How to improve the production process by using Business Process Improvement (BPI)?"***

This research identifies the root causes of finished product quality problems and delays of working time in the production process by using process mapping. This study also emphasizes improving working flows of the internal supply chain of a company which is the production and warehouse departments. Consequently, the results indicate the improvement in the production process to reduce defective products to meet the quality objective targets of the company.

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Date: August 26, 2014

CHAPTER I

GENERALITIES OF THE STUDY

In the international manufacturing business, supply chain management has become more important in companies, especially for the manufacturing industry when it deliveries products at a lower cost but higher quality than competitors. The ability to deliver the quality of products faster than the competitors will enhance the success of sale as well as gaining more market share. To get these advantages, the business must consider the uncertainty of the market and keep up with suitable strategies to gain the competitive advantages.

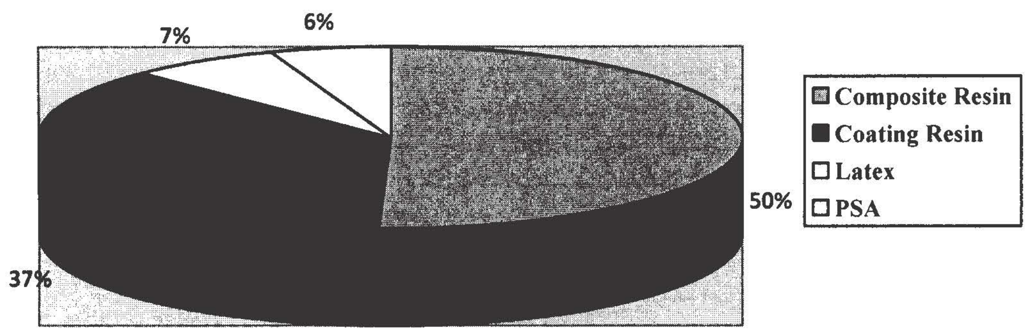
This chapter presents an introduction to the business of the ABC company. This firm is concisely described as, in the business of producing Petro Chemical Intermediate products. This chapter will present 1) background of the research, 2) statement of problems, 3) research objectives, 4) scope of the research, 5) significance of the research, 6) limitations of the research, and 7) definition of terms respectively.

1.1 Background of the Research

ABC Company was established in 1975 as a joint venture between Thai and Taiwanese companies, a company has grown to become one of the world's leading producers of polymer resins used in the manufacture of intermediate products both Batch Systems and Continuous Production process. ABC company uses modern technology for synthesis of high end chemical solutions to serve as raw materials for down-steam polymer manufacturers. Thus, the company emphasizes on improving the production process particularly on product quality in order to minimize operating cost and consistency of good product quality for customers.

ABC Company produces various kinds of chemical products such as coating resins, composites resins, Latex, and Pressure Sensitive Adhesive (PSA) as shown in Figure 1.1

Figure 1.1: Monthly Average Percentage Quantity of the ABC Company



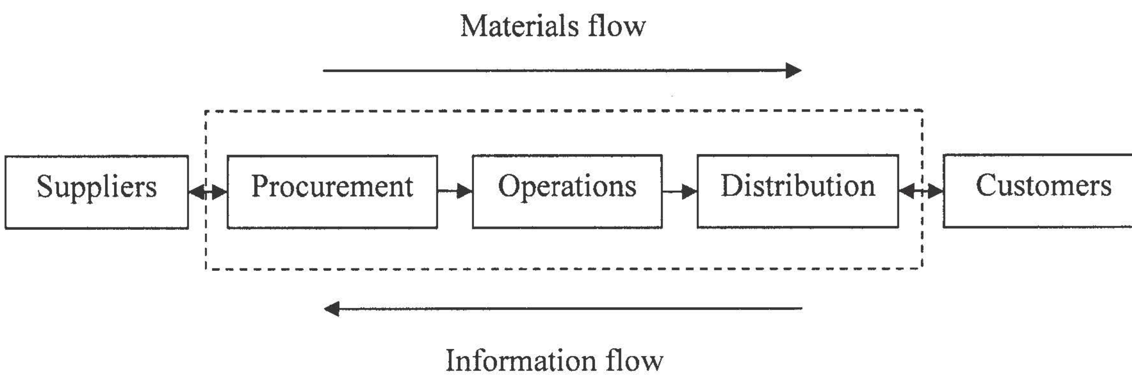
Source: Company data

Figure 1.1 shows the monthly average percentage of ABC company's production quantity from July 2013 to March 2014 which are divided into 4 product groups. It clearly illustrates that the highest quantity is in the composite resin product which is an average of 50%. For other product groups, coating resin shows an average of 37%, Latex shows an average of 7%, and PSA shows an average of 6% respectively. From the results, it shows that the featured products of ABC company are composite resin thus this research will focus on the production process of composite resin.

1.1.1 ABC Company Supply Chain Process

ABC manufacturing includes supply chain management by playing in every role from upstream to downstream. Beginning with sales receiving orders from customers, then the production department planning the schedule and material consumption quantity (MCQ) to the procurement department to buying raw materials from suppliers, production process in the plant starts when materials arrive. After the production process is complete, finished goods are moved to the warehouse and distributed to customers. The scope of ABC company's supply chain management is to smooth the flow from upstream suppliers to downstream end customers. Figure 1.2 illustrates this total system concept.

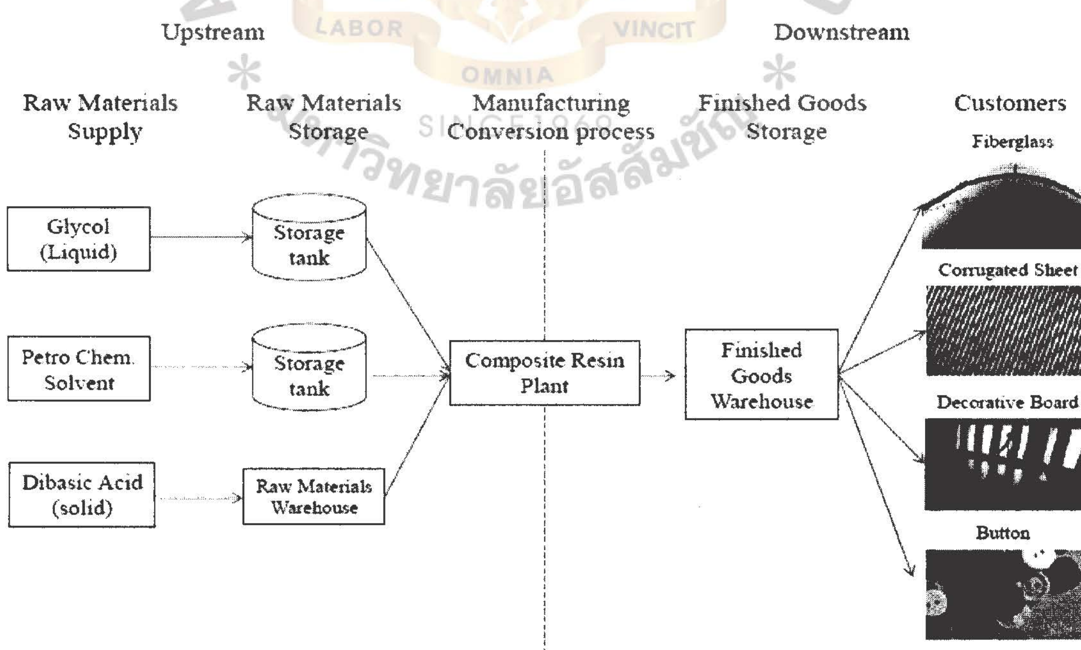
Figure 1.2: ABC Supply Chain Management Process



Source: Company data

This study focuses on the production process improvement in operations of composite resin which are used in a wide variety of secondary and tertiary industries. Composite resin is used in fiberglass, corrugated sheet compound, interior decorative board and button manufacturing.

Figure 1.3: Overview of Composite Resin Supply Chain Process



Source: Company data

Figure 1.3 shows the overview of how the composite resin supply chain process starts from upstream where both suppliers supply raw materials which are Glycol, Dibasic acid and petrochemical solvent. Liquid raw materials and solvent will be transferred into the storage tank while solid raw material will be stored at a warehouse before transferred to a composite plant for production processing. After conversion is done finished goods are transferred to be stored in the warehouse by keeping the temperature at 25°c for controlling the product quality before distributing to customers. Composite resin is a kind of petrochemical manufacturing which produces a polymer compound for many industrials including Fiberglass laminating by hand lay-up and spray-up and filament winding requiring multiple layers to produce boat, yacht, silo top, tank, car roof, door, pipe etc. Corrugated sheet by hand lay-up lamination and continuous process to produce roves. Decorative boards for table tops, furniture, door, white broad etc. Centrifugal casting process for buttons.

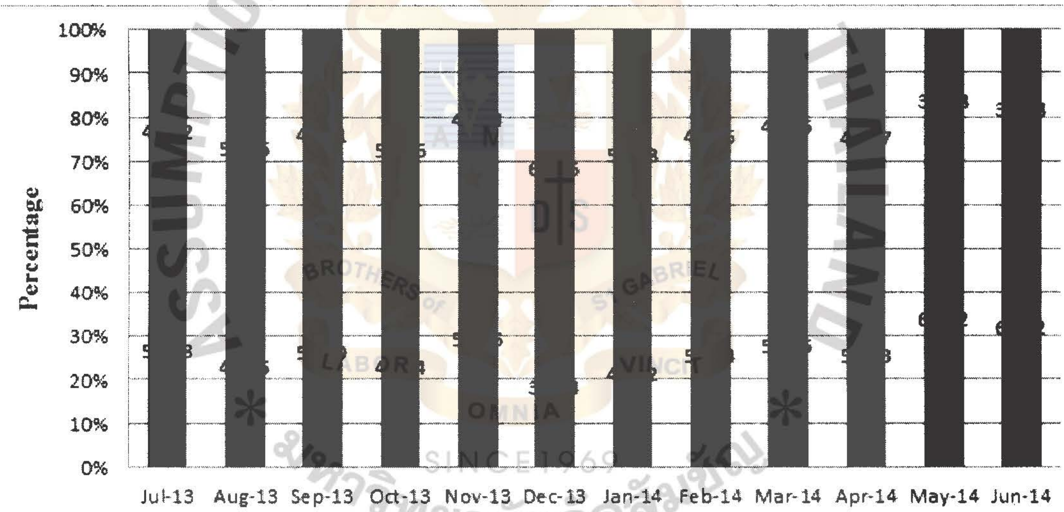
1.1.2 Composite Resin Production Process

The conversion processes of composite resin are esterification and blending. It begins with charging raw material into reactors both liquid (Polypropylene Glycol) and solid (Melic Anhydride and Adipic acid) as the most common solution. The reactor is changed through a manhole with fixed amount of raw material (Glycol and the solid anhydride). The solution is heated up to 200-220°C or more under agitation and inert gas Nitrogen is slowly applied to prevent oxidation reaction causing intensive color of the resin. The partial condenser condenses the glycol but the process also gives a by-product of dehydrated water. The esterification reaction is continued until a determined viscosity is reached. After achieving the determined viscosity the reactor is cooled down to 160°C then transferred to the dilution tank and blended with a solvent (Styrene monomer). After that dilution tank is cooled to 40° the solvent is pumped in to adjust viscosity and the adding of additives is done to reach specifications of the finished product. Then pumped through a filter into the packing tanks and filled into the drums and transferred to store in the warehouse which in under a control temperature at 25°c to keep the finished product quality in terms of chemical stabilities.

