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MATERIAL HANDLING DETERMINATION AND INVENTORY CALCULATION USING LEAN METHODOLOGY APPROACH (CASE STUDY : SOAP BAR PRODUCTION FACTORY)

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ABSTRACT

PT. X is a well known Fast Moving Consumer Good (FMCG) company that has several factory in Indonesia. The research is done in one of the factory located in Rungkut, Surabaya. The research is done in one of the block in the factory which is PW2 whose products are bar soap. In PW2, inventory problem often occured caused by unstable intermediary material flow from PW1. First, an inventory calculation of safety stock calculation is done, and the result show that the most efficient is by using 1000kg big bag. The space that is needed is for 100 big bag and a new layout plan in the substore is constructed. In the Value Stream Mapping, it is known that in the material handling activity, the lead time is 785 minutes. To further analyze the material handling activity, the Process Activity Mapping is done. From the VSM and PAM, it is known that the waste in the material handling activity are motion, transportation, inventory, and waiting. Root Cause Analysis is done to determine the root cause of the wastes. Using lean methodology approach, the lead time for the material handling activity can be reduced into 546,5 minutes.

Keywords : Lean Methodology, Safety Stock, Inventory Calculation, Root Cause Analysis

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PERHITUNGAN PERSEDIAAN DAN PENENTUAN PERPINDAHAN MATERIAL MENGGUNAKAN PENDEKATAN METODOLOGI *LEAN*

(STUDI KASUS : PABRIK SABUN BATANG)

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ABSTRAK

PT. X adalah sebuah perusahaan yang bergerak di bidang *Fast Moving Consumer Good* di Indonesia. Penelitian dilakukan di dalam salah satu pabrik yang dimiliki, bertempat di daerah Rungkut, Surabaya. Di dalam komplek pabrik terdapat beberapa blok, dan penelitian dilakukan di salah satu blok bernama PW2 *(Personal Wash)* dimana produk yang dihasilkan adalah sabun batangan. Terdapat permasalahan persediaan di dalam proses produksi di PW2, dimana alur pasokan bahan perantara dari PW1 tidak stabil dan sering mengalami keterlambatan dan menyebabkan berhentinya proses produksi. Setelah dilakukan perhitungan persediaan menggunakan pendekatan persediaan aman, diketahui persediaan paling efisien mungganakan satuan 1000 kg kantung besar, dan memerlukan ruang sebesar 100 palet. Dalam *Value Stream Mapping* yang dilakukan untuk memetakan proses perpindahan material, diketahui bahwa *lead time* sebanyak 785 menit. *Process Activity Mapping* kemudian dibangun untuk menganalisa lebih jauh, dan diketahui bahwa waktu *value added* sebanyak 59 menit, sedangkan *non value added* sebanyak 36 menit. Dari kedua analisa tersebut, diketahui jenis pemborosan yang terjadi adalah *motion, transportation, inventory,* dan *waiting.* Analisa akar masalah menggunakan metode *5 why's* dilakukan untuk menentukan akar permasalahan dari pembrosan yang terjadi. Saran perbaikan kemudian diberikan menggunakan pendekatan *lean* dan diestimasikan dapat merubah *lead time* menjadi lebih pendek yaitu sebanyak 546,5 menit.

Kata Kunci : *Lean Methodology,* Persediaan Aman, Tata Letak Gudang, Analisa Akar Masalah

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Surabaya, July 23rd 2018

Author

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CHAPTER 1
INTRODUCTION

In this chapter, the discussion on the background, problem formulation, objective, benefits, the scope, and the writing methodology about the research will be done.

1.1. Background

PT *X* is a consumer good company that has been deeply rooted in the daily life of Indonesian people. It was established in 5 December 1933. The company has been performing well, it is shown by the growing number of net sales. The graphic below will show the total net sales:

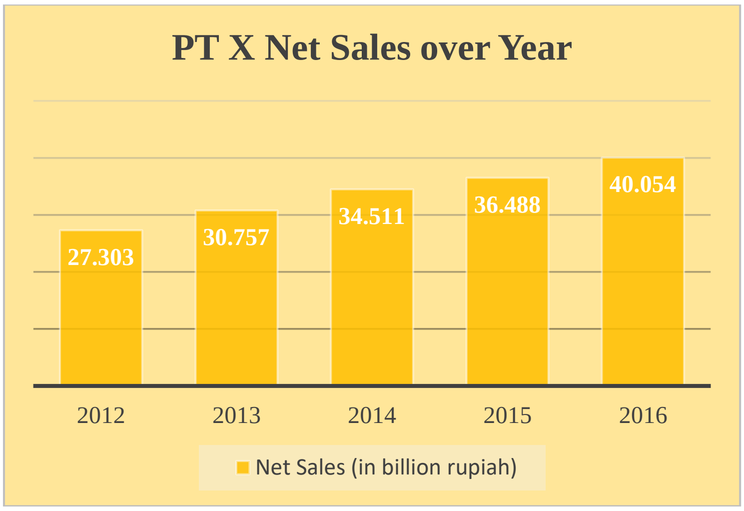

Figure 1.1 Total Net Sales over Year
(Source: Company Annual Report 2016)

From figure 1.1 , it is known that the total sales has been steadily increased overtime. It is contributed from the sales of the brands of PT. X .The brands that are produced by X varies greatly, but it can be categorized into two types, which are home and personal care, and foods and refreshment. Some example of the home and personal care brands are laundry detergents soaps, and tooth pastes. While some example of the foods and refreshment brands are bagged tea, various seasoning, and ice cream. The total sales of both category are also steadily increasing by 9.0% and 11.7% respectively

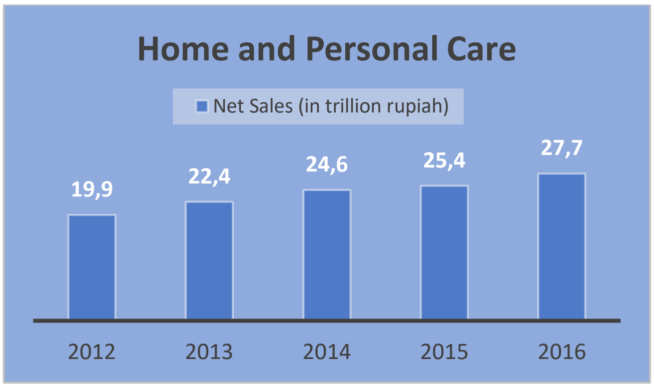

Figure 1.2 Health and Personal Care Category Net Sales
(Source: Company Annual Report 2016)

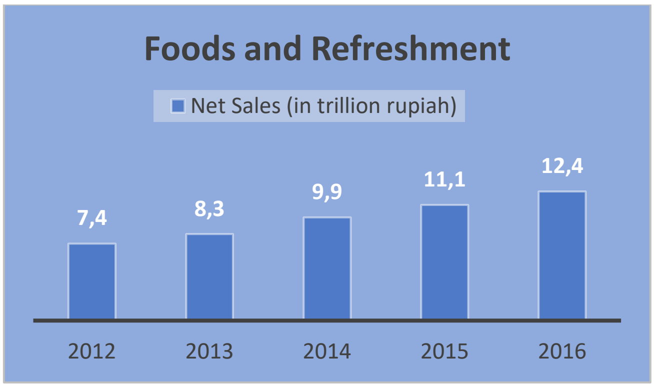

Figure 1.3 Foods and Refreshment Category Net Sales
(Source: Company Annual Report 2016)

The company has 9 factories located in Jababeka Industrial Zone, Cikarang, and Rungkut. The research will be done in the Factory located in Rungkut, Surabaya FactoryThe Factory produces a variety of product that is home and personal care products.Several product that are produced includes toothpaste, soap, and shampoo. The product that are produced here is then distributed to several customer ranging from market retailer, another distributor, or super market in most area of Eastern Java and Bali.

. In general, there are two kind of factory in Rungkut factory, each with different product produced. The first is PC (Personal Care) factory. As it is named, in this factory personal care products such as face wash, shampoo, and toothpaste are produced. The second is PW (Personal Wash) factory. In the PW factory, soap bar products with several brands like lifebuoy and lux are produced.

There are 2 factory of PW, coded PW 1 and PW 2. In PW 1, the raw material are processed into intermediary material. In this case the intermediary material are the soap chip. After the intermediary material are produced, it is sent to the packaging line, located in both PW1 and PW2. In PW 2 there are three line of production that transform the soap chip into finished product. The production line are operating 24 hours in 3 shift of worker, 6 days a week, with holiday on Sunday each week.

Because the facility of PW 1 and PW 2 are in separate buildings, there are material handling process to transport the intermediate material from PW 1 plant to PW 2 plant. To accomodate the material handling and transportation activity between the two facilities, there are a substorage in each of the facilities. A shuttle truck to transport the intermediate material from PW 1 to PW 2 sub storage also operate in each shift. In this final project, the process that will be observed will be the material handling process between PW1 and PW2.

Based on the production manager, a new regulation are to be implemented to the material handling process between PW 1 and PW 2. A mandatory 4 to 8 hours store time before the intermediate material are being processed in the next step are being implemented. This regulation is implemented to prevent cloging in the silo and mixer of the soap bar making process in the production line. The cloging may happen if the soap chip transported from the PW1 still have certain level of humidity. The humidity may dried in the side of the silo or the mixer machine, causing the silo or machine clogged and reduce its efficienccy. Not only reducing efficiency, it also lead to increasing cost to maintain the silo and mixer to clean the clogged soap chip.

This lead to a need of new plan of how the material handling and transportation activity are going to be conveyed with the new regulation. A new plan and decision on how the inventory level going to be set in the substorages are also needed. The current material handling has a lot of inneficiency. The inneficiency are caused by the unmatched unit of material between the substorage of PW 1 and PW 2. Also the different shift caused a variety of productivity between different operator.

Perumal (2014) define lean manufacturing as an operation; strategy oriented towards achieving shortest possible cycle time by eliminating waste. Furthermore, Manos and Vincent (2012) said that lean manufacturing is an approach to improve the product quality, improve productivity, reducing cost, and improving the customer satisfaction by eliminating waste. Although the lean manufacturing are initially developed to tackle the problem in automotive production process, it can be implemented in any kind of business process, including in material handling process (Acharyaa, Tuhsar K., 2011). The inneficiency of the material handling process can be analyzed according to lean methodology and then improved. Designing a new material handling activity according to the new rule also can be helped by implementing the lean manufacturing principle. By implementing the lean manufacturing principle, the new process will be more efficient although a longer cycle time caused by the mandatory store time before processing.

Based on the described above, in this research, the inneficiency of material handling activity will be analyzed using lean methodology method. First the process will be captured and defined by using value stream mapping and process activity mapping. Next the root cause of the waste and inefficiency in the material handling process will be analyzed using root cause analysis. The final process will be designing the new material handling activity. The inventory level will also be calculated by matching production rate and adding safety stock to the inventory in substore 2.

1.2. Problem Formulation

Based on the background discussion and the problem that has been shown in previous subchapter, then the problem formulation that will be solved in this final project will be how to improve the material transportation process by using lean methodology and determining the optimal inventory level in PW2 substorage at bar soap factory of the company.

1.3. Objective

The objectives for this final projects will be:

1. Defining the wastes of material handling process at the bar soap factory
2. Defining the root cause of the waste at the bar soap factory material handling process.
3. Determining the optimal inventory level in PW1 and PW2 substorage at the bar soap factory.
4. Developing improvement suggestion to tackle the waste in the bar soap factory.

1.4. Benefit

The benefits that will be gained from this final projects are:

1. PT. X bar soap factory in Rungkut can get a reference on how will the inventory level of bigbag in substore 2
2. PT. X bar soap factory in Rungkut can get reference on how to improve material handling activity using lean methodology approach
3. PT. X bar soap factory in Rungkut overall efectiveness and efficiency in material transportation process will be improved.

1.5. Research Scope

The research scope of this final project will include boundary and assumption

1.5.1. Boundary

The boundary in this final project will be:

1. The transportation process observed is material transportation process between PW1 and PW2 substorage.
2. The observation time is limited in the first and second shift, but all the worker teams are observed

1.5.2. Assumption

The assumption used in the final project are:

1. The PW1 and PW2 three production line is assumpted to be a black box

2. The production number of PW 2 is considered as demand in EOQ calculation and assumpted to be constant
3. The PW2 substorage has sufficient capacity to store the optimal inventory level.

1.6. Writing Methodology

The writing of the final project consist of several chapter. Each chapter is related with the next chapter, so the writing will be systematic and berurutan in accordance to the activity done to do the analysis and problem solving in the research. The writing systematic done in this final project are:

CHAPTER I INTRODUCTION

In this chapter the background of the research will be described and discussed. After that the problem formulation, objective, benefit, and research scope will be also described. The last part of the chapter is the writing methodology.

CHAPTER II LITERATURE REVIEW

In literature review, the theory, concepts, and method that become the foundation of the research will be described. The theory and methods described are based on the literature used such as books, papers, journals, and preceding research. The theory that will be discussed are lean manufacturing, waste classification, lean assesment, lean radar chart, fuzzy logic, value stream mapping, Brown-Gibson method, and economic order quantity.

CHAPTER III RESEARCH METHODOLOGY

In this chapter, the overall methodology used in the research will be described. The methodology dexplained the research flow and framework of the final project.

CHAPTER IV DATA COLLECTION AND PROCESSING

In this chapter, the data collection and processing methodology used in the research will be implemented and described. The data collection and processing will be explained systematically and in detail so that the result from the colecting and processing will be mathed with the objective of the research.

CHAPTER V ANALYSIS AND IMPROVEMENT PLANNING

In this chapter, the analysis of the result from the data collection and processing will be done. After the analysis is done, an improvement plan is constructed based on the result of the analysis.

CHAPTER VI CONCLUSSION AND RECOMENDATION

In this chapter, the conclusion of the research will be drawn. The conclusion drawn based on the result and finding of the data collection, processing, analysis, and improvement plan constructed. The recomendation is then written to the object of the research and also to help in upcoming research in the same field.

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CHAPTER 2
LITERATURE REVIEW

In this chapter, the methode and term that is used troughout this research will be reviewed and discussed. Those methods and terms include Lean Manufacturing, Value Stream Mapping, Process Activity Mapping, Root Cause Analysis, and Safety Stock Calculation

The diagram in figure 2.1 will show the theory framework of the term that used in the final project and described in this chapter.