1.2 Statement of the Problems

In a past several year ABC company found the increase of defective products from composite resin plants was higher than the company quality objective target which was less than five percent of defective products in every month. The Production department was faced with many problems in the production process due to some limitations such as raw material quality, machine breakdown, inefficient production process and human error. It seems that it is a hard proposition for the production department to solve for increasing productivity.

Figure 1.4: The Percentage of Defective Product in Composite Resin Production Department from July 2013– June 2014



	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14
■ DEFECT	46.12	53.75	46.91	53.86	40.44	62.86	56.38	48.26	43.35	48.57	31.68	35.48
■ PASS	53.88	46.25	53.09	46.14	59.56	37.14	43.62	51.74	56.65	51.43	68.32	64.52

Source: Company data

Figure 1.4 illustrates a percentage of defective products in the composite resin production department to classify in each defective item. The percentage of defective products in each month is over five percent of defective products. From this result the low quality products affect customer certainty by causing a problem to downstream customers end product. From this result the researcher tracked the production process by the observation method to find irregularities in the production process. There are two problems occurring during the production process which causes the product to be defective in terms of appearance and shelf life. This research is concerned with two problems which are;

1.2.1 The quality of problems in terms of appearance and shelf life which affect customer usage. When finished product appearance is poor customers cannot use it as a starting raw material for their product. For defective products in terms of shelf life it affects inventory problems of customers because their staring raw materials will expire faster according to a shorter shelf life. These problems not only make customers dissatisfied but also affect the company's reliability. When finished products are rejected from customers, it needs to be stored in the warehouse before reprocessing; and there is not enough space for the incoming product from production line.

1.2.2 From the observation method it found irregularity in production process which are communication and information flow problems. Information is delayed and missing. In addition, there is a lack of emphasis in managing and improving the work flow within the internal supply chain.

In this research, Business Process Improvement (BPI) is one of the supply chain management strategies used to improve the process to be more efficient in the working process. Therefore, this research attempts to answer the question "How to improve production process by using Business Process Improvement (BPI)?"

1.3 Research Objectives

This research objective is to apply the BPI strategy to improve the production process of the composite resin of ABC Company. The research objectives are set as follows:

1.3.1 To identify the problems in production process.

1.3.2 To study the current production processes of composite resin.

1.3.3 To identify the root causes of quality problems in the production processes.

1.3.4 To propose the improving production process and work flow between the internal supply chain.

1.3.5 To propose the implementation plan for process improvement.

1.4 Scope of the Research

This research's main focus is to study the production process of composite resin that provides an intermediate petro chemical solution for domestic customers. This would therefore, provide a better understanding of the flow of the production process and the ability to correctly identify the causes of problems related to the working processes. The methodology of business process improvement will be to reduce defected products from the production department, as well as to increase efficiency and effectiveness in the production operation.

In addition, this research would also conduct the following tasks:

1.4.1. Emphasize on product quality improvement by improving the production operation process using the Business Process Improvement (BPI) methodology. The data needed for this research were collected from performance and quality reports from July 2013 to June 2014, which included total quantity of finished product and defect problems. Activities descriptions and run hours posted and the observation techniques would also be used in analyzing and computing the results.

1.4.2 Understanding and analyzing the main core of the productions physical operations and information flows of internal supply chain processes from the start to the end of activities in the production process. This would be carried out by applying the following techniques including process mapping, problems classification and root cause analysis by using cause and effect diagrams.

1.4.3 A focus on the internal supply chain for process improvement and exploring the possible alternatives believed to be able to improve the existing production operations process and eliminating the identified problems.

1.5 Significance of the Research

After applying the Business Process Improvement (BPI) methodology with the production operation process of ABC company, the expectation of improvements are included in the findings of the causes of problem in the production process that impacted the product quality as well as the causes that affected the working flow in the production process, smoothing the flow between working activities in the production process and the increases in the production operation's effectiveness and efficiency as non-value added activities were able to be reduced.

1.6 Limitations of the Research

There are few limitations considered through this study.

1.6.1 The cause of defect products by the effect of external factors which are uncontrollable causes such as heat transfer rate to reactor temperature, different sources of raw materials and others. Thus, some defective products are caused from uncontrollable external factors.

1.6.2 This research will not cover every cause of defective products due to the limitation of technical data which is the chemical formula of a company.

1.6.3 This research may not be appropriate for other industries because each firm has different production processes due to different kinds of products.

1.7 Definition of Terms

Appearance	The visual appearance of composite resin is given by the way in which they reflect and transmit light. Described by attributes like glossy, shiny, transparent, clear, turbid, or opaque etc. (William and Cecile, 1993).
BPI	Business Process Improvement is a systematic approach to improving a process. It involves documentation, measurement and analysis for the purpose of improving the functioning of a process. (Seethamraju and Marjanivic, 2009).
Cured Time	Refers to the period of time that the hardening of a polymer material by cross-linking of polymer chains, brought to change from a liquid compound to a solid (Osswald, Tim, and Menges, 2010).
Defect product	Defined as the characteristic of a finished product which usability for the purpose which it was designed and produced. A product that is defective is any item that is not dangerous and can be sold with a discounted price depending on negotiations (Robinson, 2009).
Lead time	The amount of time taken from the starting of a production process to the finished product (Cousens, Szwejczewski, and Sweeney, 2009).

Peak temperature	The temperature of the initial mixing of reactants of a thermosetting polymer until the highest exothermic temperature is reached. For mixtures where outside energy is required, the initial time begins with the start of exposure (Lewis, Peter Rhys, and Gagg, 2010).
Process map	A simulation of process consists of production activities and document flow that uses general symbols and arrows to show the flow of the manufacturing process (Harrington, 1991).
Shelf life	Shelf life is the length of time that a commodity may be stored without becoming unfit for use or consumption. Nearly all chemical reactions can occur at normal temperatures (although different reactions proceed at different rates). However most reactions are accelerated by high temperatures, and the unstable chemical compounds are of no exception (Azanha and Faria, 2005).
Value added	Any activity of the production process that improves the product to meet customer requirements (Stevenson and Chuong, 2010).

CHAPTER II

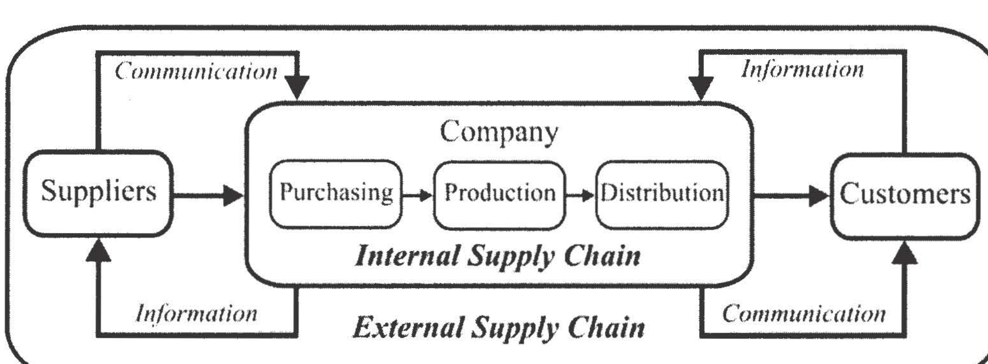
REVIEW OF RELATED LITERATURE

This chapter presents the review of the literature which is related to this research. The main focus is to conceptualize the idea and definition of Business Process Improvement (BPI) methodology by applying it through the production process. BPI methodology will be applied with supply chain management in order to improve the production process performance which will be discussed more in detail.

2.1 Supply Chain Management

Supply chain management is the administration of seamless, value-added processes among organizational boundaries to meet the target of a company to meet customer demand. Hence the process can be managed effectively upstream and downstream of the supply chain, they must be managed well inside the local firm (Fawcett, Ellram, & Ogden 2007). In every company, a various function has their own responsibility for making decisions that will measure the value. According to Potter (2008) for better processes and more competitive product results when the various functions of a company understand customer needs, a company strategy and work well together. Emphasize internal process as the objective is to increase collaboration among a company's functional groups.

Figure 2.1: Internal and External Supply Chain



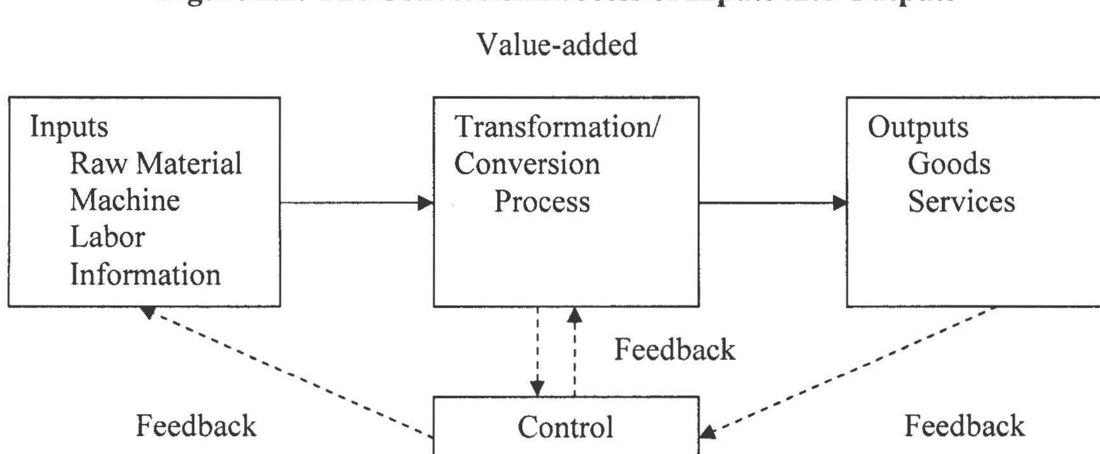
Source: Tan, (2001)

From figure 2.1 it shows that supply chain management also could be described as a linkage of each department of a company starting at raw material suppliers to finished product end users. Information and communication activities between internal and external members of the supply chain is for collaborating in every function together (Tan, 2001).