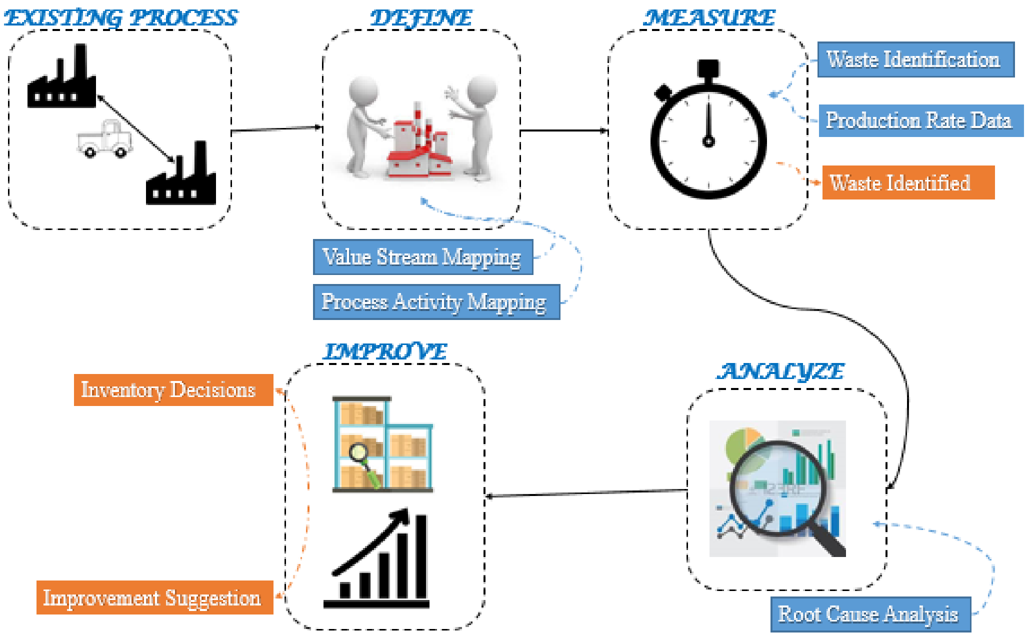

Figure 2.1 Theoritical Framework

The theory framework are following the basic of lean methodology framework, the DMAIC (Define, Measure, Analyse, Improve, and Control). First the basic theory of lean manufacturing and waste classification will be defined in 2.1 and 2.2. The value stream mapping will help in define phase to define the existing process. Value stream mapping, lean assesment, fuzzy logic, and lean radar chart will help in the measure phase. After that the root cause analysis will process the result from measure phase. It will show the root cause of problem identified from the define and measure phase. The last in the improve phase, the economic order quantity analysis will be done to determine the optimal storing level that comply with the new company regulation and the result from lean methodology analysis.

2.1. Lean Manufacturing

Lean manufacturing is a philosophy based on the desire to create the most effective and efficient production process, by eliminating unnecesary waste and adding more value to the production process. There are many definition based on the experts. Puvanasvaran (2014) define lean manufacturing as an operation; strategy oriented towards achieving shortest possible cycle time by eliminating waste. Liker (2004) said that lean manufacturing is a process management philosophy originated from Toyota Production System (TPS) that emphasize on the elimination of seven wastes for the objective of improving the overall consumen sattisfaction.

As said in the previous pharagraph, Lean manufacuring is originated from Toyota Production System (TPS) from Japan. The development of Lean is started after the world war II. At the time, Japan wants to rebuild the economy of post war. The Japanese realized that ther need to work in smarter wats to take in the US auto giants of Ford, General Motors and Chrysler. The Japanese then create a continuous progressive way of only producing what the customer want, when they want it, how much the customer want it, using the least ressource to fulfill the customer demand.

This philosophy is a bit radical at the time, because at the time, the western automotive giant thinks that to gain additional profit is to improve the manufacturing process, which is adding more cost to manufacturing cost, and then they can raise the selling price to the customer. Different with lean philosophy where to gain profit, they reduce the unnecesary manufacturing process, without compromising what the customer really want from the product. This way of adding profit by the retrenchment of the manufacturing cost tend to stabilize the selling price which attract more consumer.

To implement the Lean manufacturing, Gasperz (2006) said there are five princpile of it. Those principle are:

1. Defining what value is only from the perspective of the customer

   To defining what is value added and non value added, the value must be driven from the customer perspective because the end customer will pay for the product produced
2. Identify the value stream

   After the value is identified, identify how the value are done in the production process. Which process is actually adding to the value customer want and which process don't actually add to the value that the customer want.
3. Continuous flow process

   Continuous flow process is a principle to try to make the production process run continuously without any hindrance. This principle is done after the process which add the value to the value stream has been identified and now try to make the value addition process hinderless.
4. Pull system

   Pull system is the principle where the company only focuses on the customer need. By focusing on customer need, the production process will only produce the product in the right amount, right time,and right quality of which the customer wants.
5. Strive to perfection

   Is a principle that set the work culture of the company. This principle state that there is no perfect condition or the best solution. There only be better and better solution, so that every personal in the company must strive for a better solution.

2.2. Waste Classification

Waste is defined as every activity done in production process which is not adding value in altering the input into output along the value stream (Gasperz, 2006). In production process, this waste must be eliminated in order to make a lean production system. Gasperz then divided the waste into two type of waste, type 1 waste, and type 2 waste.

a. Type 1 waste

   Type 1 waste is the waste that present in the production process and cannot be completely removed in the production process. This is because the waste is necessarily needed in order to run the production process. For exampe the activity of coordination between worker to solve some special case production in that day. In the future, this type 1 waste need to be diminished in order to create more lean production sysytem

b. Type 2 waste

   Type 2 waste is the waste that truly doesn't add any value to the value stream. This type of waste need to be eliminated completely from the production process. Some example of this type of waste are producing defect product, or excessive motion.

The two type of waste is then explained further in the 7 type of deadly waste. Those 7 type of wastes are:

1. Defects

   This waste is related to the activity where defect product are produced. This waste make loss to the production process by employing more resource in term of rework and loss time to fix the defect product.

2. Overprocessing

   This waste is related to the unnecesarry process or activity that is done in the production process to add value to the product. This waste can happen because of the poor quality of the machine, poorly designed work method, or poorly designed product. This waste also related in producing a product with higher quality then what the customer needed.

3. Over Production

   Producing product that is not going to be bought by the customer is considered as overproduction waste. This waste basically waste many thing when done such as the time to produce it, the labour needed to produce it, and the material need to produce it. Producing only the amount that the customer will buy is very important.

4. Waiting

   Waiting is an activity caused by bottleneck event happen in the production line. This waste make a certain production process to wait for the previous process to be done to then process the product. This create unnecesary payment to the idle worker and machine waiting for working. Usually this waste happen by the unbalanced production line layout.

5. Motion

   Every motion of the worker that not necessarily adding value to the value stream is a motion type waste. Some example such as excessive walking, unnecesary reaching motion, excessive searching for a specific tool.

6. Inventory

   Excessive inventory is considered as a waste. Stocking raw material that is not going to be processed into finished product causing inventory cost to rise. Stocking raw material also raise the risk of the material to become damaged or outdated in the warehouse. Outdated material cannot be processed and thus causing a bigger loss in the company revenue.

7. Transportation

   This type of waste related to the unnecesary transportation activity to move material or work in process product. Excessive and uneffiient transportation from warehouse to the production floor or from one work station to another station need to be reduced or eliminated to create lean production system.

2.3. Value Stream Mapping

Value Stream Mapping is a diagram whose purpose is to map the production or activity process. AICS Dictionary (2005) define value stream mapping as the processes to construct, produce, or product hand-over to the market. For a production process, value stream mapping include the wole process from raw material supply, manufacturing and product assembly, to the distribution network to the user of the product (Gasperz, 2007)

Value stream mapping will identify the source of wastes along the value stream in the process. This mapping and identifying will help produce a better, more accurate solution to improve the business or production process. Without the mapping, a lean project may lead to innacurate solution or worsening the situation. VSM can provide an optimal turning point for a company that wants to implement the lean philosophy in their business process. (SdRother & Shook, 2003)

Aside from mapping the current process, VSM can also be built to design the future process. That is why VSM can be categorized into two categories based on the implementation state. The first is the current state map that map the current process, and the second is the future state map that map the future process after the suggested improvement is made.(Fariz *et al*, 2013)

There are steps to conduct improvement by using the value stream mapping. According to Abdullah (2003), steps that are needed to conduct improvement by using VSM are:

1. Identify the family product

   The purpose of identifying the family product or service is to simplify the processes in the value stream. Mapping process focuses on the product or service generation activity that has a complicated process and vary a lot, so by grouping the product or service by family will simplify the mapping process.

2. Construction of the current state map

   The construction of current state map is done based on the current activity and condition of the company. The value stream must includes all process starting from consumer order, operation process of the company, until the finished product or service arrived at the customer. The material and information flow are also included in the value stream mapping.

3. Identify the problem or wastes in the current state map

   In this phase, the identifying process of problem or waste along the value stream is done. The waste from the activity can be seen from the three category of activity. Those categories are value added activity, non value added activity, and necessary non value added activity

4. Construction of the future state map

   After the problem and waste are identified, and solution has been planned, the future state map is constructed. The future state map can be compared to the current state map to identify the benefit from improvement planned

5. Implementation of the final plan

   After the planning and the future state map is constructed, the final solution planned are implemented to the production or business process.

In constructing the value stream mapping, there are icons used. The icons used in value stream mapping are combined with the icons used in flowchart. This make the value stream mapping has unique shape to better visualize the value stream process. (Nash & Polling, 2008). The icons used in the value stream mapping and an example og VSM will be shown in figure 2.3 and figure 2.4.

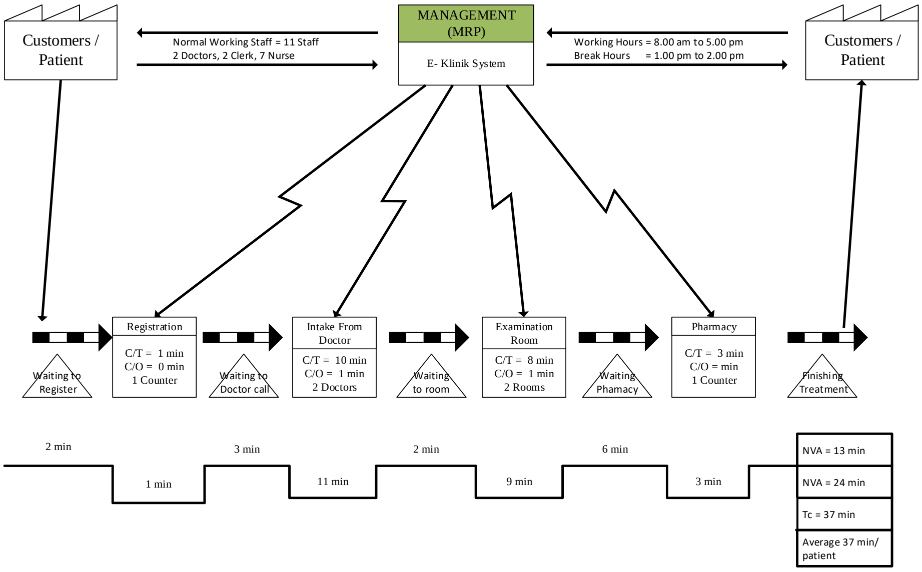

Figure 2.2 Example of a VSM

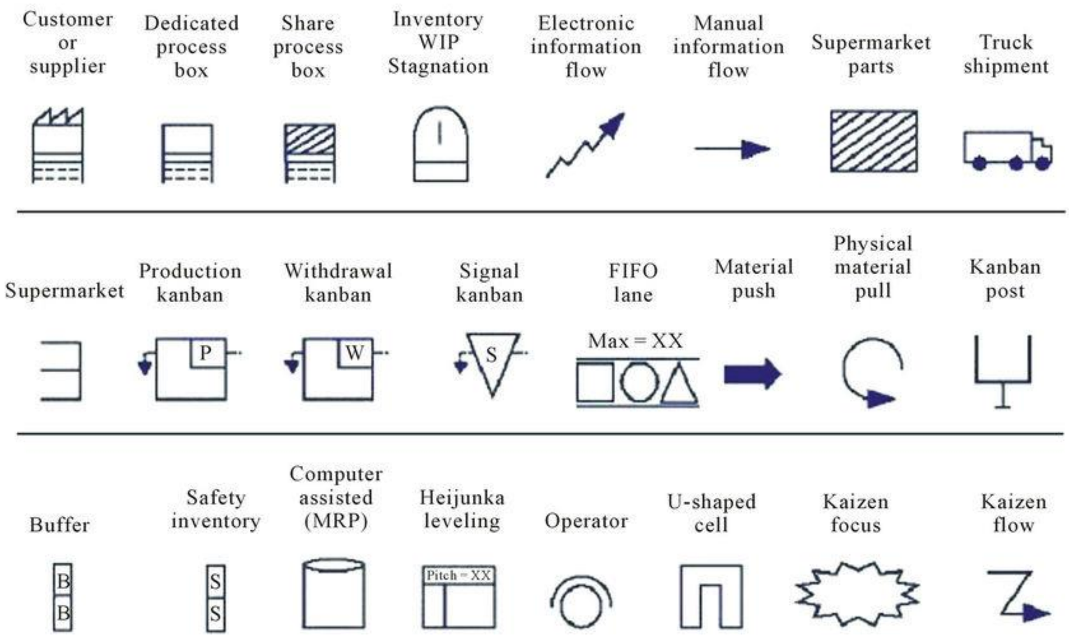

Figure 2.3 Icons Used in VSM
(Source: Nash & Polling, 2008)

To construct value stream mapping of a process, several steps can be taken. According to Hines and Rich (Hines and Rich, 2000), there are five easy step that can be taken to develop a good value stream mapping. In their book, they refer value stream mapping as big picture mapping. Both of the term use the same symbol and serve the same purpose that is to map a process generally. The five step that can be taken to develop a value stream mapping are:

Phase 1: Record Customer Requirements.

In this early phase, an identification of customer requirement is necessary. The customer requirement recorded included the type and the volume or number of the product, distribution or supply frequency. To record and develop the phase 1 value stream mapping, ask and answer the following questions:

- What is the product family or families to be mapped?
- What is the customer demand or how many products are wanted, and when?
- How many different parts are made?
- How many products are delivered at a time?
- How often are deliveries required?

- What packaging is required?
- How much stock does the customer hold?
- Any special information like multiple delivery points or delivery windows?

After it has been recorded, develop corresponding symbol into the VSM. Figure 2.4 gives example how phase 1 mapping looks like from Hines and Rich (2000).

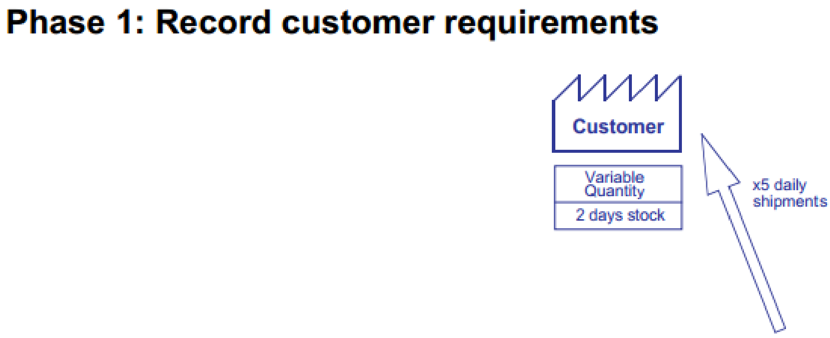

Figure 2.4 Phase 1 of Value Stream Mapping Construction Example
(Source : Hines and Rich, 2000)

Phase 2 : Add Information Flow

In this phase, information flow are mapped. The information flow are from customer to the supplier of the process. To construct the information flow, ask question or develop answer to the question of :

- What sort of forecast and call-off information is supplied by the customer?
- Who (or which department) does this information go into the company?
- How long does it stay there before being processed?
- Who do they pass it to as it moves towards suppliers?
- What sort of forecast and call-off information do you give your suppliers?
- What order quantities do you specify?

Figure 2.5 give example of how will a phase 2 value stream mapping looks like.

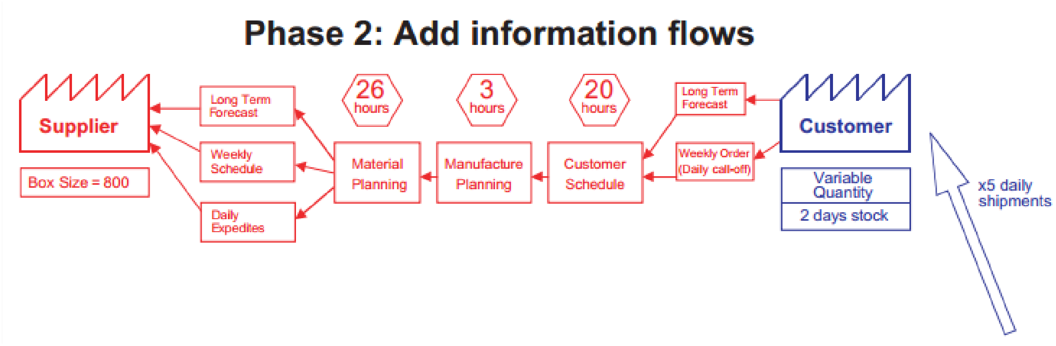

Figure 2.5 Phase 2 of Value Stream Mapping Construction Example (Source : Hines and Rich, 2000)

Phase 3 : Add physical flows

In this phase, the physical flow of the process are mapped. The physical flows are from the raw material until the finished product. The phase consisted of two parts, which are inbound flows of raw material and/or key components and internal process. To complete the inbound flows of raw material ask and asnwer the following question :

- What is your demand or how many products are wanted and when?
- How many different parts are required?
- How many products are delivered at a time?
- How often do deliveries occur?
- What packaging is used?
- How long does it takes to deliver?
- What packaging is used?
- How long does it takes to deliver?
- Any special information on the material such as more than one suppliers supplies a part?

Then, to complete the internal process, ask and answer the following question?

- What are the key steps in the process?
- How long do they tipically take?
- At which points is inventory stored?

- At which points are there quality checks and what is the level of defects?
- Are there set rework loops?
- What is the cycle time of each operation?
- How many products are made and moved in a batch at each point?
- What is the up-time of each operation?
- How much product is tested in each point?
- How many hours per day does each work station work?
- How many people work at each work station?
- What is the typical changeover time at each workstation?
- Where is the inventory held and how much is there?
- What are the bottlenecks points?

The figure 2.6 will show the result of phase 3 value stream mapping construction.

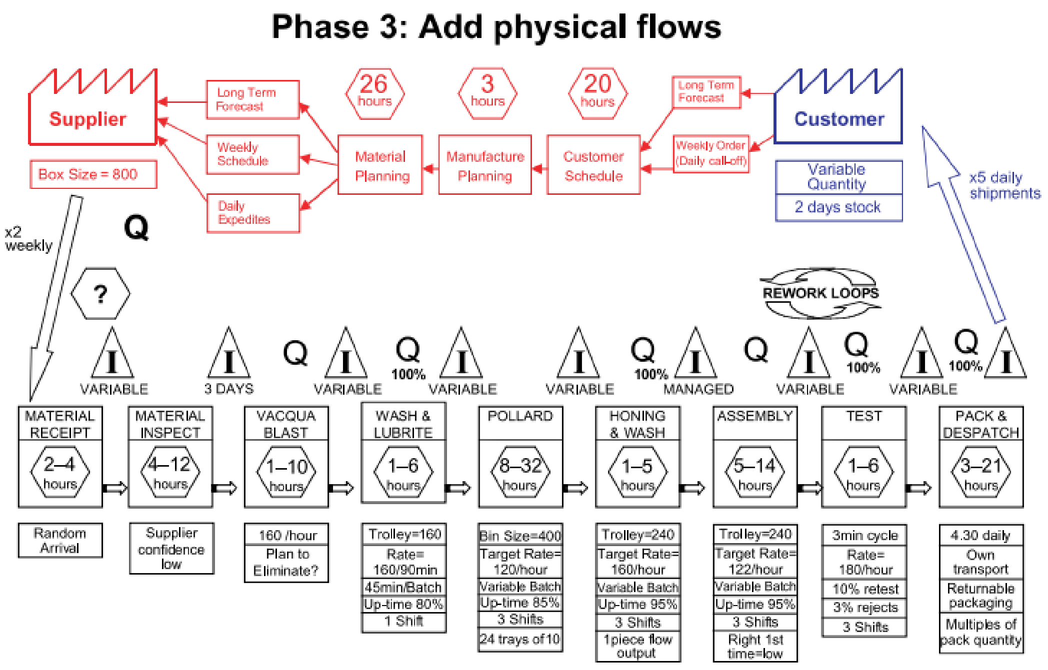

Figure 2.6 Phase 3 of Value Stream Mapping Construction Example
(Source : Hines and Rich 2000)

Phase 4 : Linking physical and information flow

In this phase, the physical flow and information flow are going to be linked. After in phase 2 and phase 3 information and physical flow are mapped, in this phase, the both flow will be linked. To link both of the flow ask and aswer the following questions:

- What sort of scheduling information is used?
- What sort of work instructions are produced?
- Where is the information and instruction sent from and to?
- What happens when there are problems in the physical flow?

Figure 2. 7 will show how a phase 4 value stream mapping construction will looks like.

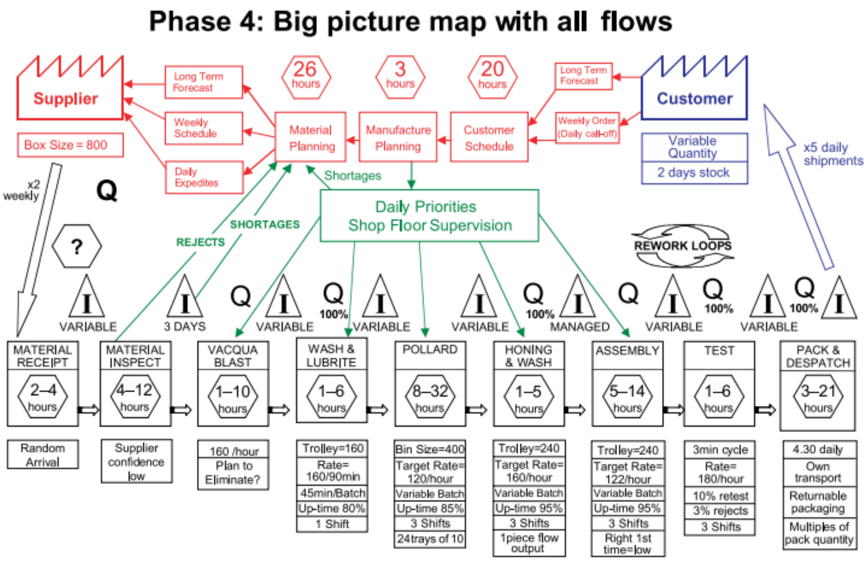

Figure 2.7 Phase 4 of Value Stream Mapping Construction Example (Hines and Rich, 2000)

Phase 5 : Complete Value Stream Mapping

In the final phase, the mapping result are completed with a lining tool below the map. The lining tool addition is to show the production lead time and value adding time in the process. In adding the line, value adding time can be estimated by using the upper and lower limit. After the line is added, the value stream mapping is finished and can be used to be further analyzed to find the main problem and find the oppotunity of improvement. Figure 2.8 will show how a complete value stream mapping looks like.

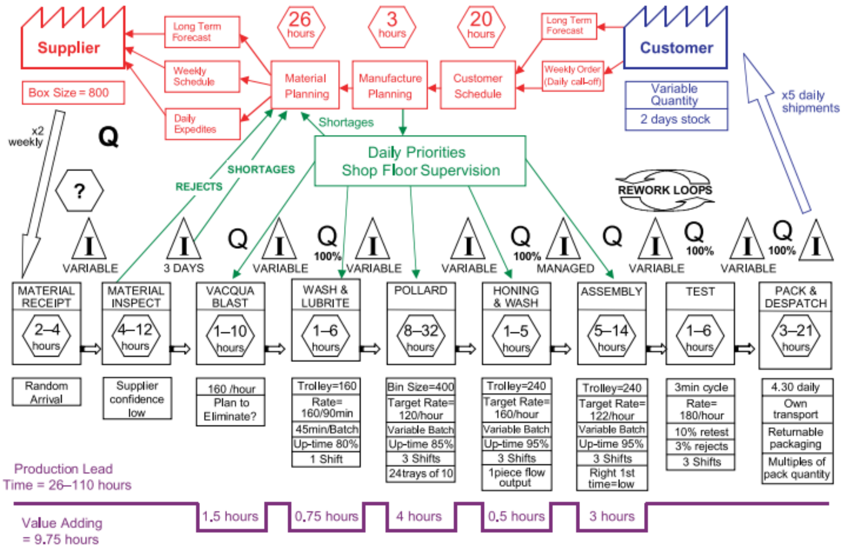

Figure 2.8 Complete Value Stream Mapping Example
(Source: Hines and Rich, 2000)

2.4. Process Activity Mapping

Process activity mapping is one part of the value stream mapping tools. There are several value stream mapping tools available to be used, such as, supply chain resource matrix, production variety funnel, quality filter mapping, and other tools. The tools are used to aid the understanding of the existing value stream mapping and help the process of providing improvement based on the waste in the value stream mapping. (Hines & Rich, 1997).

Process activity mapping is the main tools in detailed mapping that is related to order fulfillment process. Before, it is only used in production floor or manufacturing company. Basically, process activity mapping is used to identify the lead time and a chance of improving productivity in phisycal and informational flow, not only in the factory area, but also in supply chain area (Hines & Taylor, 2000)

According to Hines & Taylor (2000) there is three step that can be followed to develop a process activity mapping. The steps are

1. Step 1 : Fill in the main body of chart

In the first step, the information related to the overall activity is being noted. The information can be about the area of witch the activity is done, the distance of the movement happened, time of activity, and needed worker for the activity. Usually in the table, the definition or the name of the activity done in the process will be put in the left column. The figure below give example of the step 1 in constructing process activity mapping

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator
CNC Setup Process					
1	Searching and picking up tools for manual plate cutting		40	0,2	1
2	Manual cutting of plate			0,5	2
3	Fetching the forklift			0,5	2
4	Transporting plate from inventory to laser cutting area	Forklift	40	1,5	2
5	Moving material to the scales	Forklift	4	0,4	2
6	Material scaling			0,3	2
7	Moving material from scale to workbench	Forklift	5	0,3	2
8	Setting up the CNC machine			0,25	1
Laser Cutting Process					
9	Putting the plate to the laser cutting machine		1,5	0,05	2
10	Program set up in the CNC Machine			0,01	1
11	Laser cutting process by CNC machine	CNC Machine		0,08	1
12	Scrap deattachement from the material			0,09	2
13	Putting the scrap in corresponding place		6	0,1	2
14	Putting the cutting result to the pallet			0,04	2
15	Weighing of the scrap and the cutting result			0,25	2
16	Fetching the forklift			0,5	2
17	moving the cutting result to bending process		10	1	2

Figure 2.9 Step 1 of constructing Process Activity Mapping

2. Step 2 : Assign flows

In the next step, for each activity that has been recorded before, a classifiation process is done. In this step, the activity is classified into several categories, which are operation, transportation, inspection, and storage/delay. The explanation for each categories will be given below:

- Operation, is the activity that is categorized as a value added activity and must be done
- Transportation, is the activity where movement of material or people that needs to be reduced or avoided
- Inspection, is the activity where checking is done. The checking can be in qualitative or quantitative aspects from products or information
- Storage/Delay, is the activity where a product or information wait to be processed. In waiting no other activity are done.

For each activity, the categorization will be done using checks in the corresponding column. A symbol will be assigned to each category of activity. Figure 2.10 will give example of the step 2.