2.1.2 Production Process

The production process is focused on the conversion of inputs into those outputs that are required by customers. Factors of production include the buildings or plant in terms of manufacturing, machinery, operation system and people to control or monitor the conversion processes. The converted input resources are raw materials and components that are converted into finished products. Any production process involves a group of activities in a production process. At each section value is added in the activity of production. Therefore adding value is not only about manufacturing, but involves the marketing process about promotion, advertising and the delivery that makes the finished product more attractive. Adding value includes creating a product more desirable to a customer so that they will effort more for it. It is very important for businesses to identify the processes that add value, so that they can enhance these processes to the ongoing benefit of the business.

Figure 2.2: The Conversion Process of Inputs into Outputs



Source: William (2010, p. 5)

Figure 2.1 illustrate the production process by converting inputs into outputs. In this research the input can be identified as raw materials, machinery, labor and information all combined together in a transforming or conversion process. After passing through all of those process the outputs can be either finished products or services. To make sure that the desired outputs are produced, a company takes measurements at every section in the conversion process (feedback) and then compares them to the standard of specification to determine whether corrective action is needed (control).

The objective of applying supply chain management with production process is to manage every function in an organization that is involved with product quality, supply utilities, design of plant location, creating operating systems, and improvement of technology. Meanwhile the other related functions are also important such as sales forecasting, managing of inventories, planning of production capacity, production schedules and more.

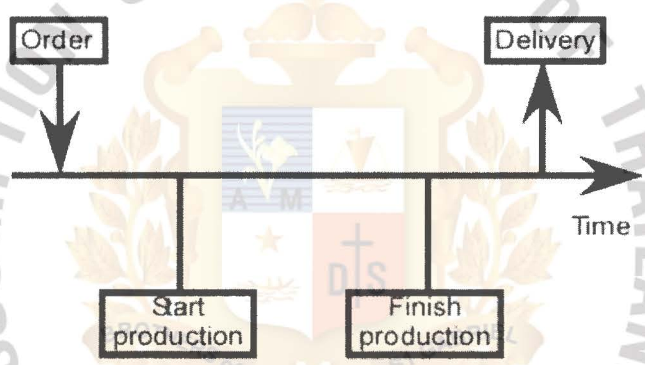
In this research the scope is about production process in the chemical industry that add value to raw materials by blending or mixing them to perform a chemical reaction, filtration to make the chemical compound clean and packing it into required packaging by customers. Production processes can be either continuous or by batch to create a desired finished product to customers. Therefore these process can operate efficiently by using large installations of manufacturing plants, which cost very high investment. If large quantities are demanded, this justifies continuous production (thus higher investment). If demand is low, the investment into a large installation is not worthwhile, and batch production is used. Also, these processes are difficult to control which often results in typical symptoms such as variable yield and returning flows of material (Fransoo and Rutten, 1994).

Different sources of raw materials lead to a variation of quality. For example, variations in the moisture contents, acidity, color, viscosity or concentration of active ingredients in raw materials may cause variations in the ingredient. All of these are uncontrollable factors to the quality of finished products.

2.1.3 Lead Time in Manufacturing

Cousens, Szwejczewski, and Sweeney (2009) stated that a lead time in manufacturing is used to measure the timing of the production process. It shows how long it takes from the start of inputs to be a finished product. Lead time has many meanings, depending on the type of process and working background, this is the way to define the meaning of lead time. In the scope of this research lead time is counted from raw materials requisition until finished products are stored in the warehouse.

Figure 2.3: Lead Time in Manufacturing



Source: The Author

Lead time will determine the performance of the production process by comparing it to standard time. Manufacturing lead time measures how quick response the finished product to customers – how long it take in the production process in the factory to measure from time tracking in each activity.

2.1.4 Value Added

Stevenson and Chuong, 2010 described the value add in the case of a company taking a product that may be considered a homogeneous product, with few differences (if any) from that of a competitor, and provides potential customers with a feature or add-on that gives it a greater sense of value. To increase the value of something given by the company to its product or service to fulfill the need of customers.

2.2 Business Process Improvement (BPI)

Business environments are complex with increasing competition, changes in stake holder requirements and new strategies are driving a company and in order to survive in a global business the companies are constantly striving to improve and manage their business process (Seethamraju & Marjanivic, 2009). There are many methodologies that help improve their processes. Ability to improve companies performance have been important since the start of the industrial era. The well-known of practice documented in the area of performance improvement is Business Process Improvement (BPI) (Harrington, 1991). Hammer and Champy (1993) introduced this concept by concluding that one of the benefits of success by using BPI is an increase in overall performance such as cost, quality of the product, service response speed and improvements in cycle time.

2.2.1 Definition of Business Process Improvement (BPI)

Business Process Improvement is a systematic approach to improving a process. It involves documentation, measurement and analysis for the purpose of improving the functioning of a process. It can be informal or formal and touch a variety of company functions: manufacturing, information technology, and customer service, etc. Regardless of the process that needs to be enhanced, the improvement procedure follows a various path.

Barry (1998) defined "Business Process Improvement (BPI) is the process of assessing, analyzing and improving the business process that are important to an organization's success". Supported by Zairi (1997) it was proposed that the business process improvement is a method to improve the set of process activities in each function of the company.

2.2.2 Process Improvement Methodology

Adesola and Baines (2005) presented a complete seven-step roadmap recommended to improve the business process. These are described as follows:

Step 1: Collect the data and identify the problems for improvement to achieve the business needs. The aim of this step is to gather data and elaborate on all of the problems which occur in the process. The researcher must select processes which have the major effects on customer requirements. Selecting the right process to be changed will act as the target to the point of the improvement process. This step needs data to be reviewed for in depth information and the people who understand the current problems.

Step 2: Understand the process (As-Is). In this step, the aim is to gain a complete mapping of the current process (as-is) and investigate the process flow to understand the operating activities in the selected processes. This way you can fully understand the process from the begging and set realistic improvement objectives and be able to answer these questions "What in the process is broken, Which step is the major cause of the problem?"

Step 3: Model and Analyze the process. Root cause analysis tools such as Pareto Analysis and cause and effect diagrams will be applied in this step. The results from the root cause analysis will illustrate all of the possible causes of the problems and clearly identify which are the main issues to be solved in next step.

Step 4: Redesign process (To-Be). In this step the improved process is purposed to collect the weak point or get rid of the problematic activities in the process. After constructing the to-be process the mapping will show what this process will look like and identifies additional areas. The results of this phase determine whether a process improvement recommendation will be fully undertaken.

Step 5: Implementing the improved process involves implementation of changed practices, roles and responsibilities and measuring systems. Communication plans must be implemented comprehensively at this step. This may have been clearly defined during the redesign phase; however, those closely involved in the process and who have a major stake in its effectiveness must determine what to implement when and how.

Step 6: Assess new process and methodology. Review and evaluation takes the process improvement effort full circle to look at whether the process is meeting goals and objectives and whether additional improvements and/or analysis may be needed. Review process verification findings against goals & objectives compare the measurements with the expected results with the goals and objectives for the process.

Step 7: Review the strategy for measuring process performance with those who have key roles. Relate these measures to the goals and objectives. Develop strategic views of the business and establish an action plan to meet the target implementation plan.

Figure 2.4: A Generic Model for Business Process Improvement

Source: Adesola and Baines (2005)

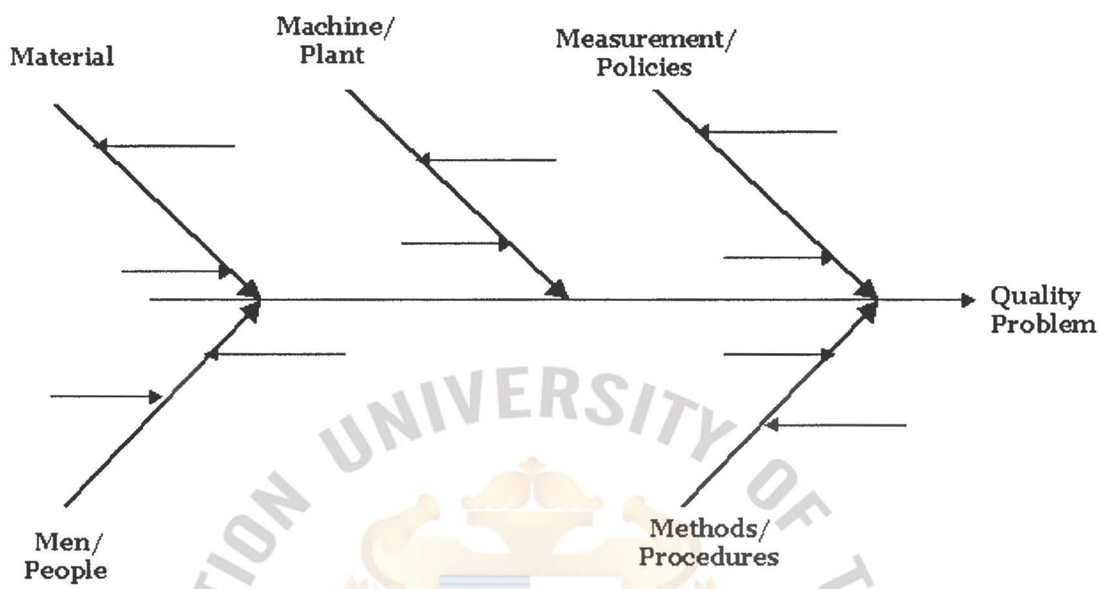
2.3 Cause-and-Effect Diagrams

A cause-and-effect diagram offers a structured approach to the search for the possible causes of the problems. It is also known as a fishbone diagram because of its shape, or an Ishikawa diagram, after the Japanese professor who developed the approach to aid workers overwhelmed by the number of possible sources of the problems when problem solving. This tool helps to organize problem solving efforts by identifying categories of factors that might be causing problems. Often this tool is used after brainstorming sessions to organize the ideas generated. Figure 2.3 illustrate one form of a cause-and-effect diagram.

Ishikawa (1990) showedt the causes of a specific event. Common uses of the Ishikawa diagram are product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation. The categories typically include:

- Man: Anyone involved with the process.
- Methods: How the process is performed and the specific requirements for doing it, such as policies, procedures, rules, regulations and laws.
- Machines: Any equipment, computers, tools, etc. required to accomplish the job.
- Materials: Raw materials, parts, pens, paper, etc. used to produce the final product.
- Measurements: the measurement instruments adequate for the process? Are they maintained correctly and regularly calibrated? Are the measurement instruments affected by environmental conditions such as temperature, vibration, dirt, etc.?

Figure 2.5: Format of a Cause-and-Effect Diagram



Source: Dale, Van der Wiele and Van Iwaarden (2007)

2.4 Process Flow Chart

Graham (2004) introduced the first structured method for documenting process flow, e.g. in flow shop scheduling, the flow process chart. A process flow chart is a visual representation of a process. As a problem solving tool, a flow chart can help investigators in identifying possible points in a process where problems occur. Also used to review and critically examine the overall sequence of the operation by focusing on the movements of the operator or the flow of materials. These charts are helpful in identifying nonproductive parts of the process (e.g., delays, temporary storages, distances traveled). Appendix B describes the symbol used in constructing a process flow chart.