3. Step 3 : Analyze

After the classification of the activity has been done, then the analyze process is done. The analyze process will defined in each process, what type of activity is dominant and which part of activity that can be reduced or improved. Figure 2.11 will give example of the step 3

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator	Activity					Notes
						Operation	Transport	Inspection	Storage	Delay	
CNC Setup Process											
1	Searching and picking up tools for manual plate cutting		40	0,2	1		→				
2	Manual cutting of plate			0,5	2	•					
3	Fetching the forklift			0,5	2		→				
4	Transporting plate from inventory to laser cutting area	Forklift	40	1,5	2		→				
5	Moving material to the scales	Forklift	4	0,4	2		→				
6	Material scaling			0,3	2	•					
7	Moving material from scale to workbench	Forklift	5	0,3	2		→				
8	Setting up the CNC machine			0,25	1	•					
Laser Cutting Process											
9	Putting the plate to the laser cutting machine		1,5	0,05	2	•					
10	Program set up in the CNC Machine			0,01	1	•					
11	Laser cutting process by CNC machine	CNC Machine		0,08	1	•					
12	Scrap deattachement from the material			0,09	2	•					
13	Putting the scrap in corresponding place		6	0,1	2		→				
14	Putting the cutting result to the pallet			0,04	2	•					
15	Weighing of the scrap and the cutting result			0,25	2	•					
16	Fetching the forklift			0,5	2		→				
17	moving the cutting result to bending process		10	1	2		→				

Figure 2.10 Step 2 of constructing Process Activity Mapping

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator	Activity					Notes
						Operation	Transport	Inspection	Storage	Delay	
CNC Setup Process											
1	Searching and picking up tools for manual plate cutting		40	0,2	1		→				
2	Manual cutting of plate			0,5	2	•					
3	Fetching the forklift			0,5	2		→				
4	Transporting plate from inventory to laser cutting area	Forklift	40	1,5	2		→				
5	Moving material to the scales	Forklift	4	0,4	2		→				
6	Material scaling			0,3	2	•					
7	Moving material from scale to workbench	Forklift	5	0,3	2		→				
8	Setting up the CNC machine			0,25	1	•					
Laser Cutting Process											
9	Putting the plate to the laser cutting machine		1,5	0,05	2	•					
10	Program set up in the CNC Machine			0,01	1	•					
11	Laser cutting process by CNC machine	CNC Machine		0,08	1	•					
12	Scrap deattachement from the material			0,09	2	•					
13	Putting the scrap in corresponding place		6	0,1	2		→				
14	Putting the cutting result to the pallet			0,04	2	•					
15	Weighing of the scrap and the cutting result			0,25	2	•					
16	Fetching the forklift			0,5	2		→				
17	moving the cutting result to bending process		10	1	2		→				
Total	17 steps		106,5	6,07		9	7	0	0	0	

Figure 2. 1 Step 3 of constructing Process Activity Mapping

2.5. Root Cause Analysis (RCA)

Root cause analysis is a method used to analyze the root cause of a problem that cause risk. RCA is done to hep organization to identify the risk of a problem in a process, and identify the cause of the problem. In planning a solution for a problem, undesired outcome from the solution may occur and cause another problem. RCA is done so that no undesired outcome may occur from the solutin planned.

There are several important characteristic in the RCA method. Those characteristic are: (1) the ability to identify the root cause of a problem, (2) show the interdependecy between the cause, (3) the relation between factors, (4) and the category of the cause (Dogget, 2006). Several tools of RCA are widely used nowaday, such as Cause and Effect Diagram (CED) or also known as Fishbone Diagram, interrelationship diagram, current reality tree (CRT), and five why's. In this final project, the used tool is the five why's tool.

Five why's is a RCA tool developed by Saikichi Toyoda for Toyota Industries Corporation. This tool is an approach to find root cause from question that is ask 5 times. This five why's tool is an effective approach to be used as the foundation of problem solving activity, easy to use, and can be applied in variety of problem (Serrat, 2009). There are three element to achieve the most effective use of five why method, those are:

1. Accurate and complete problem statement
2. Complete answer to the problem and fit the the actual reality
3. Root cause definition that has to be finished.

The implemented mechanism in five why's tool is by identifying the root cause that is categorized by 5 classes. According to Wedgwood (2006) the classification of the problem cause class are:

1. Fisrt why : Symptom
2. Second why : Excuse
3. Third why : Blame
4. Fourth why : Cause
5. Fifth why : Root Cause

2.6 Safety Stock

Safety stock is stock in the warehouse that is used on emergency situation (Waters, 2003). Safety stock is used by the company to hinder the situation of shortage caused by uncertain demand. Generally, cost incurred because of shortage cannot be calculated and have a very large cost, for example the stop of production line and loss of customer trust.

In the ilustration it can be seen that safety stock is needed when uncertain situation occur like late delivery or high demand in certain period. The safety stock level can be calculated by using equation 1:

$$SS = Z \times \sigma \times \sqrt{LT} \qquad \text{.......................................(1)}$$

Where

SS : Safety stock

Z : Service level

σ : Demand standard deviaton

LT : Delivery lead time

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CHAPTER 3
RESEARCH METHODOLOGY

In this chapter, the research methodology that will be the base of conducting the research will be explained. The research methodology are followign the DMAIC framework of lean management, that are the Define, Measure, Analyze, Improve, and Control. In this research, the control phase are not included and replaced by conclusion and suggestion. The following diagram will show the research methodology.

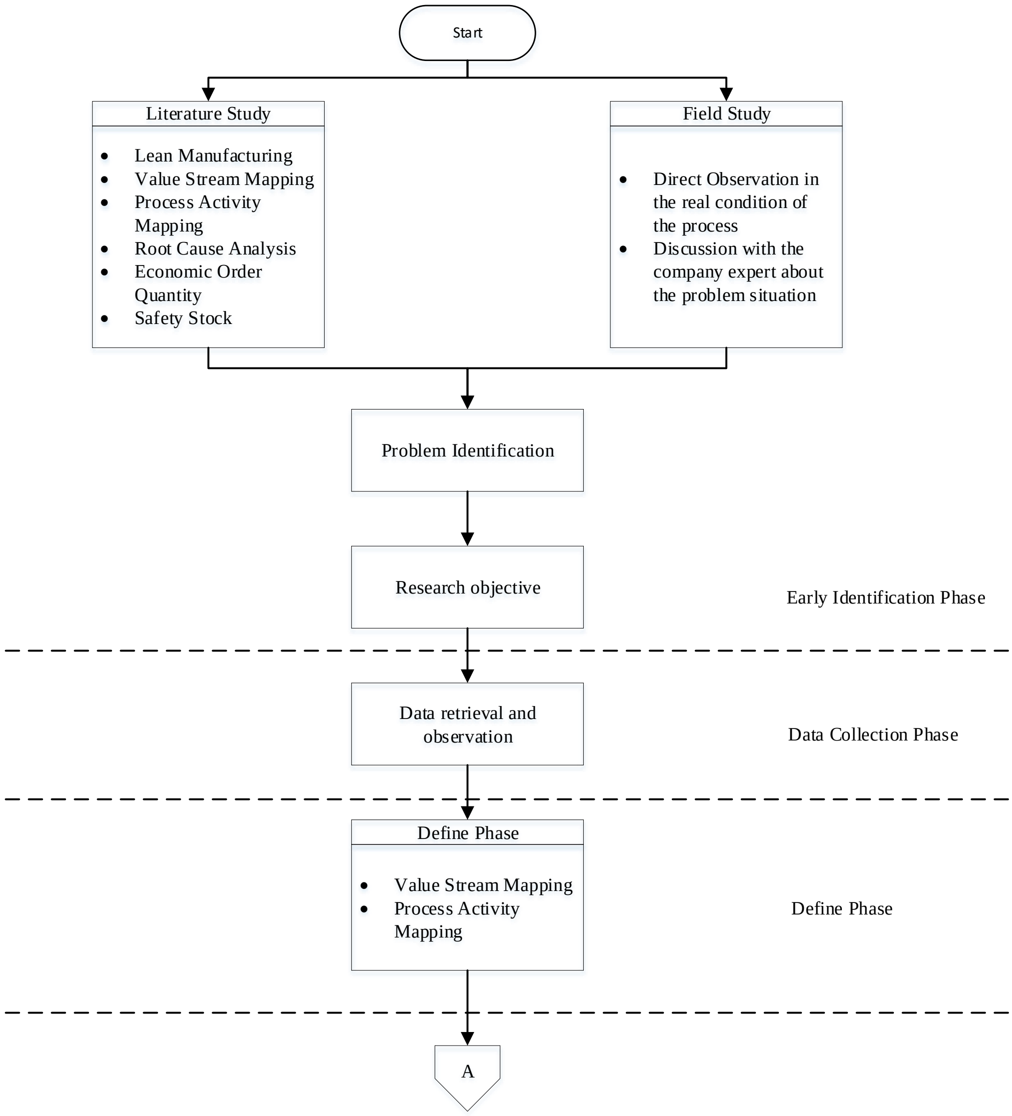

Figure 3.1 Flowchart of Research Methodology

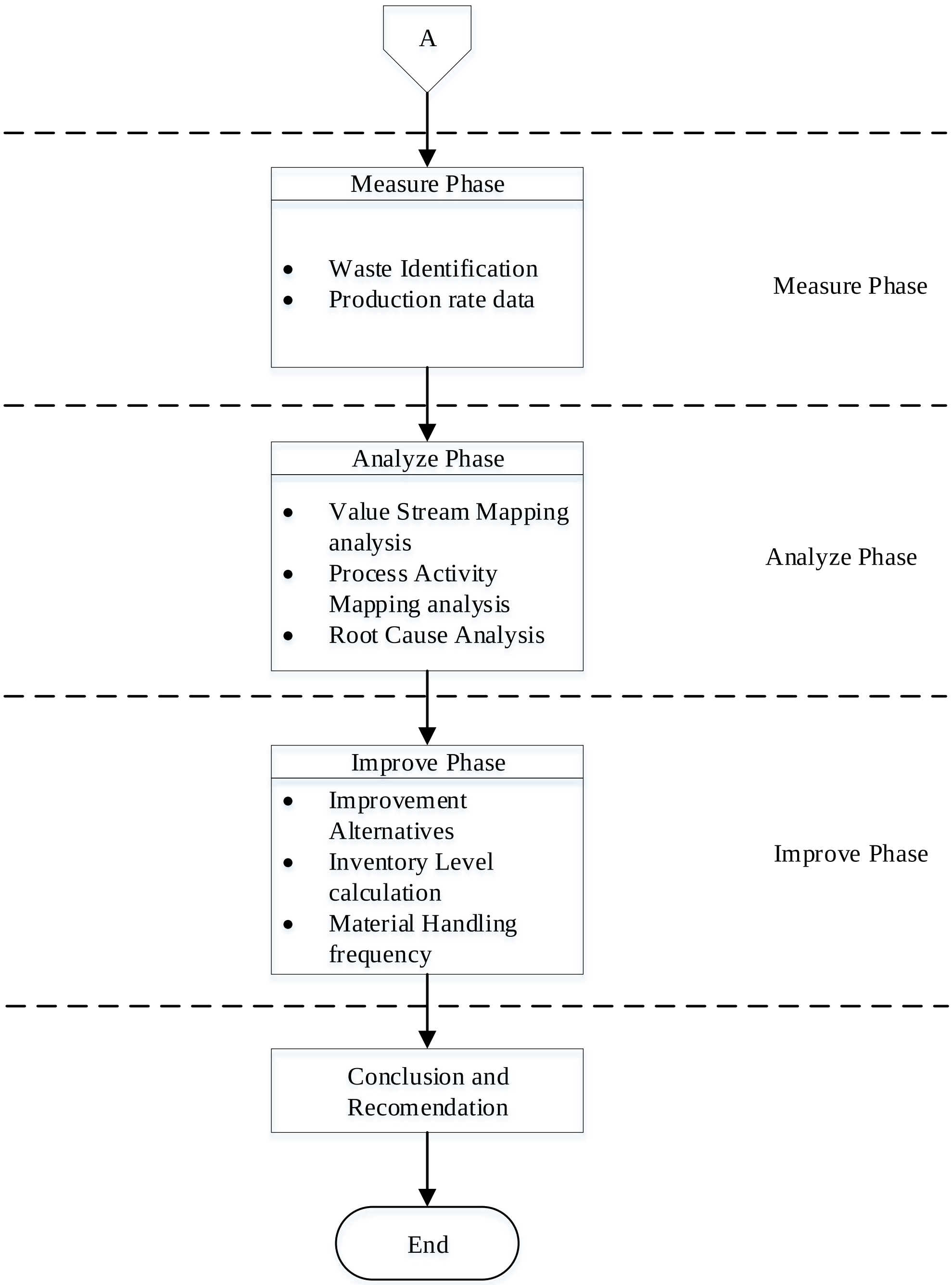

Figure 3. 1Flowchart of Research Methodology (cont'd)

3.1. Early Identification Phase

The early identification phase is the phase done early in the research process. The early identification process consists of:

a. Field Study

   The field study is the activity where the direct observation to the object is done to know the current condition of the process. In this activity, the basic of the problem and the current condition of material handling activity will be acquired.

b. Literature Study

   In this activity, a study in the literature is done to know the theoritical basis of the possible solution to the problem in the company.

c. Problem Formulation

   Based on the field study done in the existing condition, then the problem that want to be solved in this research is how to improve the material transportation process by using lean methodology and determining the optimal inventory level in PW2 substorage at at the bar soap factory

d. Research Objective Determination

   The objective that want to be achieved in this research are defining the wastes of transportation process at the bar soap factory, defining the root cause of the waste at the bar soap factory, determining the optimal inventory level in PW2 substorage at the bar soap factory, and developing improvement suggestion to tackle the waste at the bar soap factory

3.2. Data Collection Phase

In the data collection phase, the data collecting activity for the research purpose is done. Data that will be collected is the performance of the material handling process in the company. The performance of the material handling process will be observed and analyzed. Beside the performance, the production rate of the production line in PW2 factory will be collected. The production rate will be assumed as the demand in inventory level calculation. The data is collected from the company data source.

3.3. Define Phase

In this phase, the description of the existing material handling activity condition will be done. The define phase will be done in the following stages:

a. Value Stream Mapping (VSM) construction of the existing process

   The value stream mapping construction is done to know how the information and material flow of the material handling process. The Value Stream Mapping will map the material handling activity. The construction process is based on the observation of the process and then by confirmation by the company expert.

b. Process Activity Mapping construction of the VSM

   After the value stream mapping are constructed, to better define the activity in the process, a process activity mapping will be done. The process activity mapping will break down the activity done in the material handling process. From the breakdown, the activity can be categorized into 4 type of activity so that it will be easier to judge whether a part of activity is waste or not.

3.4. Measure Phase

In measure phase, the measurement of the current process will be done. The measure phase consists of:

a. Waste Identification

   After the value stream mapping and process activity mapping is constructed, next the waste identification process will be done. The activity currently done by the process is measured and then be defined the waste. The waste identified are based on the activity classification of the process activity mapping. After the waste is identified, it is summarized and verified by the company expert.

b. Production rate data

   The production rate data are then collected and shown. The production rate data gives picture of the current production level. In the measure phase, the current process are defined, so the production rate data will be collected from the last 20 weeks of the production.

3.5. Analyze Phase

In the analyze phase, the result of the data processing and collection from the define and measure phase will be analyzed. The activity in analyze phase includes:

a. Value Stream Mapping Analysis

   The analysis is done to know how the current process is going. The value stream mapping will show how information and material flow are flowing through the overall process of the material handling. After in the define phase the value stream mapping is constructed, in this phase, the value stream mapping will be analyzed.

b. Process Activity Mapping Analysis

   In order to better visualize the material handling activity in value stream mapping, the process activity mapping is constructed. The process activity mapping show a more detailed process happen in a specific process of value stream mapping. After the process activity mapping has been developed in the define phase, in this phase it is analyzed and discussed.

c. Root Cause Analysis

   After the waste has been identified in the waste identification process, the next step is to analyze what cause the waste. In this part of the research, the waste is analyzed using root cause analysis to find the root cause of the problem. The root cause analysis will be using the five why's method. The output from this process will be the root cause of every waste identified.

3.6. Improve Phase

In the improve phase, the plan to tackle the root cause of the waste identified in the analyze phase will be done. The improvement plan will be constructed to accomodate all type of waste that are identified in the material handling process. Aside of that, a calculation of inventory level will also be done to determine the optimal inventory level to buffer at the substore at PW2. The inventory level calculation will be based on the production rate data, and the calculation of safety stock.

3.7. Conclusion and Suggestion Phase

In this phase, the conclusion of the research will be drawn. The conclusion is drawn based on the objectives of the research. The suggestion will be given to the upcoming research in the same field.

CHAPTER 4
DATA COLLECTION AND PROCESSING

In this chapter, the data collection and processing will be done. The data collected are mainly about the production rate and material handling activity. The data are obtained from the company data and conducting interview with corresponding source.

4.1. General Overview of the Company

In this subchapter, the general description of the company will be discussed. The description consists of the company profile, vision and mission of the company, objectives and organization structure. The layout of the factory will also be shown especially where the research done.

4.1.1. Company Profile

The observation object is a well known Fast Moving Consumer Goods (FMCG) Company in Indonesia. Established in 1933, continuously improving and expanding business, at the end of 2011, recorded at the 6-th in Indonesian stock exchange as the most capitalized company. The company has 9 factories located at Cikarang, Karawang, and Surabaya, and a head office in Jakarta.

The product of the company includes Home and Personal Care and Foods and Refreshment. The products brand of the company has been a well known brand in Indonesia and in the wotld. The company business expands from production, marketing, and distribution to the consumer.The vission and mission of the company will be described below:

VISSION:

To become the first choice of the customer, consumer, and the society.

MISSION:

- Works to create a better future everyday
- Helps Customer to feel safe, maintain good apearance and enjoys life through good brand and services for them and other people

- Inspires people to do small steps everyday to contribute to the big change in the world
- Continuously develop a new business way that enables the company to grow twice and reduce the impact on the environment simultaniously

4.1.2. Organization Structure

In this subchapter, a general picture of the company organization structure will be given. This is to give a general picture of how information and hierarchy of the organization in conducting business activity in the company is done. The organization structure in the company consisted of a General Manufacturing Manager Rungkut as a leader. Below the General Manufacturing Manager, there are several manager, such as SU Planning Manager, Engineering Manager, Production Manager, Manufacturing Excellence Division & TPM Asst. Manager, Quality Manager, Finance Manager, and several HRBP SC RKT. Figure 4.1 will show the organization structure:

4.1.3. Existing Production Process in The Factory

In this subchapter, an overview of the production process in the company will be shown. As stated before, the product of PW (Personal Wash) factorty is mainly soap bar. Several kind of soap bar are produced. It varies in colour, brand, and weight. In summary, the factory produce 2 brand of soap bar, the first one has 4 variant in Indonesian market, and the second one also has 4 variant in Indonesian market.

The production process of the soap bar can be broken down into 3 big parts, which are the continuous soap making process, drying process, and packaging process. The forst two process are making the base material that can be turn into variety of products, which named as soap chip.

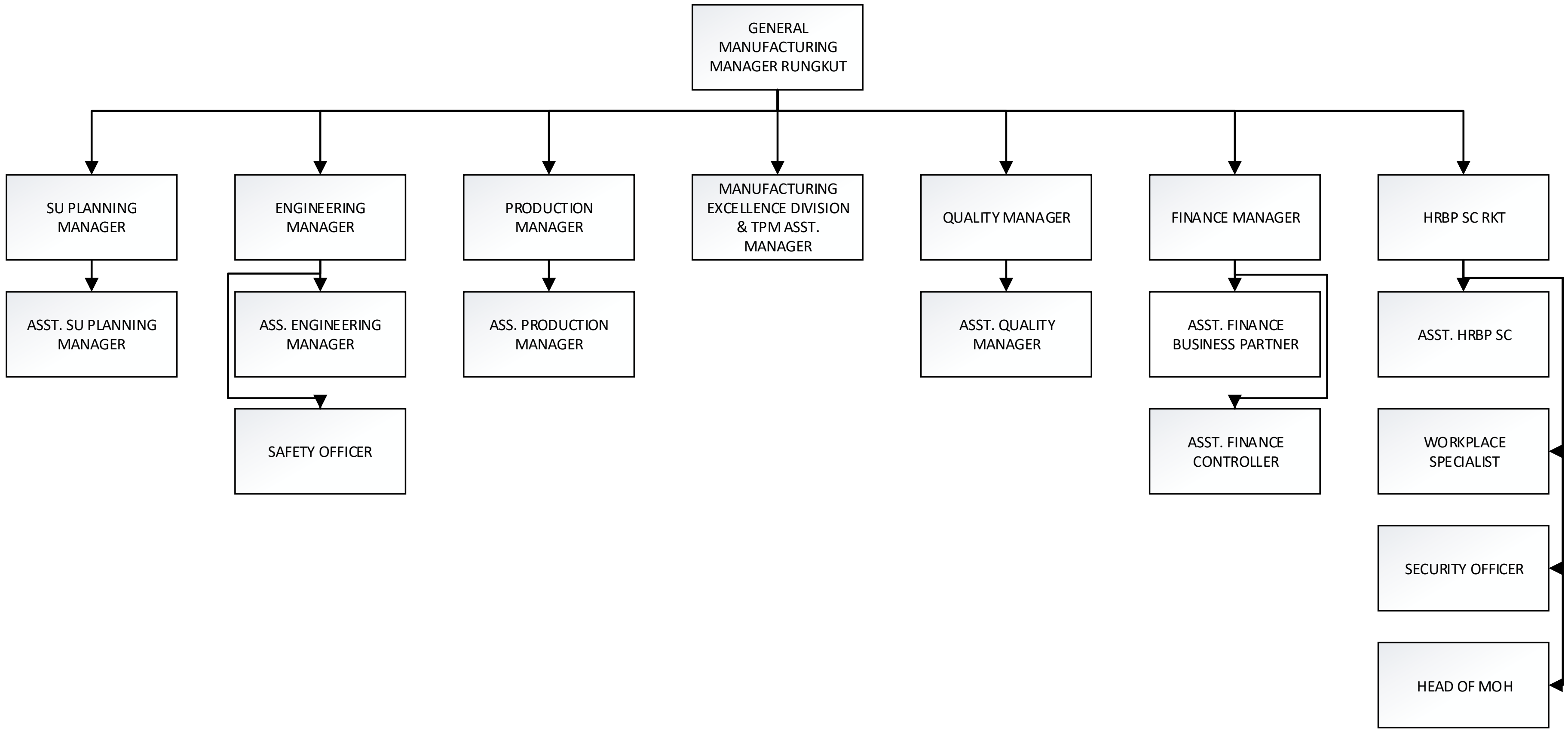

Figure 4.1 Organization Structure of the bar soap factory in Rungkut

1. Continuous Soap Making Process.

In this process, the first step of making soap is done, which are saponification reaction and continuous glicerin separation. In saponification reaction, two main material are mixed, which are the caustic soda (NaOH) and blended oil. Blended oil are mixture of variety of palm oil, which are the Refined Bleach Deodirized Palm Oil (RBD PO), Refined Bleach Deodorized Palm Oil Stearic (RBD POS) and RBD PKO. Before mixing the two liquid, the blended oil needed to be heated to 90^{o}C to make the saponification according to specification. After the blended oil are heated, the caustic soda and blended oil are mixed in High Sear Mixer (HSM). In the high sear mixer, the two liquid are mixed together with a very high rotation, at 5200 rotation per minute. The two liquid are mixed in the HSM for only 10 seconds.

The real saponification reaction are happened after the HSM, which is at the plug flow reactor tube type.In the reactor tube, the mixed liquid undergone the saponification reaction. The reaction can take time for 10 to 14 minutes. In the reactor tube, a steam coil are constantly giving heat to avoid getting freezed on the wall of the reactor tube. The output from the reactor tube is called as crude soap.

After the saponification producing crude soap is done, next the crude soap will be processed at Rotating Disc Contractor (RDC). In the RDC process, the crude soap are prcessed to separate the soap from the glicerine content. RDC is a separation tools that has a rotating axis with horizontal planes along the vertical axis with static ring on the walls. In the RDC process the separation of glicerin and the soap are done using 10- 12% NaCL wash liquor that is a mixture of nigre lye and salt water. Before the salt water are injceted into the RDC, the salt water is heated using a heat exchanger. The salt water are used in the process so that it can disolve glicerin content without dissolving the soap mixture process are because the salt water can dissolve glicerin wthout also dissolving the soap mixture.

In the RDC, the separation process will make a liquid with a clear line, the white slime like substance on top, and lye liquid on the bottom. The lye liquid are the separated glicerin from the crude soap before. The lye mixture are dumped from the bottom part of the RDC and filled the dilution lye tank. In this tank the lye are stored and can be reused for glicerin separation process or dumped to be treated.

The white slime like substance on the top of the RDC are called the washed soap. The washed soap then streamed to the surge tank to contain the washed soap. In the surge tank, the washed soap temperatur are kept to be in 85^{o}C to prevent the washed soap freezing. After that, the exit flow of washed soap from the surge tank are going through fitting process by adding NaOH 47% and water. The fitting process are done to complete the soap structure by reducing the NaCL content. This is because if in the washed soap, the NaCL content is too big, it can cause a too hardened soap and make the soap prone to cracking.

After the fitting process has finished in the washed soap, the liquid will undergo a centrifuge process. The centrifuge process aims to separate two phase in the washed soap which are the soap phase and nigre lye phase. The two phase are separated because they both have different density. The centrifuge turn will cause the nigre lye phase, which has bigger density to be thrown to the wall of the tube and then flow to the ubder part if the centrifuge. The separated nigre lye liquid then can be reused in the RDC process.

Aside from the nigre lye, the centrifuge process also produce the second phase which is the soap phase. The soap phase produced by the centrifuge process are called the neat soap. The neat soap is then contained in the relay tank, then after that, moved to the final tank for the continuous soap making process, which is the neat soap tank.

Along the process, there may be defected washed soap or neat soap. Later in the packaging process, also defected soap chip could be produced. Those defected material will be moved to a scrap fitting tank. The scrap fitting tank is functioned to cook the soap in batch. From the scrap fitting, the material then undergo the RDC to separate glycerine, to centrifuge to separate the nigre lye. Basically, from the scrap fitting tank, neat soap making process will be done.

To summarize, the continuous soap making process are process to transform the raw material of soap, which is the caustic soda and blended oil to become neat soap. The flow diagram in figure 4.2 will show the continuous soap production process.

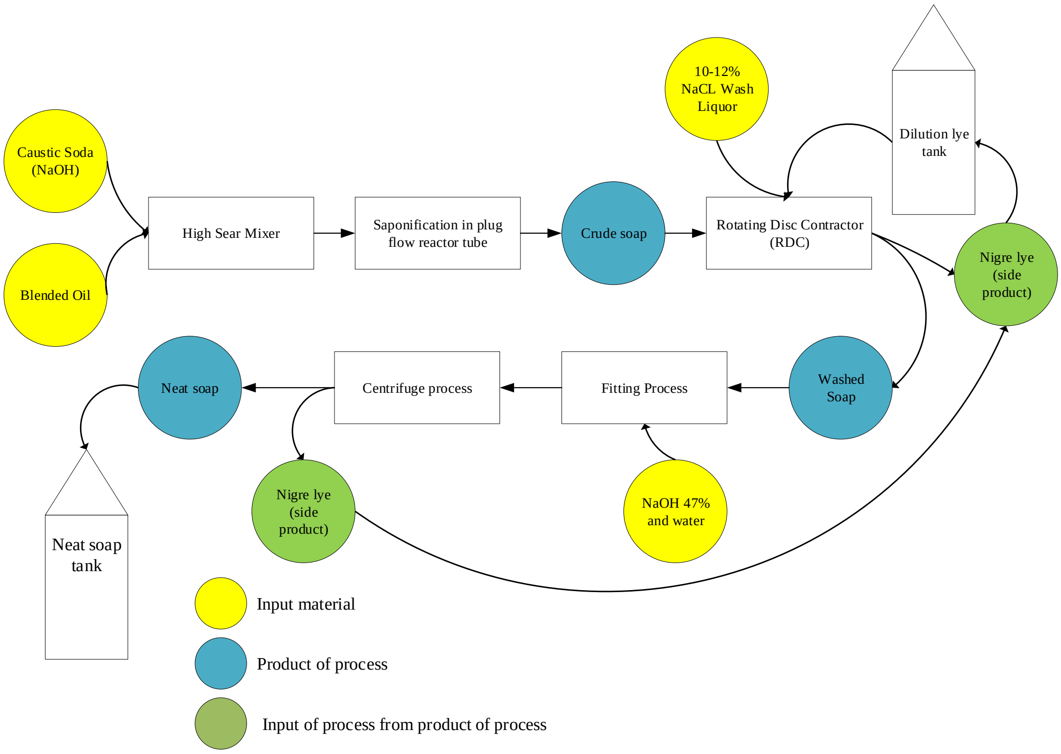

Figure 4.2 Flow Diagram of Continuous Soap Making Process

2. Drying Process

In the drying process, the neat soap produced from the continuous soap making process will be processed into soap chip or "noodle". First, the neat soap are pumped to the feed tank. From the feed tank, the neat soap are moved in to the heat exchanger, where the neat soap are heated to 120^{o}C-140^{o}C. The heated neat soap will evaporate the water content in the neat soap.

After the neat soap has been through the heat exchanger, a mixture of citric acid, versene, and turpinal are injected to the neat soap mixture. The mixture functioned to imply some characteristic to the neat soap. Citric acid to netralized any free alkali (NaOH) that are still left in the neat soap. Meanwhile, the versene and turpinal are to nonactivate the Fe compound and prevent moulding or smell in the neat soap.

The soap flow is then moved into the drier / atomizer, which is a tank shaped structure with a nozzle on the top part of it. The soap are pumped inside in spray form and then stick to the wall of the drier. The sticked soap are then dried and scrapped using a scrapper inside the drier.

The drying process will produce side products that are the water vapor and a little bit of soap dust. The water vapor and soap dust will be sucked in to a cyclone. The cyclone will separate the water vapor and the soap dust. The soap dust are filtered and then be moved in to the scrap fitting tank.