Allan and Rosario (1989) began training business people in the use of some of the tools of industrial engineering at his Work Simplification Conferences in Lake Placid, New York. A 1944 graduate of Mogensen's class, Art Spinanger, took the tools back to Procter and Gamble where he developed their Deliberate Methods Change

Program. Graham (1950), Director of Formcraft Engineering at Standard Register Corporation, adapted the flow process chart to information processing with his development of the multi-flow process chart to display multiple documents and their relationships.

2.5 Case Study of Business Process Improvement

Paper (2000) explained a case study of BPI methodology applied by Caterpillar MEC (Mossville engine center) including five steps (select process, mapping process, improve process, verify process and implementation). The process improvement step consist of three major "activities" (Also called methods within this approach) of process improvement. This is not unusual that all three activities for process improvement are applied. At Caterpillar the process improvement normally starts with the simplification of the process. Moreover "tools and techniques" for the improvement step are recommended such as brainstorming of each operation involved.

But these tools and techniques were not assigned to activities. The scope of the case study consists of a definition of "roles" in an example of project improvement team, management review team, micro and macro process team involved in the improvement activities.

Seethamraju and Majanovic (2009) proposed the work of BPI methodology unlike the other "traditional" process improvement applications. The focus in not on constructing current as-is processes and creating a new to-be process, the emphasis is on the value of process knowledge team to work to the development of a "to-be" model in a general agreement process. According to this methodology, different activities that perform the process improvement include data collection, process analysis, creating new process and implementation. The methodology does not describe the results of each phase. The only difference is between BPI team members and employee work shop participants, but there is no allocation of roles to differentiate phases of the methodology approach.

2.6 Summary

In conclusion, the BPI methodology has been reviewed because it is an effective way of improving the process flow to be more fluent. Many authors who implemented BPI can generate appropriate communication, coordination and control of the process which results in improving the productivity and quality of products.

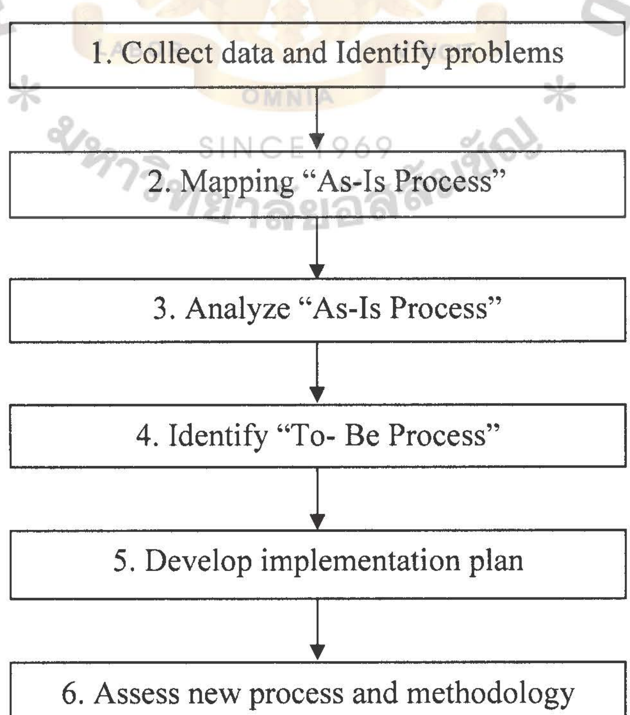
This research will cover six of the seven steps of BPI according to the limited time to monitor implemented result, which including 1) Collecting data and identifying problems 2) Mapping "As-Is Process" 3) Analyzing "As-Is Process" 4) Identifying "To- Be Process" 5) Developing an implementation plan and 6) Assessing new processes and methodology. For the last steps, review the strategy cannot be applied without the results from the implementation step.

CHAPTER III

RESEARCH METHODOLOGY

A conceptual framework of this research is to define a cause that effects to the product quality and improves the production operation process of ABC company by applying the Business Process Improvement (BPI) methodology. This chapter present 6 steps of BPI including 1) Collect data and identify problems to illustrate all of the problems in the production process, 2) Mapping “As-Is Process” to understand current processes and indicating which activities are problems in the production process. 3) Analyzing “As-Is Process” to identify the root cause of the problem by using cause and effect analysis. 4) Identify “To- Be Process” to propose the improved process for solving the problem. 5) Develop an implementation plan to validate the improved process in working operations and 6) Assess new process and methodology compared to the expected results with the goals and objectives for the process. Figure 3.1 shows research methodology of BPI as the following tasks:

Figure 3.1: Research Methodology



Source: Adesola and Baines (2005)

3.1 Collect Data and Identify Problems

Data collection is displaying the data in a suitable format for analysis. Emphasizing the production operation process, the data collection aim is to gather information for supporting the conclusions of the results and achieving the purpose of the study. There are two types of data selected for this research which are secondary and primary data.

Secondary data supported in this research includes:

1. Performance and Quality report of Composite resin from July 2013 to March 2014
2. Finished product testing report of Composite resin

The aim of the documentation review is to collect data of the operations process such as working lead time in each activity. Also physical and information flows, such as the flows of materials, finished goods, and other related information is necessary.

Primary data supported in this research includes:

1. Production process details to provide process mapping
2. Time in working processes by using time keeping methods.
3. Working details in production operation processes.

The primary data is collected by using observation method including problem consideration, objectives of improvement in the production process. Information in the production process are obtained by observing the working process. Selecting the main production operation processes of composites are observed and measured for process time during each process activity. The results of observation during each activity is to facilitate the understanding of the process which helps to identify causes of problems and proposes of possible improvements.

3.1.1 Problems Classification of Composite Resin

From the secondary data review of the Monthly Performance and Quality report of Composite resin from July 2013 to June 2014, it found the problem of high quantity of defective products in the composite resin production process. These are classified into 9 defect categories and the data is shown in table 3.3.

Table 3.1: Defect Product Quantity from July 2013 to June 2014

Defective Item	Defective Quantity (Tons)	Percentage
Peak temp.	1764.50	32.15
Appearance	1438.44	26.21
Shelf life	821.03	14.96
Cured time	746.90	13.61
Color	340.40	6.20
Molecular weight	265.16	4.83
Acid value	67.16	1.22
%Non-volatile	32.17	0.59
Viscosity	11.97	0.22
Total	5487.73	100.00

Source: Company data

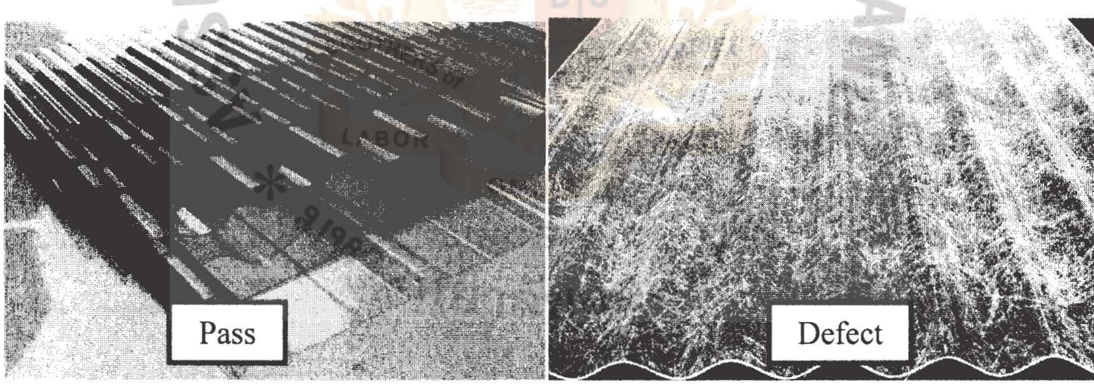
Table 3.1 shows the quantities and percentages of defective products in 9 problems; Peak temp. 32.15%, Appearance 26.21%, Shelf life 14.96%, Cured time 13.61%, Color 6.02%, Molecular weight 4.83%, Acid value 1.22%, Percentage of Non-volatile content 0.59% and Viscosity 0.22% respectively in the total amount of 5487.73 tons.

From the result of the product quality problem it included 9 categories of defective items. Each item has different affects to the end customer usage, the data is collected and reviewed from the finished product testing report describe as follows:

3.1.1. Peak Temperature

Peak temperature of composite resin is the determination of a thermosetting polymer until the highest exothermic temperature is reached. For mixtures where outside energy is required, the initial time begins with the start of exposure. In this case peak temp can be higher or lower than specification, if peak temp is too high it will affect to corrugated sheet manufacturer by the cracking the tile in their production line. On the other hand, if peak temp is too low the tile will deform or distort from the standard shape shown in the figure below.

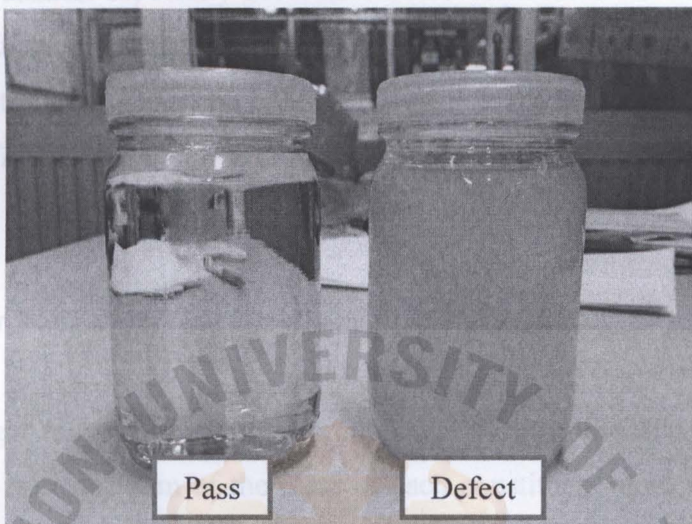
Figure 3.2: Comparison between Pass and Defect Product of Peak Temperature



3.1.2 Appearance

The appearanceof the visual composite resin is given by the way in which they reflect and transmit light. For composite resin customers, appearance is the critical specification to make value to their end product because molding industrial material such as fiberglass, corrugated sheet and button emphasizes transparent characteristic. The defect comparison between pass and defect of appearance is shown in figure 3.2.

Figure 3.3: Comparison between Pass and Defect Product of Appearance



3.1.3 Shelf Life

Shelf life is the length of time that a commodity may be stored without any problem for customer usage. For composite resin chemical reactions can spontaneously occur at normal temperatures. It leads to shorter aging in terms of raw materials and affects customer inventory problems.

3.1.4 Cured Time

Cured Time refers to the period of time of the hardening of a polymer material by cross-linking of polymer chains, brought to change from liquid compound to solid. For composite resin customers molding industrial cured time is one of the major specifications to making their finished product cure at the standard time in the production process. If curing takes longer than a customer's standard specification time, it will affect by delaying in customer production process.