The scrapped soap from the drier are then come out from the bottom of the drier and then entered the pre plodder. In the pre plodder, the soap is compressed using a turning screw. The turning scrow also push the soap to come out from the other end. The pre plodder produced a long noodle like soap, named the "soap noodle". After the pre plodder, then the noodle soap entered the final plodder, where the noodle soap will be compresed further and cut into 2 cm pieces. The noodle soap with 2 cm pieces length is named the soap chip. This soap chip is then ready to be processed in the packaging process. It is transported into silo bin where the soap chip is contained. The flow diagram of the drying process can be seen in figure 4.3

3. Packaging Process

The packaging process is the final process of the soap bar making process. After from last process the soap chip is inserted to the silo bin, the soap chip is then flow to the mixer process. In the mixer process, the soap chip will be mixed with additives chemical, such as the perfume, colouring, and other additives. The corresponding additives chemical will be corresponding with the brand of the product that is on production. In the mixer, the soap chip are mixed with the additives for 12 minutes in temperature of 35-40^{o}C.

After the soap has been mixed in the mixer, next, it will enter the roll mill process. In the roll mill, the soap will be cooled down and rolled. The process aims to homogenize the soap mixture from the mixer. After the roll mill, next is the preplodder and final plodder process. Same as the process in the soap chip making, the pre and final plodder functioned to comprese the soap. From the final plodder, a continuous strip of bar soap are produced.

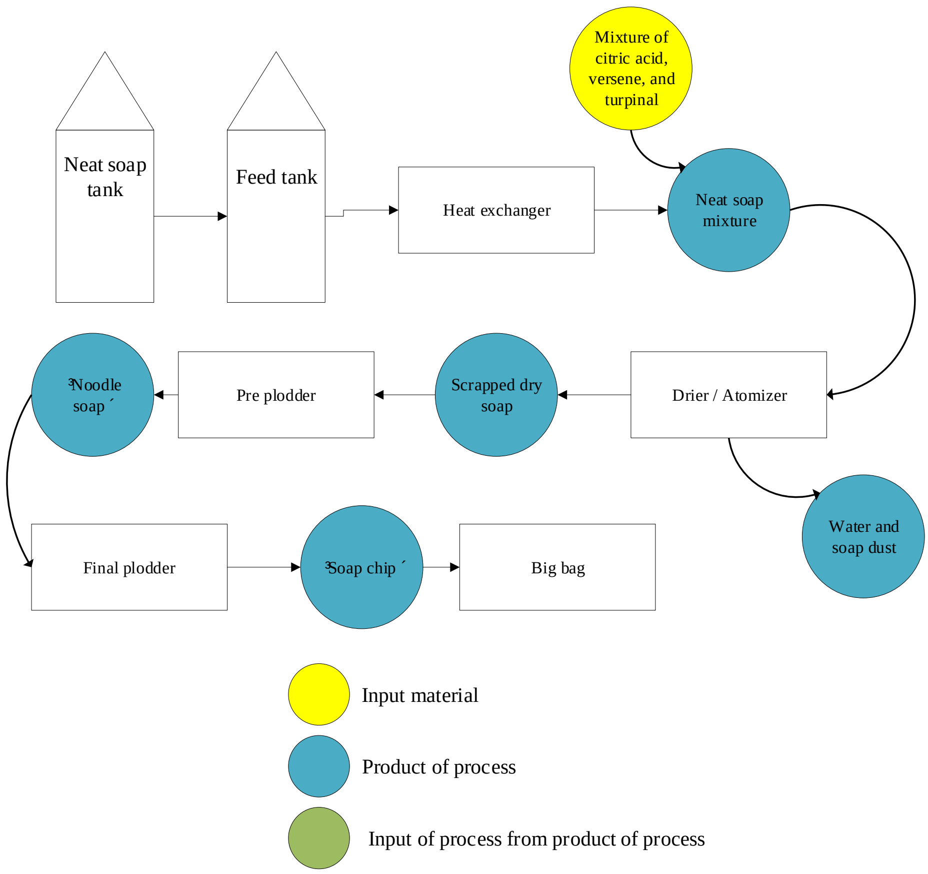

Figure 4.3 Flow Diagram of Drying production process

Next, the strip of soap is then cut into size using TV Cutting machine. The cutting machine is automated and can be set up to several size according to the batch produced. The cutting machine produce a long block shaped bar soap. After the soap has been cut, the next step is to stamp the soap. The soap is stamped using a fully automated stamping machine. The machine stamp the soap into the final shape of the product. When stamping the long block of soap, scrap soap will be produced. The scrap soap is then moved using conveyer to the pre plodder and final plodder to be used again.

After the individual bar soap has been produced by the stamp machine, the bar soap is then packaged in individual package, and then put in a cartoon. The packagine process are using automated machine. The final product will be a cartoon of bar soap that is then stored in the warehouse. Figure 4.4 will show the packaging process flow diagram

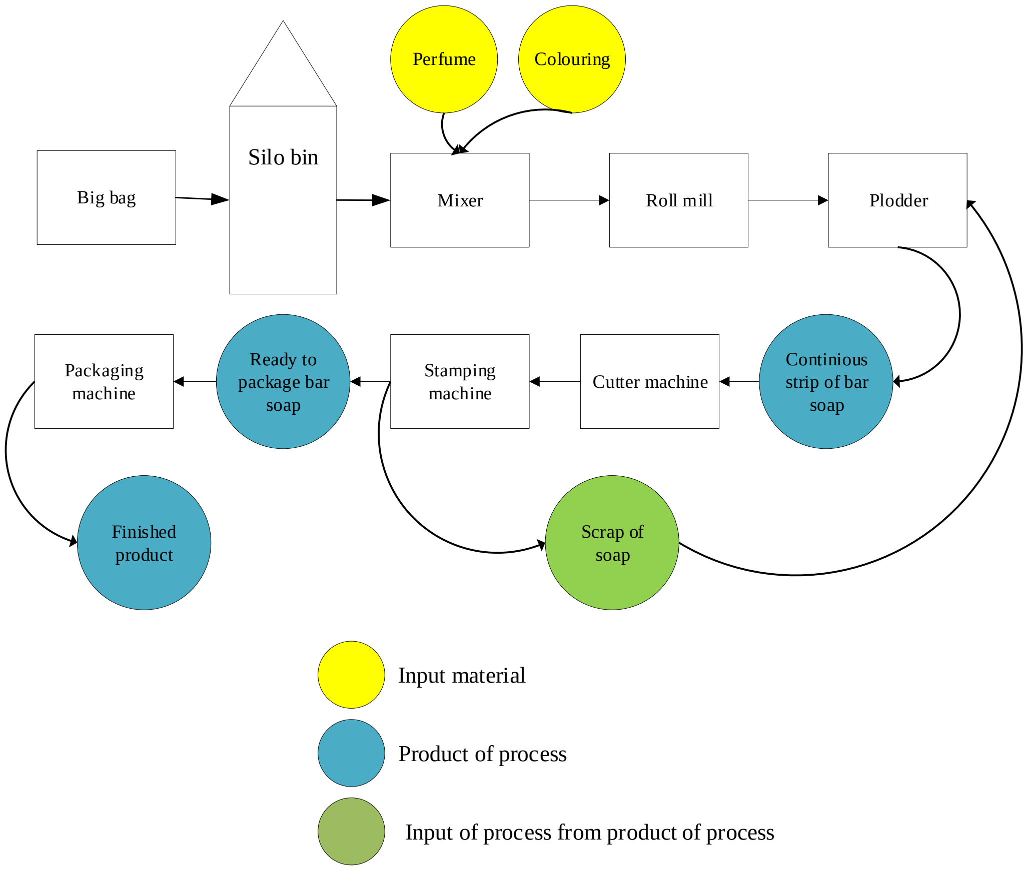

Figure 4.4 Flow Diagram of Packaging Process

The PW2 factory only doing the packaging process. Three line in the PW2 factory, line 15, 16, and 17 are doing packaging process from silo bin to final product. That is why, the soap chip from drier proces needed to be transported using shuttle truck to the substore in PW2 building. The research only focused on the transportation, material handling between PW1 and PW2 and also calculating the corresponding efficient inventory level in PW2 substore.

4.1.4. Substore 2 Layout

In this subchapter the layout of the inventory space in substore 2 where the research is conducted will be shown. The research is conducted between drier 6 facility to substore 2 facillity. However, the focus is on the existing inventory layout in the substore 2. The figure 4.5 wil show the exsting layout of the inventory space in substore 2.

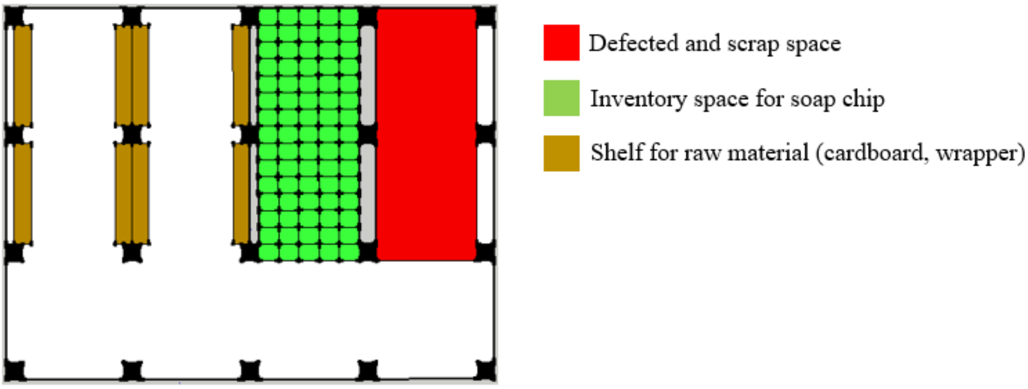

Figure 4.5 Current substore2 layout

In the figure 4.5 it is shown that the existing condition of inventory space for big bags are capable of storing 65 big bags. Beside the big bags inventory space, it is prepared for defects product and scrap of production waste. The brown coloured box indicating the shelf and racking system that is prepared for storing raw material of cardboard and wrapper. The racking system also prepared for storing some products that is for special demand or that is remained from a stopped brand.

4.2. Define Phase

In this subchapter, the process in define phase will be discussed and shown. The define phase will give a base view of the process observed. As said in the research methodology, the define phase will be consisted of value stream mapping construction and process activity mapping.

4.2.1. Value Stream Mapping

In this subchapter, the value stream mapping construction process will be shown. The value stream mapping will describe the current condition of the process in PW2 factory. Value stream mapping will give description of the information and material flow through the process observed. The advantage of using value stream mapping is that the material and information flow can be displayed in one visual representation. It also give rough information of how the process runing, whether it is lean enough or not. The process of value stream mapping construction will be done according to the 5 step according to chapter 2.3.

4.2.1.1. Phase 1 : Record Customer Requirement

In the first phase of value stream mapping construction, the customer requirement will be identified. The requirement include the type of brand, how much the product required, and how is the frequency of requirement being sent. In this research, the customer are assumed to be the distributor, where the distributor are responsible to distribute the produced product to other warehouse. In figure 4.6 it is shown the first phase of value stream mapping construction.

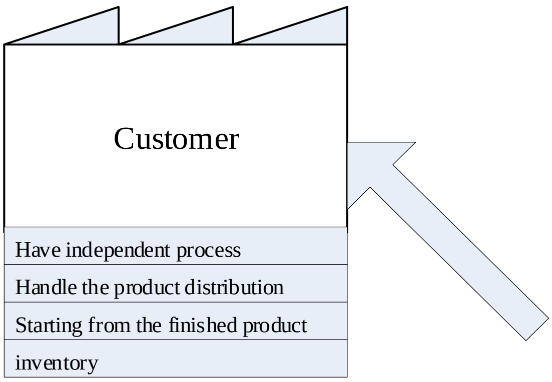

Figure 4.6 Phase 1 of VSM Construction

The customer requirement are calculated and estimated by the marketing department of the company. In the department, estimation of product to be sold in certain period is made. The estimation based on various condition such as the historical data, season of the period, and economical condition of Indonesian market. The estimation and calculation of product needed by the customer are done for each type of brand produced by the factory. To conclude, the requirement are recorded each year by the marketing department to be then be estimated.

4.2.1.2 Phase 2 : Add Information Flow

In the second phase, the information flow from the order come from the customer until the product is delivered will be constructed. The information will include all kind of information and the processing of information. The information flow constructed can be seen in figure 4.7

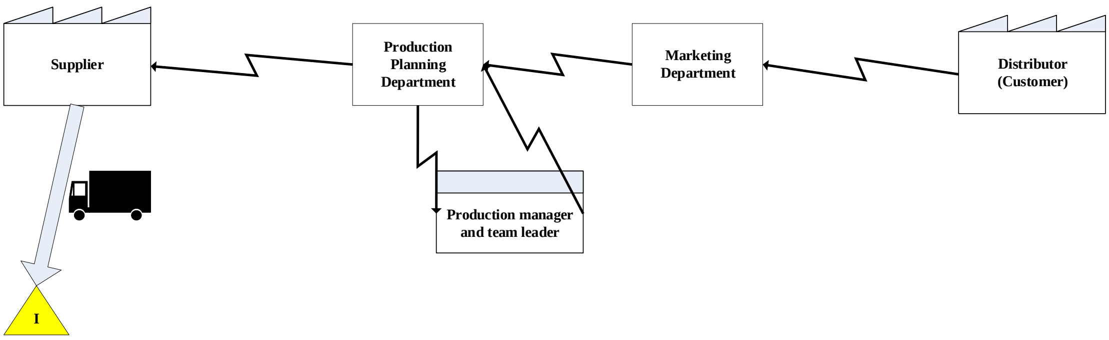

Figure 4.7 Phase 2 of VSM construction

Figure 4.7 show the summary of the information flow. The detailed information flow will be explained in figure 4.8, and will be discused below:

1. First, the customer, in this case, is the distributor buy the product from the free market. The number of products bought is then counted as the demand from the market. In the factory, the product produced occasionally for overseas market too (export)
2. The marketing department then receive data and information of the market. The data is about the volume of the product sold throughout the year. The data is taken in a yearly basis. Because the variety of products sold, it is recorded based on the product type and the volume sold.
3. The marketing department then do a yearly forecasting about the product sales. The forecast is included the volume of what product to be produced in specific time.

4. The forecasted data is then transfered to production planning department. The production and planning department then develop a whole year production schedule.
5. The production schedule is then transferred to the production manager and team leader. Both of them then proceed to do and produce the corresponding amount and type of product needed daily.
6. The real amount produced each day and each shift is then recapitulated by the team leader. All the target from the production planning department and the achieved target are reported in daily production master data. The data is then reported back to the production and planning department
7. The information of the produced and ready to ship product is then delivered to the logistic company, then the product is transported to the distribution center.

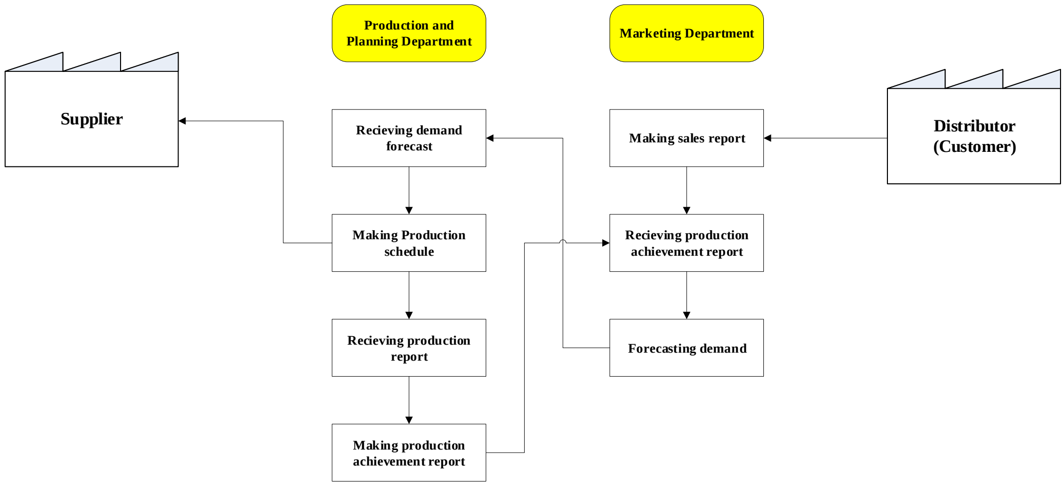

Figure 4.8 Detailed Explanation of Information Flow

4.2.1.2. Phase 3 : Add Physical Flow

In the third phase, the physical flow will be constructed in the Value Stream Mapping. The physical flow will describe the material flow in the production process from the raw material into finished product. The physical flow addition can be seen in figure 4.xxx. The physical flow will only describe the production process in PW2 factory, which is the production line 15,16, and 17.

1. Raw material storage (caustic soda and blended oil tank)

   The material being put in the storage include the caustic soda and the blended oil. Both of the liquid are stored in the tank later to be pumped into the high shear mixer to undergo the soap chip production process. The raw material also include the wrapper for the soap, and the cardboard.
2. Soap chip production process

   The soap chip production will transform the caustic soda and blended oil, as well as other additive to become soap chip. The process includes from the continuous soap production process and the drying process. The soap chip is then put in the big bag and transported to substore two.
3. Substorage 2 activity

   In the substorage 2 activity, the big bag is then stored to inventory slot and wait to be put in the Silo. The activity include unloading of big bag from shuttle truck, putting the big bag in inventory point, and can be pumped or using lift to be moved to the Silo.
4. Mixer

   In the mixer, the soap chip is then mixed with perfume, coloring, and other additives. The mixer work in batches of soap chip, supplied from the Silo, usually 160 kg each batch. In the mixer, the soap chip are mixed with the additives for 12 minutes
5. Roll mill.

   In the roll mill, the soap will be cooled down and rolled. The process aims to homogenize the soap mixture from the mixer. The roll mill process happen in batches accordingly from the mixer with cycle time of 7 minutes every batch.
6. Plodder

   In the plodder, the homogenized soap chip is then pressed and solidified. The plodder use two step, which is pre plodder to first press the soap chip and final plodder to re press and solidified the soap chip. The output from this process is long continuous bar of soap. The plodder process is continuously done, but for it need 1 minutes to produce 7200 equivalent pieces of bar soap.

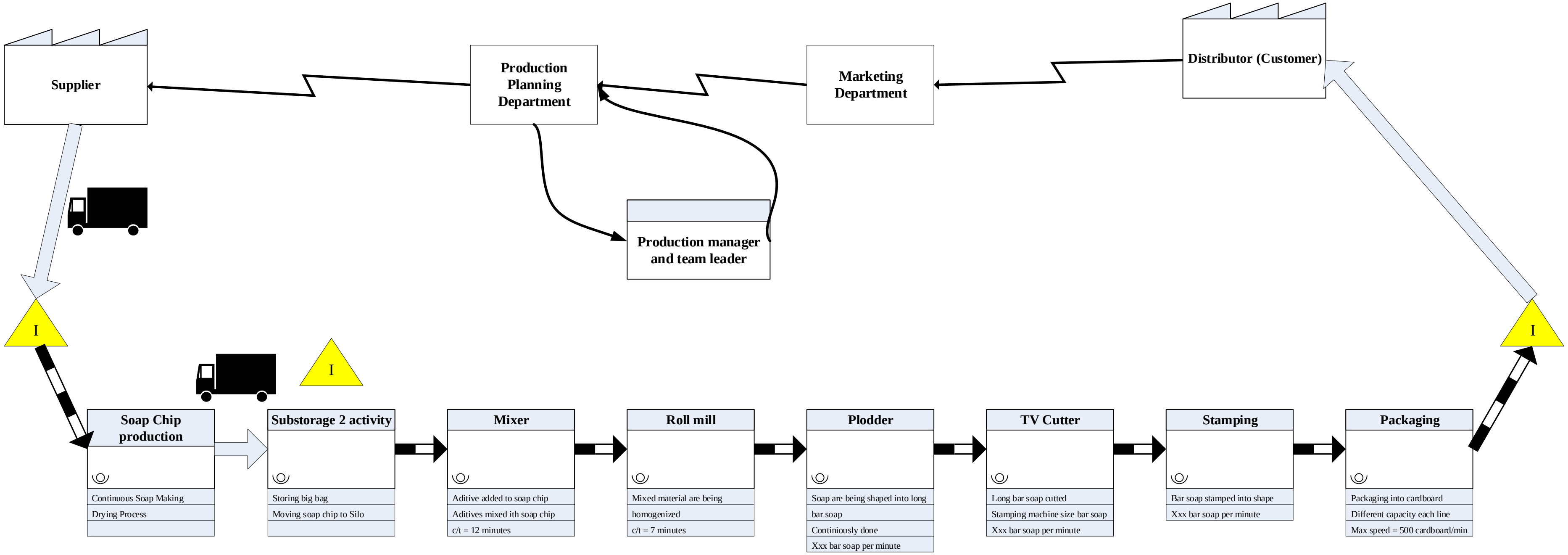

Figure 4.9 Phase 3 of VSM construction

7. Cutter machine

   The cutter machine will cut the long continuous bar of soap into block shape. The length of each piece of block will be set so that it match the length of the next process, which is stamping. The cycle time for the process is 1 minutes

8. Stamping

   In the stamping process, the block of bar soap is stamped into shapes by stamping machine. In one stamp, 12 bar of soap can be produced. The capacity of the machine is 7200 bar soap per minutes. So the cycle time for stamping machine is considered 1 minutes.

9. Packaging

   In the packaging process, the bar soap is then wrapped and placed in the cardboard. The packaging machine are automated so it doesn't require any operator. The operator only feed the machine with the wrapper and cardboard. The cycle time for packaging 500 cardboard is 1 minutes.

4.2.1.3. Phase 4 : Linking Physical and Information Flow

In this phase, the physical flow will be linked with the informational flow. It aims to describe how informational flow affect the physical flow. In the production process of PW2, the Daily Production schedule are known by the team leader and the team leader of each line are responsible to make the production process run accordingly with the production schedule. The production schedule are issued by the production department, which is informational flow and then it linked to the production process by the team leader. The figure 4.xxx show the phase 4 of values stream mapping construction.

4.2.1.4. Phase 5 : Complete Value Stream Mapping

After all the information flow and physical flow of material are linked, the value stream mapping is then completed by the timeline segment. The timeline segment show the time of each process and show whether it is a value added activity or non value added activity. The line is placed under the physical flow. Figure 4.11 will show the complete value stream mapping.

In the research, the focus of the analysis will only be in the material handling activity. The value stream mapping provided before map the whole process of the bar soap production process. A value stream mapping will also be constructed for the material handling activity. The boundary of the analyzed process is from the drier 6, which is the end of the continuous soap making process until the begining of packaging process. Figure 4.xxx show the value stream mapping of the material handling process.

4.2.2. Process Activity Mapping

After the value stream mapping has been constructed, next the process activity mapping will be done. The process activity mapping is constructed to better analyze the process happen in the material handling activity. In this subchapter, the process activity maping construction will include phase 1 and phase 2 which are fill in the body parts and assign flows.