3.1.5 Color

For polymer industrial especially decorative board manufacturers who emphasize on color of their finished product. Color of this kind of product is determined by starting with a raw material which is the composite resin. If the color is distorted from the standard specification the composite resin finished product will be rejected from the customer.

3.1.6 Molecular Weight

Molecular weight refers to the mass of a molecule in the composite resin compound. It is calculated from the sum of the mass of each constituent atom multiplied by the number of atoms of that element in the molecular formula. The methods are based on viscosity of finished products. If molecular weight is higher than the standard specification it will affect the flow rate of liquid raw materials in the corrugated sheet production line and in delaying the customer production process.

3.1.7 Acid value

According to the environmental control of the chemical compound. acid value is the determination of the acid concentration in composite resin. For customer acid value specification is set maximum at 25 mg KOH/g. concerned with worker health. If the composite resin compound has an acid value higher than 25 mg KOH/g., it will be rejected by the customer because of safety and environmental regulations.

3.1.8 Percentage of Non-Volatile

Composite resin is a mixture between polyester and petro chemical solvents. Percentage of non-volatile means the value of polyester compound excluding the solvent. The specification of non-volatile percentage is set at 65-70%, if non-volatile percentage is lower than this rank it will affect the glossiness of customer finished products. The comparison between pass and defect of non-volatile percentages which affect to the glossiness of decorative board customer is shown in figure 3.5.

Figure 3.5: Comparison between Pass and Defect Product of Non-Volatile

3.1.9 Viscosity

Composite resin is a chemical compound in a liquid form. Viscosity is the important part of measuring liquid compound property. Finished product specification of viscosity is determined by customers before accepting a product, if viscosity is out of rank ever higher or lower the finished product is rejected by the customer.

3.1.2 Cause of Defect Problems

The finished product from the production process tested the specification if any defective problems occur, the finished product testing report is sent to the production department. In this step it illustrates the cause of product defect in each problem by reviewing the finished product testing report. The report describes the differences caused by problems depending on each defective characteristic shown in Table 3.2

Table 3.2: Cause of Product Defect Problems.

Defect Problems	Cause of Problems	Summary
1.Peak temp.	The raw materials purchased from suppliers had a problem with chemical stability. This problem is difficult to avoid in the production process and thus affected to the final peak temp.	Material
2.Appearance	Finished good stuck in the packing tank which has a heat cumulative making the temperature higher than 30°c. The composite resin will turn to turbid liquid instead of clear liquid if it is stuck more than 2 hours.	Method
3.Shelf life	Finished good left over in production plant. After adjusting specifications composite resin becomes a finished good. The aging of the final product will be shorter if waiting is not store at 25°c within 6 hours.	Method
4.Cured time	QC staff did not follow to the standardized testing method by using the wrong testing conditions and instruments.	Man
5.Color	Poor quality of starting raw materials (Melic Anhydride and Adipic acid). It makes the composite resin turn to a yellow color instead of a transparent liquid.	Material
6.Molecular weight	Machine break down during conversion process causes uncontrollable reactor temperature. Thus, the conversion process time cannot follow the temperature profile.	Machine
7.Acid value	Unstable acid concentration of starting raw materials from suppliers (Melic Anhydride and Adipic acid) which affects the end acid value of the final product.	Material
8.%Non-volatile	Production staff add too much solvent than the chemical formula defined in the work order.	Man
9.Viscosity	Low accuracy and precision of testing instrument (Viscometer) does not follow the calibration due date.	Measurement

Source: Company data

3.1.3 Indication of Internal and External Factor (Uncontrollable)

From the problem elaboration cause of product defect it illustrates that there are many factors affecting product quality including both internal and external factors. Kaoru Ishikawa (1968) described the common uses of the 5M's analysis are design to control product quality and defect prevention, to identify consequential factors causing a product defect problems. Causes are grouped into major categories to identify these sources of problems. The 5 M's categories typically include Method, Manpower, Materials, Machinery and Measurement. Uncontrollable external factors and internal factors from the production department are shown in table 3.3.

Table 3.3: Indication of Internal and External factor (Uncontrollable)

Internal factor	External factor (Uncontrollable)
Method – Delay in production process	Material – Poor quality raw material from suppliers
	Machinery – Inefficient preventive maintenance plan
	Measurement – Low accuracy of testing instrument not follow calibration due date
	Man – QA staff testing error use wrong testing method

Source: Company data

From table 3.3 the internal and external factors are indicated by using 5 M's method described in the following: External factors mean the uncontrollable factor from outer production department including 1) Poor quality of raw material from many sources of suppliers 2) Machine breakdowns during production process caused by inefficient preventive maintenance plans and unsupported spare parts from the maintenance department 3) Measurement problems from the quality assurance department staff using wrong testing methods and 4) Man caused by human error in the working process.

For internal factors in the production department, working procedures of the production process need to be controlled following a standard time. The product quality problems involved appearance and shelf life caused by defect of internal problems of the production department because of the delay in the production process. Many times finished good leave in the packing tank which has a heated cumulative making the temperature rise to higher than 30°c. The composite resin will turn opaque instead of a clear liquid if it is stuck more than 3 hours and the problem of the shelf life stability if finished product are not stored in a controlled temperature within 6 hours.

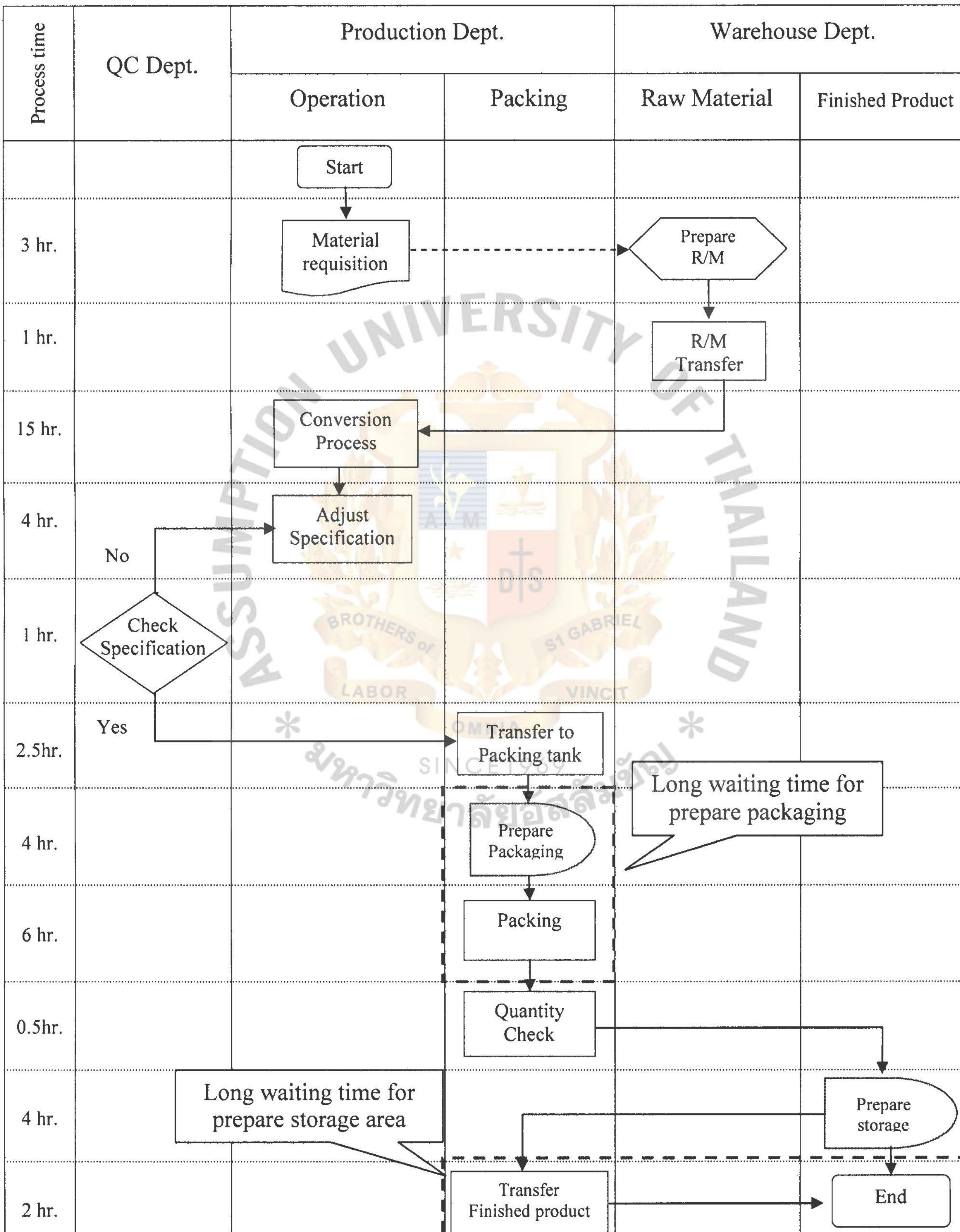
Thus, this research will focus on the appearance and shelf life defect problems because from the data analysis it shows that these two problems occur in the production process. It is a responsibility of the production department to correct internal factors and reduce defective product quantity to meet quality objective targets. Emphasizing on improving production process by reducing waiting time in the production process and smoothing the internal supply chain while working to reduce the problems of appearance and shelf life.

3.2 Mapping "As-Is Process"

The main purpose of this step is to elaborating the current production process maps and understand the activities in each process which could indicate the problems taking place in the ABC production process. The mapping is used as a technique designed to illustrate and understand the process more effectively. After the process was drawn, it was constructed in the process flow chart of both internal and external department activities. The processes mapping illustrates the overall processes to provide a better understanding of both information and production processes flows from the beginning of the process, starting from the materials requisition of raw material until the finished goods are transferred from the production plant to store in the warehouse. The needed data for this step was obtained from the production procedure.

The beginning of the production process is when the production department created a work order of the product meanwhile the material requisition document automatically creates a bill of material then sends it to the warehouse department. After raw materials are prepared following the bill of material, it's transferred to the production plant. Next, the operator starts to check the amount of raw material then charge it into the reactor. The conversion process of heating raw material in the reactor until completes the process time control then cooling and transferring the intermediate product to dilution tank. In the dilution tank the additives are added to intermediate product and adjusted the specification as defined in the work order for making it become a finished good. Next, filtration is done to make composite resin clean if not it will be filtered again. When the cleanliness is passed the finished goods are transferred to the packing tank and they check the specification before packing them into the drum. After packing is done the finished goods are transferred to be stored in the warehouse which is controlled at the temperature of 25°c for maintaining the appearance and shelf life of the finished product. The processes mapping illustrates the overall processes to provide a better understanding of both information and production processes flows shown in Figure 3.2.

Figure 3.2: Current Production Process of Composite Resin



From the current processes mapping it found 2 activities delaying the production process which are prepare packaging and transferring finished goods to store in the warehouse. These activities are delays of the production process and affect to product quality because the finished goods of the composite resin need to be stored in a controlled temperature warehouse at 25°c to keep a clear appearance and maintain their shelf life stability.

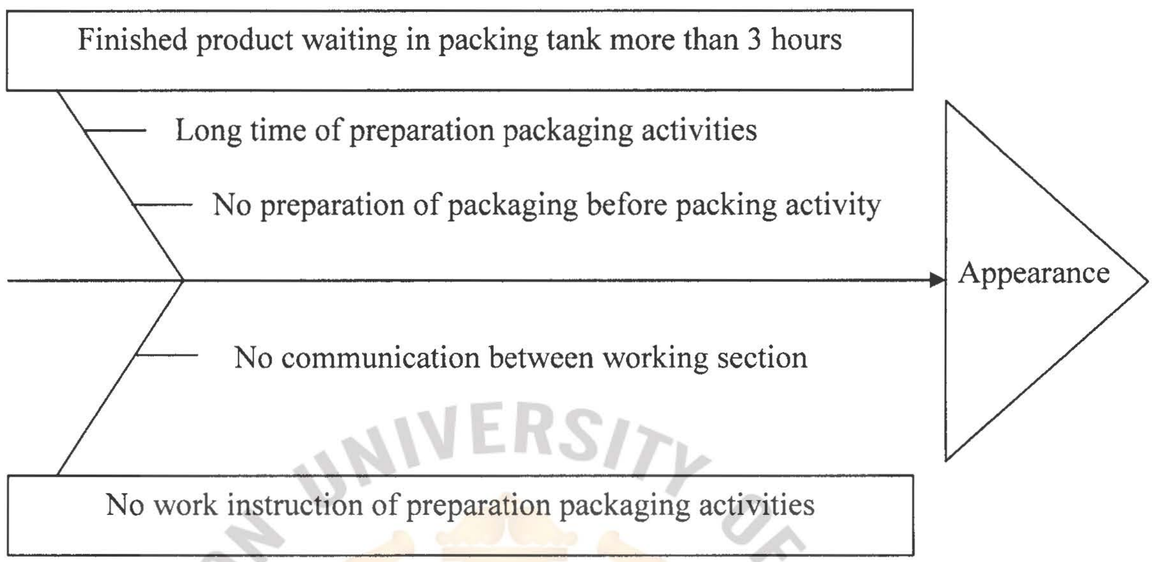
3.3 Analyze "As-Is Process"

The purpose of this step is to analyze the current existing process and identify root causes of problems that have an impact in the product quality of the appearance and shelf life of the composite resin. In order to understand the root cause of the problem, a cause-and-effect diagram technique is selected. The purpose of implementing the cause and effect diagram in this research is to identify the root cause of the appearance and shelf life of the problem will be identified in the fish bone diagram.

3.3.1 Root Cause Analysis of Appearance Problem

In order to identify the cause of the defective product in the appearance problem the document review of the finished product testing report is necessary. From the report it described that the appearance of composite resin will become an opaque liquid instead of clear liquid because the finished product is spending a long time at a temperature of 30°c for more than 3 hours. Therefore in production process at packing activities the finished product is waiting in the packing tank with heat cumulative temperature at 32°c to 35°c for a long time causing defects in appearance problem the reasons are shown in Figure 3.3

Figure 3.3: Cause and Effect Diagram of Appearance Problem

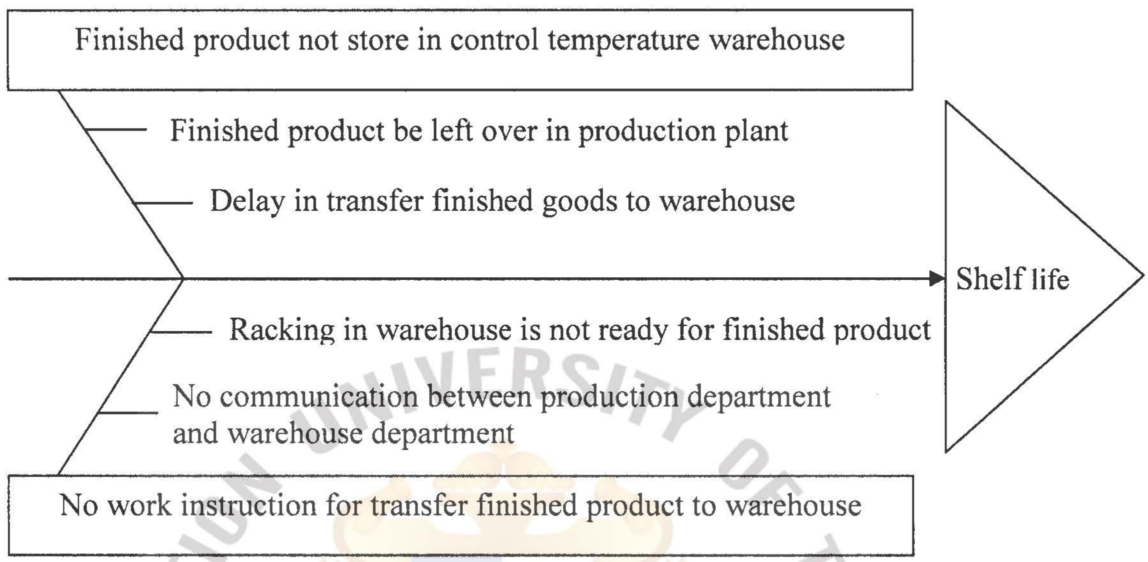


The results from the cause and effect diagram of appearance problems shows the main problem because of no work instruction for packaging preparation before the finished goods are done. Packaging preparation including loading drums into packing area, making product labels and checking packaging cleanliness. Another cause is no communication between working sections making delays in packing activity. Hence finished products are waiting in a warm packing tank for more than 3 hours.

3.3.2 Root Cause Analysis of Shelf Life Problem

After document review is finished the product testing report showed that the composite resin shelf life stability is under the control of the finished product temperature after filling it into drums. The specific temperature to keep a long shelf life stability is at 25°c, if higher than this a shelf life of composite resin will be shorter. From process mapping the finished product needs to be stored in the warehouse which can control the temperature at 25°c instead of the production plant. Causes of defects in shelf life problems are shown in Figure 3.4.

Figure 3.4: Cause and Effect Diagram of Shelf Life Problem



Result from the cause and effect diagram of the shelf life problem show the main problem is because of no work instructions for transferring finished goods to store in the warehouse. The finished product cannot be transferred to be stored in the warehouse because racking in the warehouse is not ready for finished products. Warehouse department needs to set a racking number for finished product in order to follow the FIFO system. Thus there is a problem of working activity between the production and warehouse department.

From root cause analysis of both defective product problem appearance and shelf life is from activities at the end of the production process which are packaging preparation and transfer of finished products to be stored in the warehouse. Identical problems have no instructions for critical activities in the production process and lead to long waiting times occurring in the packing activities and delaying the transfer of finished products to be stored in the warehouse.

3.4 Identify "To-Be Process"

The main objective of this step is to propose the improved process for solving the problems in the production process. The focus will be on the packaging preparation activity and transfer of finished products to the warehouse. The work instruction system will create to promote the effective and efficient work flow between the internal supply chain. Based on the analysis of the production process, critical areas were found that have the most impact on the delay of the process time of both inbound and outbound processes had been selected, analyzed and identified for improvement.

The expected results focused on two activities, waiting time for packaging preparation and delay in transfer of finished products to the warehouse. The waiting time for packaging preparation starts counting from the specification and is passed until starting to fill into the drums. The process time is measured based on the actual performance in the production department. The delayed problem of transfer finished products to store in the warehouse is counted after the production manager approved the finished product transaction document and sent it to the warehouse department. The improved performance of the working flow by creating work instructions between production and warehouses will be propose in this step.

3.5 Develop an Implementation Plan

This step will develop an implementation plan following the production process improvement. The objective is to improve the working flow between internal supply chain performance by reduce waiting time in packing activity and reducing delays of the transfer of finished goods to store in the warehouse. Moreover, to improve the working flow performance the work instruction will apply in to-be process and then implemented in order to control the production process time at critical activities that affect the product qualities. The implementation plan will involve internal departments, different working sections and external departments concerned in the internal supply chain. In this case, internal is between processes and packing teams in the production department. External department is between the production and the warehouse department.

3.6 Assess New Process and Methodology

This step of the BPI methodology will assess improved processes or process validation. The objective is to evaluate new processes after implement by collecting data and comparing it between as-is and to-be processes. Process validation is the collection and evaluation from the process design stage which establishes significant evidence that new processes are capable of consistent production process improvement. The evaluation takes the process improvement in order to measure that the process is meeting goals and objectives and whether additional improvements and/or analysis may be needed. Comparing the measurements with the expected results with the goals and objectives for the process. This is completed on a regular basis to be sure the process is meeting the desired outcomes.

CHAPTER IV

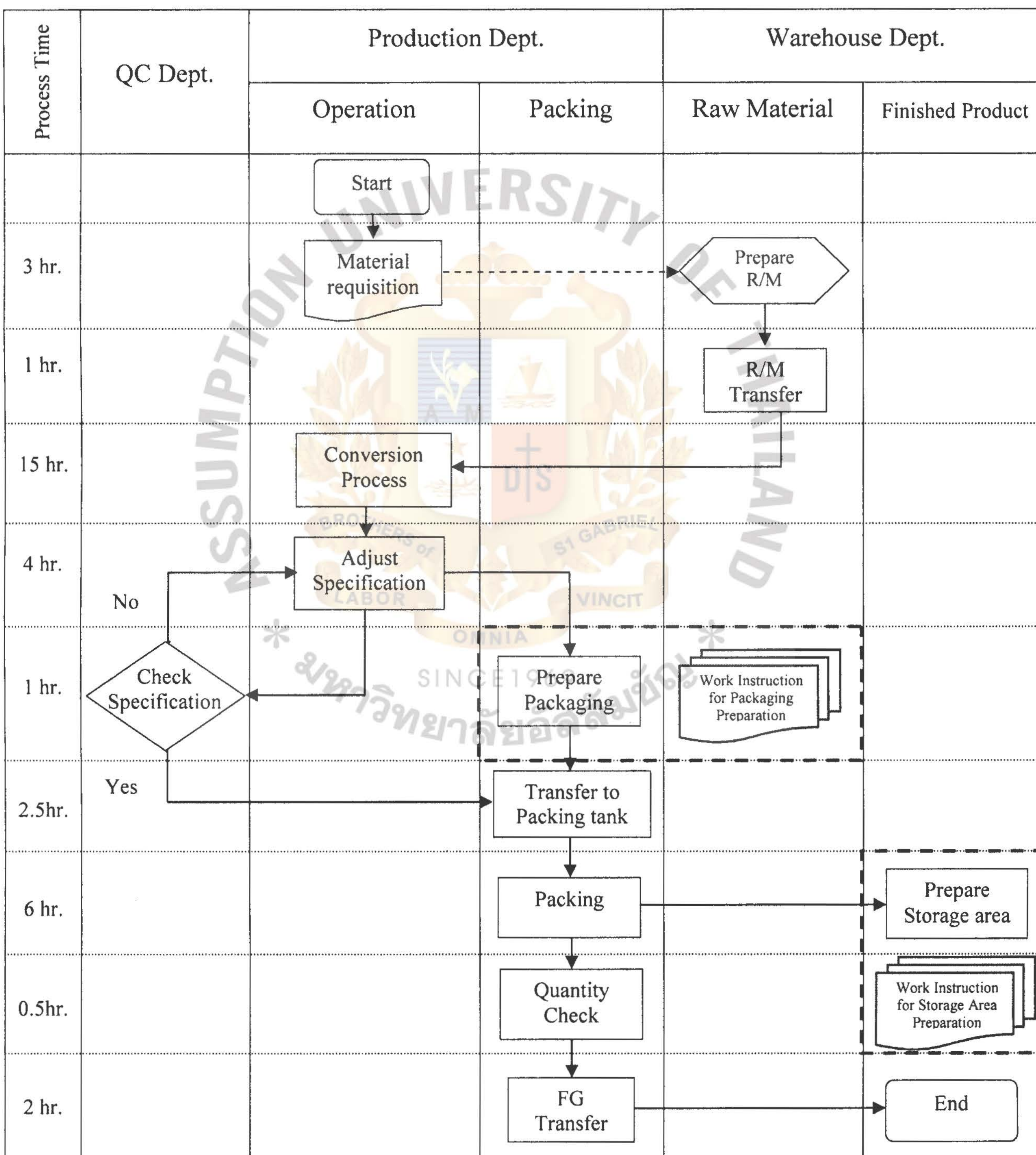
PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

The previous chapters illustrate the results of the data collection and analysis to identify problems. From the document review of composite resin production process it found that appearance and shelf life defect problems are caused from delaying at the end of production process at packing and transfer finished products to the warehouse. Moreover the results found the root cause of the appearance and shelf life problems is the communication problem of internal supply chain. In this chapter, by applying the Business Process Improvement (BPI) methodology to propose "to-be" process to improve working flow of composite resin production process by creating work instructions for controlling the production time and smoothing the communication within the internal supply chain. The development of an implementation plan will be adopted to verify each working section and new process assessment by benchmarking between "as-is" and "to-be" process for measuring the performance of improved processes.

4.1 Identify "To-Be Process"

This section of the research shows the proposed improvement to the"To-Be process" for solving the problem in the production process. From observation techniques it found critical problems of delay in two activities which are waiting time for packaging preparation and delay in transfer of finished product to the warehouse. After the conversion process in done, finished product is filled into a drum otherwise if it is waiting in the packing tank which has a heat the appearance will turn into turbid liquid instead of transparent liquid. The delayed problem of transferring finished products to store in the warehouse is counted after the production manager approved the finished product transaction document and sent it to the warehouse department. The improve performance of working flow by established work instruction for inter production department working section which is between the operation and the packing team and also across internal supply chain which is between the production and the warehouse department show in Figure 4.1.

Figure 4.1: To-Be Production Process of Composite Resin



From figure 4.1 it illustrates the improved production process including work instructions for packaging preparations before packing activity and storage preparations before transfer of finished product to the warehouse.

4.1.1 Eliminate Waiting Time for Packaging Preparation

From chapter 3 it found the cause of finished product appearance problems was delays at the packing activity, finished product waiting in the packing tank because no preparation of packaging before the specification is passed. The problem of this situation comes from no work instruction for operators to describe the working steps between working sections that leads to miscommunication in the production process.

According to the to-be process they describe the addition of work instruction of packaging preparation in the production process in order to solve the problem of delay at the end of a process which is packing activity. Work instructions of the packaging preparation (see in Appendix C) described the working steps and communication between operations and the packing team in order to control production process time by eliminate waiting for packaging preparation.

In conclusion of this work instruction, first at the beginning of the working shift operation and packing team planning packaging preparation before the production process is reached to adjust specification activity. Foreman of the operation team would send work orders of packaging preparation (see in Appendix D) to foreman of packing team in order to report the results of and control prepared packaging which is a drum. Packaging Preparation steps include 1) load drum into packing area 2) prepare finished product name and lot number and 3) check amount of the drum. Finally, packing teams to summit work orders to the operations team for reporting the status of packaging before packing activity.

4.1.2 Eliminate Waiting Time for Storage Preparation

From root cause analysis of finished product shelf life problem, it was found the major problems of delay in transfer finished product to store in the warehouse. Finished product is left over in production plants and cannot be transferred to store in the warehouse because racking in warehouse is not ready for finished products. The problem of this situation comes from no work instructions for operators to describe the working steps between the production and the warehouse department that lead to miscommunication of the transfer of finished goods to store in the warehouse.

From to-be process it shows the improvement of the production process by creating work instruction to clarify steps of the transfer of finished products from production plant to the warehouse storage. Work instruction of the transfer of finished products (see in Appendix E) described the step of linkage in internal supply chain which are production and warehouse department. Moreover in order to increase the production process performance by applying planning schedules of the transfer of finished products form (see in Appendix F) that help production and warehouse planning together to make sure that storage is ready for receive finished product from production plant.

Thus, the improved process including work instruction for operator to clarify step of working and planning schedule between both side of working function which are production and warehouse might help to reduce miscommunication problem and eliminate waiting time for storage preparation.

4.2 Develop an Implementation Plan

This section focus on an implementation plan according to proposed improvement in the production process. This could be performed in order to improves the production process performance and eliminate waiting in the working process which are waiting time for packaging preparation and waiting time to prepare storage areas in the warehouse. According to improved process by addition of work instruction for packaging preparation, preparing the storage area in the warehouse to clarify steps of the working process of both inbound and outbound processes. The implementation plan involved internal production department and across internal supply chain function to the warehouse department. Thus, to illustrate the focus of the implementation plan, the master schedule plan for process improvement including internal production department and across functional department is presented in Appendix G.

4.3 Assess New Process and Methodology

This step illustrate the assessment of improved processes in order to verify the applicable of the methodology. The objective of this step is to evaluate improved process after implementing collected data and comparing it between as-is and to-be processes. Process validation is the collection and evaluation from the process design stage which establishes significant evidence that improved process is capable of production process improvement. The assessment is to measure the improved process is meeting research objectives and whether additional improvements and/or analysis may be needed. Compared to the results before and after improving to verify the effectiveness of the methodology. The result are shown in table 4.1.

Table 4.1: Comparison Result of Current Process and Improved Process

Step	Activity in Production Process	As –IS (hr.)	To be (hr.)
1	Material requisition	1	1
2	Prepare Raw material	3	3
3	Transfer raw material	1	1
4	Conversion process	15	15
5	Adjust specification	4	4
6	Check specification	1	1
7	Transfer to packing tank	2.5	2.5
8	Waiting for Prepare packaging	4	0
9	Packing	6	6
10	Quantity check	0.5	0.5
11	Waiting for Prepare storage	4	0
12	Transfer Finished product to warehouse	2	2
	Total Production Process Time	44	36

From the results in table 4.1 it shows that after implementing BPI methodology to the production process it can eliminate waiting time of packaging preparation and storage area preparation. Moreover, also reduce lead time from 44 hours to 36 hours equal to 18.18% reduction in total production process time.

4.4 Summary

This chapter explained how to improve production process by using Business Process Improvement (BPI). Data collected by using observation techniques and used to construct process mapping of composite resin production process. From root cause analysis of the appearance and shelf life product defects two major problems are identified. The first problem is long wait time of finished products in the packing tank before packing process because of a lack of communication between working sections in the production department. The second problem is a delay in the transfer of finished products to store in warehouses to keep the temperature at 25°c for controlling product quality. By applying BPI methodology to the production process they can eliminate waiting time of packaging preparation and storage area preparation. Moreover, also reducing lead time from 44 hours to 36 hours equal to 18.18% reduction in total production process time. New improved production processes combined with implementation plans for a consistent work flow and reducing waiting time are proposed, thus working instructions are created to control the working section and internal supply chain of the company.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This research is focused on the improved production process for ABC company. The improvement mechanism is concerned with business process improvement methodology. Thus, in this chapter it provides the discussion of the findings summary, conclusion, theoretical implication, limitations and recommendation for future research will be presented.

5.1 Summary of the Findings

The purpose of performing this research is to improve the production process for solving product defects of appearance and shelf life of composite resin by reducing waiting time in the production process. From reviewing related literature it indicated that BPI methodology is appropriate to be applied and implemented in this research for solving the quality problems of finished products. ABC is one of many companies that is faced with delays and waiting in the production process. From these problems it attempts to have the research question which is "How to improve production process by using Business Process Improvement (BPI)?" Thus, the objective of this research is stated to find the root causes of quality problems in the production processes.

From the previous chapter, the root cause analysis focused on appearance and shelf life defective product problems of composite resin occurring in the production process. In conclusion, the significant findings obtained from this research are described as follows:

5.5.1 Long Waiting Time for Packaging Preparation

In the production process at the packing activities, the finished product is waiting in a packing tank with heat at a cumulative temperature of 32°c to 35°c for a long time leading to the product defecting in appearance problems. This research found that there is no work instruction for packaging preparation before the finished goods are done. Packaging preparation includes loading drums into the packing area, making product labels and checking packaging cleanliness. Thus, the root cause is no communication between working sections which makes delays in packing activity.

5.5.2 Finished Product Delay to Transfer to Warehouse

To stabilize the finished product quality of the composite resin, after filling finished product into the drum it needs to be stored in a control temperature warehouse. The specified temperature to keep a long shelf life stability is at 25°c; if higher than this a shelf life of composite resin will be shorter. In this case, finished products left over in the production plant which has a high temperature from the surrounding reactors. This research found the problem of communication problems between the production and the warehouse department. Thus, the production staff working without work instructions for transferring finished products to the warehouse.

5.2 Conclusions

This research applied BPI methodology to improve the production process. The problem was identified and analyzed and followed a systematic method of BPI then proposed the improved process. BPI was illustrated to be an efficient methodology to improve the working flow in the production process. In this research, the use of work instructions for improving coordination between working section and the internal supply chain of a company was proposed and implemented. A company would achieve BPI strategy for reducing the future defects of a product of the composite resin production department.

The methodology met the validation criteria of process improvement in terms of usability, efficiency and effectiveness. It has been shown that benefits can be received from using the BPI methodology and is consistent to the research objectives having been successfully achieved.

5.3 Theoretical Implications

This case study used BPI methodology to solve the problem of working flow and information flow that occurred in ABC Company. From this research, it showed that the BPI methodology indicates the systematic approach to solve the problem in this case was applied with the production process. In order to find the right cause of problems, production staff learn to conduct data collection from both primary and secondary data. Primary data is collected by observation techniques in the production process and the secondary data is collected from the document review. Then, mapping current as-is processes and understanding the activities in each process which could indicate the problems taking place in the production process. Cause and effect diagrams are used to identify the root cause of the problems. Thus, the improved production process is proposed to solve the problem.

The intended results of this research illustrated the effectiveness improvement of production process by using BPI methodology. This research also shows the improvement of internal supply chain performance of a company. The reduction in production process time by controlling working flow and reduced time in terms of non-value added. The reduction of waiting time in the production process leads to smoothing the supply chain process from upstream to downstream. Finally, this research shows that BPI is one of the supply chain management methodologies to improve production processes and increase the internal supply chain of a company.

5.4 Managerial Implications

This research would assist ABC Company to indicate the problem of instruction and working flows between inter departments and other departments in the supply chain by using BPI methodology. This research summarized the proposed improvement and implemented processes for reducing the problems of defective products which is caused from delays in the production process. Data collection and identifying problems by using root cause analysis are applied with process mapping is conducted.

Six's steps of BPI are discussed in detail with the current production process of ABC Company.

This research emphasize at internal process the objective is to increase collaboration among company's functional groups. In this research, proposed the implementation plan for production department between working section which are operation and packing teams. For internal supply chains between production and warehouse department to improve instruction and working flows together.

The benefit of this research is ABC Company is able to apply BPI strategy to other working functions for more competitive product results when the various functions of a company understand customer needs, company strategy and work well together.

5.5 Limitations and Recommendations for Future Research

This research data was collected only from the ABC Company. The cause of defective product problems in the production process could be effected by external factors which are uncontrollable causes such as different sources of raw materials, human error of testing methods from other departments and machine breakdowns during production process. Thus some defect products caused from uncontrollable external factors. This research would not cover every cause of defective products due to limitations of the technical data which is the chemical formula of a company. For other companies, the problems and troubleshooting could not be appropriate for other industries because each firm has different production processes due to different kinds of products.

Future research may discover more benefits by applying the BPI strategy with other industries. For BPI methodology in future research, it should analyze the updated data of at least 1 year in order to gain the significant information using in BPI methodology.

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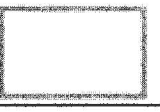
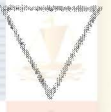
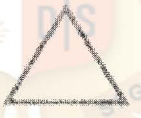
APPENDICES

Appendix A: Table of Defect Product Quantity from July 2013 to June 2014

Defective Item	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Quantity (Tons)	Defective Percentage	Cumulative Quantity	Cumulative Percentage
Peak temp.	109.56	61.79	158.66	175.41	164.95	185.94	202.04	195.59	159.05	134.07	60.43	157.00	1764.50	32.15	1764.50	32.15
Appearance	176.19	164.50	78.88	104.89	95.09	105.26	176.18	119.88	60.30	123.91	113.24	120.13	1438.44	26.21	3202.94	58.37
Shelf life	89.24	35.52	44.88	66.11	37.01	51.80	125.27	36.81	94.50	54.55	120.78	64.57	821.03	14.96	4023.97	73.33
Cured time	81.66	144.93	49.45	79.42	73.79	41.28	33.51	58.04	17.53	85.85	17.05	64.40	746.90	13.61	4770.87	86.94
Color	38.67	59.95	19.79	0.00	47.17	7.73	46.36	0.00	15.83	33.12	45.61	26.17	340.40	6.20	5111.27	93.14
Molecular weight	10.10	8.05	29.75	31.95	25. 55	22.94	36.20	6.84	23.41	21.08	27.63	21.64	265.16	4.83	5376.44	97.97
Acid value	0.00	0.00	0.00	14.01	0.00	0.00	6.70	0.00	37.22	2.80	0.00	6.44	67.16	1.22	5443.59	99.20
%Non-volatile	0.00	0.00	0.00	0.00	0.00	0.00	28.95	0.00	0.00	0.00	0.00	3.22	32.17	0.59	5475.76	99.78
Viscosity	0.00	8.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79	0.24	0.99	11.97	0.22	5487.73	100.00

Appendix B: The Symbols Used in Constructing a Process Flow Chart

Name	Symbol	Description
Process		Process or action step
Flow line		Direction of process flow
Start/ terminator		Start or end point of process flow
Decision		Represents a decision making point
Connector		Inspection point
Inventory		Raw material storage
Inventory		Finished goods storage
Preparation		Initial setup and other preparation steps before start of process flow
Alternate process		Shows a flow which is an alternative to normal flow
Flow line(dashed)		Alternate flow direction of information flow

Appendix C: Work Instruction of Packaging Preparation

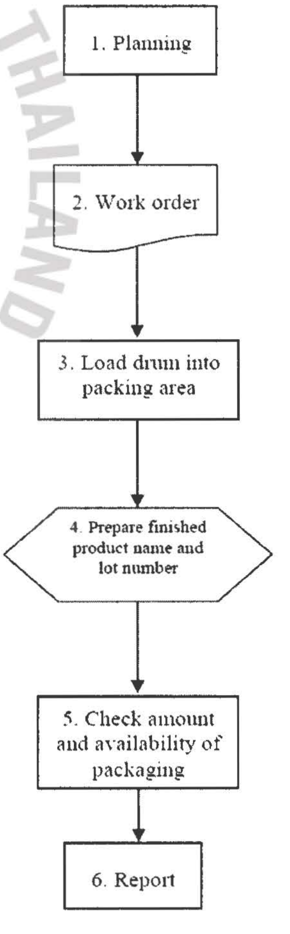
ABC Co., Ltd. Document Number : PD-W-X-XXX	**WORK INSTRUCTION** **Packaging Preparation**	Production Department Prepare Date : Effective Date :

Operator : Operation Foreman, Packing Foreman, Packing Staff

Location : Production Plant / Packing Area

Document Involve : Work Order of Packaging Preparation

Step	Working Description	Working Flow
1.	Operation and packing foreman meeting at the beginning of the shift for planning the packaging preparation before finished product specification pass and transfer to packing tank.	
2.	From planning in step 1. foreman of operation team would prepare work order of packaging preparation including finished product details such as product name, lot number, reactor and time. The summit to foreman packing team.	
3.	Load drum into packing area which is assigned the location in work order.	
4.	Prepare packaging follow steps in work order including packaging details: item number, packing size, lot number of packaging and amount of packaging. For label details: finished product name and lot number.	
5.	Foreman of packing check availability of packing again to make sure that packaging is ready for packing activity from packing tank.	
6.	Foreman of packing summit work order of packaging to operation team for report status of packaging before packing activity then fill finished product into drum.	



Prepared by :	Reviewed by :	Approved by :
Production Supervisor	Production Manager	Factory Manager

Appendix D: Work Order of Packaging Preparation

ABC Company	Work Order of Packaging Preparation	Dept. : Section : Date :

1. Finished Product Details

Product Name	Lot Number	Shop Order	Reactor	Time	Order by (Operation Foreman)	Receive by (Packing Foreman)

2. Packaging Details

Item	Packing Size	Lot Number of Packaging	Status	Amount	Record by (Packing Foreman)

3. Label Details

3.1 Check Lable Plate Name

No.	Product Name	Prepare by (Operator)	Correct		Status	Check by (Packing Foreman)	Remark
			Yes	No			

3.2 Check Lable Plate Number

No.	Product Lot Number	Prepare by (Operator)	Correct		Status	Check by (Packing Foreman)	Remark
			Yes	No			

Prepared By	Received By	Approved By
Packing Foreman ....../....../......	Operation Foreman ....../....../......	Production Supervisor ....../....../......

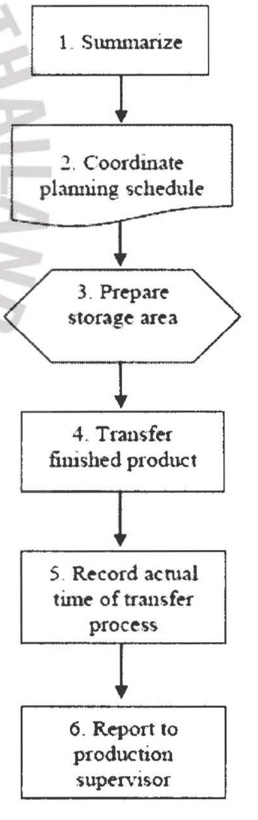
Appendix E: Work Instruction of Transfer Finished Product

ABC Co., Ltd. Document Number : PD-W-X-XXX	**WORK INSTRUCTION** **Transfer Finished Product to Warehouse**	Production Department Prepare Date : Effective Date :

Operator : Packing Foreman (Production dept.), FG Foreman (Warehouse dept.)

Location : Warehouse / Finished product storage

Document Involve : Finished product transfer schedule planning

Step	Working Description	Working Flow
1.	Production department summarize finished product including finished product name, lot number, packing size and amount before transfer to warehouse storage.	
2.	Production and warehouse department coordinate planning the schedule to setup time for transfer finished product from production plant to storage in warehouse.	
3.	Warehouse prepare storage area before receive finished product.	
4.	Production transfer finished product to warehouse storage.	
5.	Packing foreman record actual time from start to the end of transfer process for collect data to analyze performance of the process.	
6.	Packing foreman report actual time to production supervisor.	

Prepared by :	Reviewed by :	Approved by :
Production Supervisor	Production Manager	Factory Manager

Appendix F: Finished Product Transfer Planning

ABC Company	Finished Product Transfer Planning	Dept. : Section : Date :

Planning Schedule								Actual Result	
No.	Finished Product Name	Lot Number	Packing Size (kg)	Amount Drum	Transfer Time	Planner		Transfer to Warehouse	
						Production Dept.	Warehouse Dept.	Start Time	Finished Time

Remark ______________________________

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Planning Report			Result Report
Planning By	Check By	Approve by	Report By
Packing Foreman ....../....../......	Production Supervisor ....../....../......	Production Manager ....../....../......	Packing Supervisor ....../....../......

Appendix G: The Implementation Plan of Improved Production Process

Step	Description phase of production process Improvement	Implemented by	Schedule											
			Month 1				Month 2				Month 3			
1	Conduct training all related staff for understanding in improved process concept.	PD Manager	■											
2	Review the critical point of production process.	PD Manager	■											
3	Draw up work instructions and documents involve in improved process.	PD Supervisor		■	■									
4	Clarify working step and communication flow follow work instructions.	PD Supervisor				■								
5	Pilot improved production process in production line.	PD and WH staff					■	■	■	■				
6	Collect actual result and summarize congestion of the process.	PD and WH staff									■			
7	Verify the result, analyse and report for manager.	PD Supervisor									■			
8	Discuss in the design and performance of improved production process	PD Supervisor PD Manager										■		
9	Conclude the result of improved product.	PD Manager											■	
10	Approve for work instructions and documents involve in improved production process	Factory manager												■