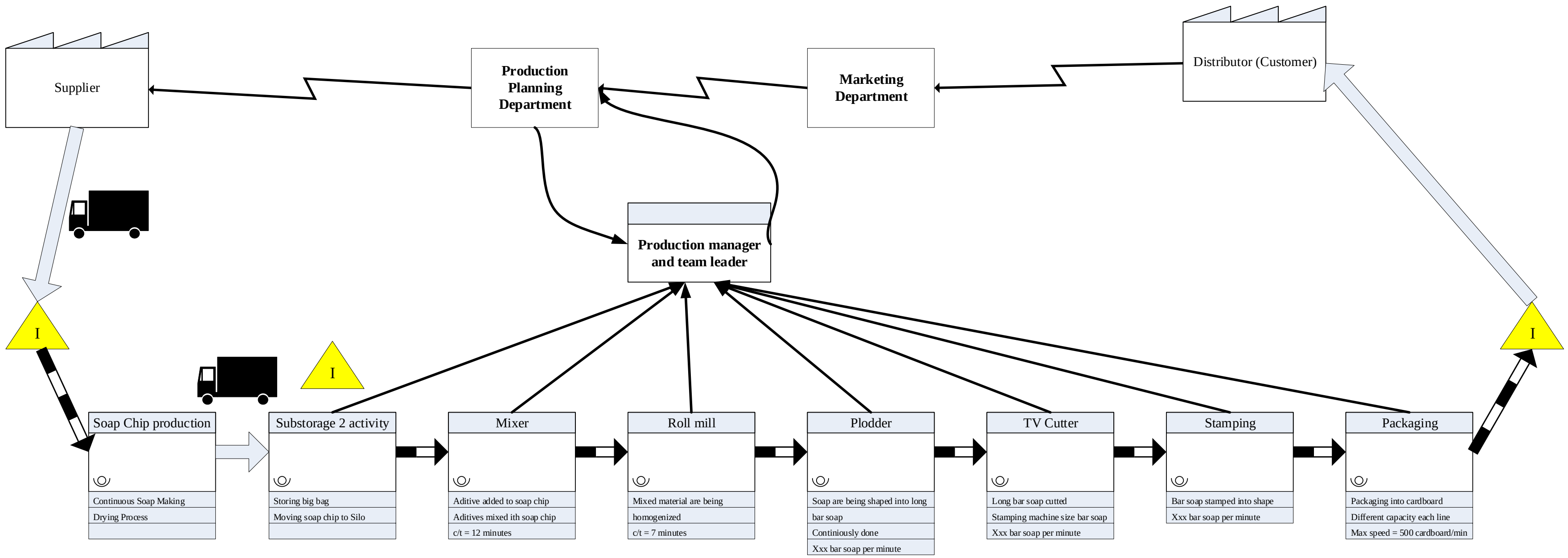

Figure 4.10 Phase 4 of VSM construction

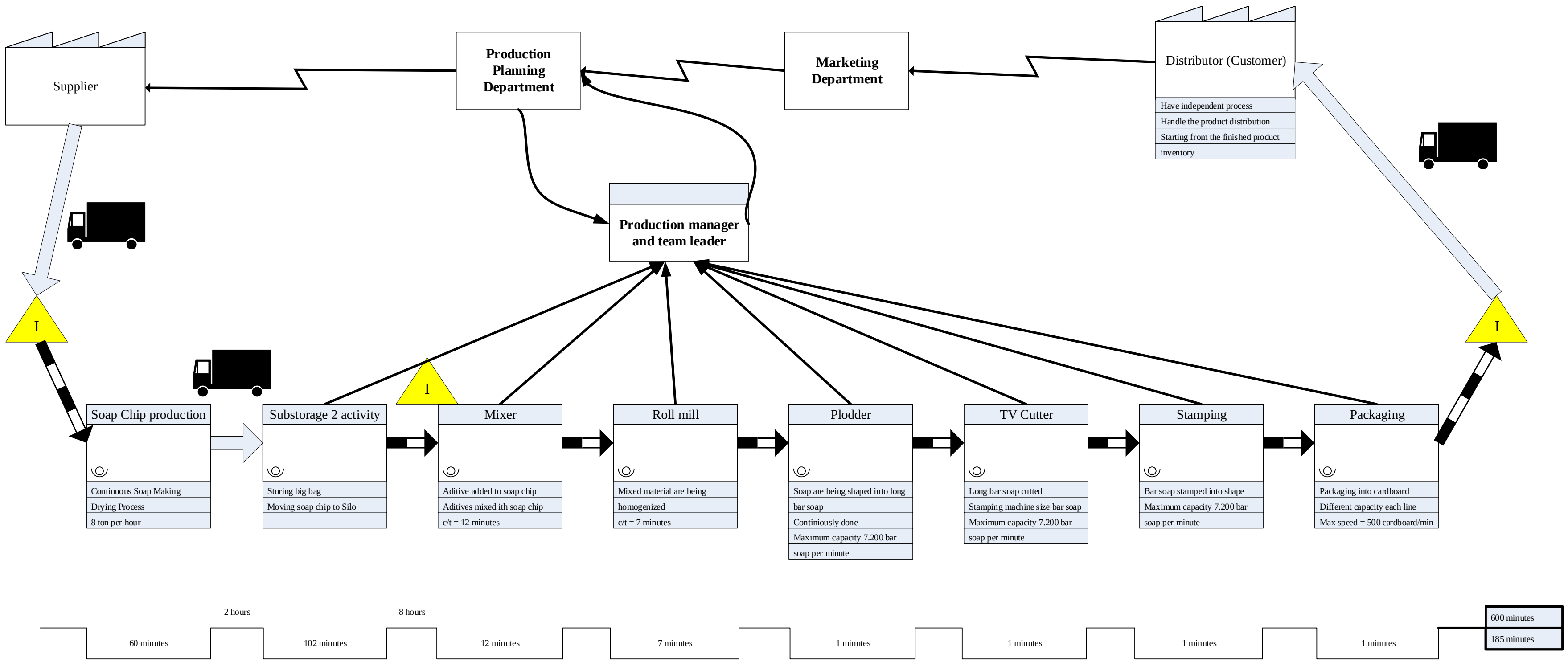

Figure 4.11 Complete VSM Construction

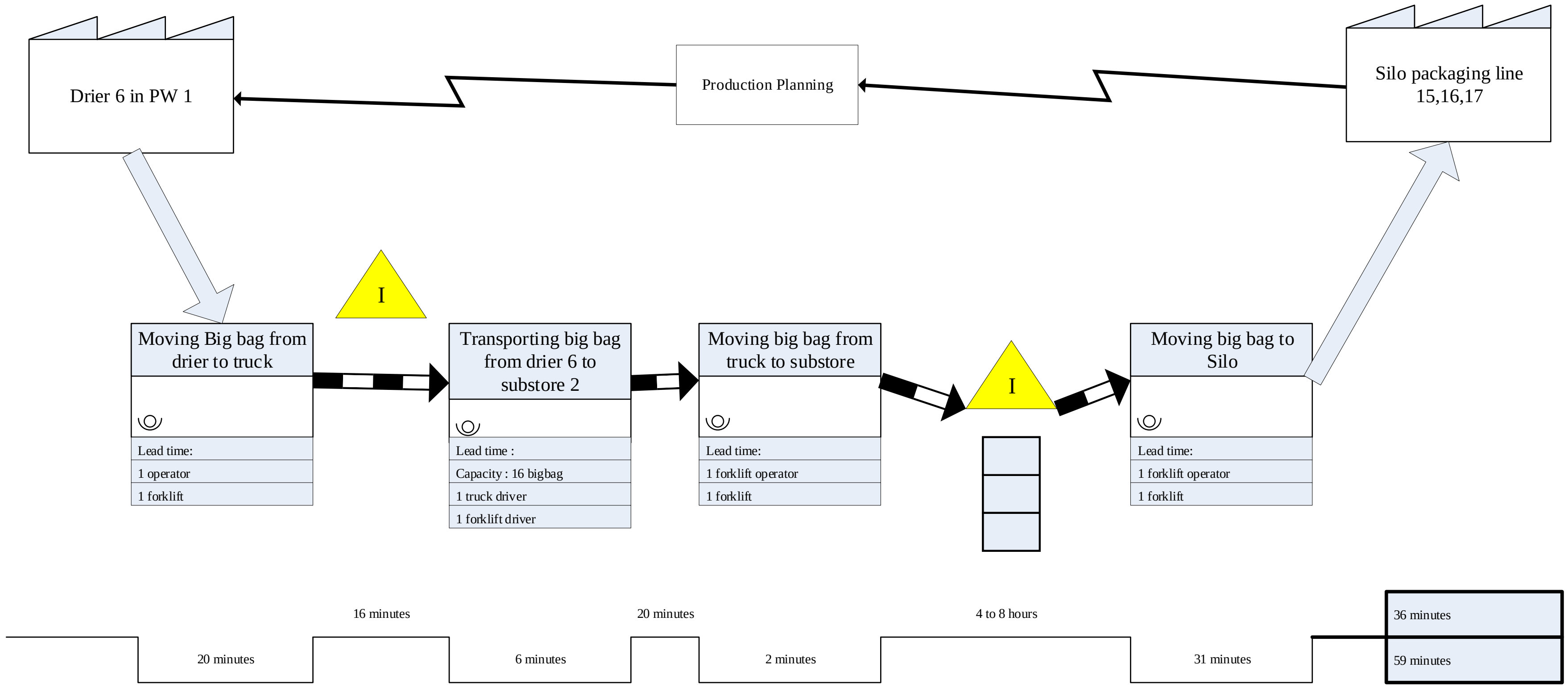

Figure 4.12 VSM for Material Handling Activity

4.2.2.1. Phase 1 :Fill In The Body Part

In phase 1, the activity are observed and recorded in the process activity mapping. The process that is observed based on the value stream mapping of the focused object, which is the material handling activity from drier 6 to substore at PW 2.The activity in the VSM consists of 4 process, which are moving big bag from drier to truck, transporting the big bag from drier 6 to substore 2, unloading the big bag and moving the soap chip to silo. The table 4.1 show the process activity mapping of material handling activity

Table 4.1 Process Activity Mapping Phase 1

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator
Moving big bag from drier to truck					
1	Setting up the forklift	Forklift		1 min	
2	Going to drier 6		310	2,5 min	
3	Putting the big bag in the shuttle truck			15 min	
4	Return journey to the PW2		310	2,5 min	
5	Moving the big bag from truck to the loading bay			15 min	
Transporting big bag from drier 6 to substore 2					
6	Setting up the shuttle truck	Shuttle truck		5 min	
7	Going to drier 6		310	3 min	
8	Waiting for loading process			15 min	
9	Return journey to the PW2		540	3 min	
Moving big bag from truck to substore 2					
10	Operator setting up forklift	Forklift		1 min	
11	Forklift going to unloading dock			30 sec	
12	Lifting big bag from unloading dock to inventory			30 sec	
Moving big bag to Silo (a)					
13	Moving big bag from inventory point to hoist place	forklift		45 sec	
14	Putting down used big bag from pump	hoist		77 sec	
15	Lifting the big bag to place of the pump	hoist		60 sec	
16	Opening and waiting for the big bag to be emptied			28 min	

Table 4.1 Process Activity Mapping Phase 1 (Cont'd)

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator
Moving big bag to Silo (b)					
17	Moving big bag from inventory point to lift	Forklift		30 sec	
18	Lift moving up	lift		1 min	
19	Moving big bag from lift to temporary place	handtruck		45 sec	
20	Lifting big bag with hoist	hoist		45 sec	
21	Opening and waiting for the big bag to be emptied			3 min	
22	Putting big bag back and tidy up	hoist		1,2 min	

The activity of moving soap chip to silo are separated into two type. This is because the process can be done with the pump or by moving using lift directly to the silo place, which is at the 4^{th} floor. In the first phase of process activity mapping construction, a total of 23 activity has been recorderd.

4.2.2.2. Phase 2: Assign Flows

In phase 2 of process activity mapping, the activity that has been recorded is then categorized into 4 type of activity. The categories are operation, transportation, inspection, and delay. From the 23 activities that has been recorded, the table 4.2 gives the categorization of each activity.

Table 4.2 Process Activity Mapping Phase 2

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator	Activity					Notes
						Operation	Transport	Inspection	Storage	Delay	
	Moving big bag from drier to truck										
1	Setting up the forklift	Forklift		1 min		●					
2	Going to drier 6		310	2,5 min			→				
3	Putting the big bag in the shuttle truck			15 min		●					For 16 big bags
4	Return journey to the PW2		310	2,5 min			→				
5	Moving the big bag from truck to the loading bay			15 min		●					For 16 big bags
	Transporting big bag from drier 6 to substore 2										
6	Setting up the shuttle truck	Shuttle truck		5 min		●					
7	Going to drier 6		310	3 min			→				
8	Waiting for loading process			15 min						Δ	For 16 big bags
9	Return journey to the PW2		540	3 min			→				
	Moving big bag from truck to substore 2										
10	Operator setting up forklift	Forklift		1 min		●					
11	Forklift going to unloading dock			30 sec			→				
12	Lifting big bag from unloading dock to inventory			30 sec		●					For 16 big bags

Table 4.2 Process Activity Mapping Phase 2 (Cont’d)

No	Flow Process	Tools/ Medium	Distance (m)	Time	# of operator	Activity					Notes
						Operation	Transport	Inspection	Storage	Delay	
Moving big bag to Silo (a)											
13	Moving big bag from inventory point to hoist place	forklift		45 sec			→				
14	Putting down used big bag from pump	hoist		77 sec		●					For one big bag
15	Lifting the big bag to place of the pump	hoist		60 sec		●					For one big bag
16	Opening and waiting for the big bag to be emptied			28 min						Δ	For one big bag
Moving big bag to Silo (b)											
17	Moving big bag from inventory point to lift	Forklift		30 sec			→				
18	Lift moving up	lift		1 min							4 big bags capacity
19	Moving big bag from lift to temporary place	handtruck		45 sec		●					For one big bag
20	Lifting big bag with hoist	hoist		45 sec		●					
21	Opening and waiting for the big bag to be emptied			3 min						Δ	
22	Putting big bag back and tidy up	hoist		1,2 min		●					

4.3. Measure Phase

In this subchapter, the measure phase will be done. As stated in the research methodology, the measure phase will measure and give the current condition of the process as it is. The measure phase will be consisted of waste identification and production rate data. The waste identification will measure the current process waste, and the production rate data will give the current production rate to be calculated later in the inventory level calculation.

4.3.1. Activity Classification

In this subchapter, the waste identification activity will be done. The waste identification will be done based on the activity described by the process activity mapping. Then the activity will be categorized into three category of Value Added (VA), Necessary non Value Added (NNVA), and Non-Value Added (NVA) activity. The classification will be done by classifying the opration type in the process activity mapping as the value added activity, transportation and inspection as necessary non value added activity, and inventory or waiting as non value added activity. The classification of tranportation and inspection as necessary non-value added activity is because the activity don't actually add value to the product, but is necessary to be done. In lean manufacturing approach, this type of activity is better to be averted or minimized. Meanwhile the inventory and waiting type of activity is classified as the non value added activity because it doesn't add any value to the process and made the resource to produce wasted. After each activity has been defined into each category, the corresponding waste from the process will also stated. The activity classificaiton for the material handling activity are:

1. Moving big bag from drier to truck.

The activity classification of mocing big bag from drier to truck activity can be seen in table 4.3

From table 4.3 it can be seen that there is 20% of necessary non value added activity. For value added activity, there is 80%. Meanwhile there are no non value added activity in the moving big bag from drier to truck.

Table 4.3 Activity Classification of Moving Big Bag from Drier to Truck

No	Activity	Activity Classification		
		NVA	NNVA	VA
1	Setting up the forklift			
2	Going to drier 6			
3	Putting the big bag in the shuttle truck			
4	Return journey to the PW2			
5	Moving the big bag from truck to the loading bay			
Total		0	1	4
Percentage		0%	20%	80%

2. Transporting big bag from drier 6 to substore 2

The activity classification for transporting big bag from drier 6 to substore 2 can be seen in table 4.4 below

Table 4.4 Activity Classification of Transporting Big Bag from Drier 6 to Substore 2

No	Activity	Activity Classification		
		NVA	NNVA	VA
6	Setting up the shuttle truck			
7	Going to drier 6			
8	Waiting for loading process			
9	Return journey to the PW2			
Total		1	1	2
Percentage		25%	25%	50%

From table 4.4, it can be inform that 50% of the activity are categorized as value added activity. For the non value added and necessary non value added activity 25% of it.

3. Moving big bag from truck to substore 2

The activity classification of moving big bag from truck to substore 2 can be seen in the table 4.5 below

From table 4.5 it can be informed that there are 67% of necessary non value added activity in the process. For value added activity, there are 33%, and there is no non value added activity in the process.

Table 4.5 Moving Big Bag from Truck to Substore 2

No	Activity	Activity Classification		
		NVA	NNVA	VA
10	Operator setting up forklift			
11	Forklift going to unloading dock			
12	Lifting big bag from unloading dock to inventory			
Total		0	2	1
Percentage		0%	67%	33%

4. Moving big bag to Silo

For the moving big bag to Silo there are two ways. The first is by using pump, the activity classification is shown in table 4.6

Table 4.6 Activity Classification of Moving Soap Chip from Big Bag to Silo using Pump

No	Activity	Activity Classification		
		NVA	NNVA	VA
13	Moving big bag from inventory point to hoist place			
14	Putting down used big bag from pump			
15	Lifting the big bag to place of the pump			
16	Opening and waiting for the big bag to be emptied			
Total		1	2	1
Percentage		25%	50%	25%

In the moving big bag to Silo using pump activity, 50% of the activity are categorized as necessary non value added activity. Meanwhile both non value added activity and value added activity has 25%. For the second method of moving big bag to Silo are using lift, the activity classification is shown in table 4.7

For the moving soap chip to Silo using lift activity, 50% of the activity are value added activity. 33% activity are categorized as necessary non value added activity, and 17% of the activity are categorized as non value added activity

Table 4.7 Activity Classificaiton of Moving Soap Chip from Big Bag to Silo using Lift

No	Activity	Activity Classification		
		NVA	NNVA	VA
17	Moving big bag from inventory point to lift			
18	Lift moving up			
19	Moving big bag from lift to temporary place			
20	Lifting big bag with hoist			
21	Opening and waiting for the big bag to be emptied			
22	Putting big bag back and tidy up			
Total		1	2	3
Percentage		17%	33%	50%

4.3.2. Waste Identification

In this subchapter, the waste in the production process will be identified. The activity that is classified as necessary non value added activity and non value added activity will be identified as waste. The activity that is classified as waste will be given in table 4.8.

Table 4.8 Waste Identification in the Material Handling Process

No	Activity	Activity Classification		Waste
		NVA	NNVA	
1	Setting up the forklift			Motion
6	Moving the big bag from truck to the loading bay			Transportation / motion
7	Setting up the shuttle truck			Motion
9	Waiting for loading process			Waiting
11	Operator setting up forklift			Motion
12	Forklift going to unloading dock			Transportation / motion
15	Putting down used big bag from pump			Motion
16	Lifting the big bag to place of the pump			Waiting

Table 4.8 Waste Identification in the Material Handling Process (Cont'd)

No	Activity	Activity Classification		Waste
		NVA	NNVA	
17	Opening and waiting for the big bag to be emptied			Waiting
19	Lift moving up			Waiting
22	Opening and waiting for the big bag to be emptied			Waiting
23	Putting big bag back and tidy up			Motion

Table 4.9 Recapitulation of the activity classification

Waste	Transportation		Motion		Waiting	
(%)	17%		42%		42%	
Activity classification	NVA	NNVA	NVA	NNVA	NVA	NNVA
total	0	2	0	5	3	2

From the table 4.8 and 4.9, it can be informed that the waste happen in the process are waiting, motion, and transportation. The transportation waste have 17% from all the waste, the motion waste has 42% portion and waiting waste has 42% portion. The non value added activity are all forming the waiting waste. This happen in the waiting for the soapchip from big bag being transferred into the Silo.

Aside from the waste identification from the process activity mapping, some waste also identified based on the observation in the substore 2. Unorganized placement in the inventory space become the most common things in the substore 2. This behaviour can be categorized as inventory waste. Also, it can lead for other potential waste to happen such as motion waste, overprocessing waste, transportation waste, and defects waste.

The motion waste could happen from the condition because it can create more step and unnecesary motion to be done to execute an action. For example, because of the cluttered things, it is needed to sort out from the inventory space to reach for the specific material needed. This also closely related to overprocessing waste where the same thing could happen.

The transportation waste could also happen because it add more time to move the material throughout the inventory space. Because of the clutered material, the distance travelled by handtrucks or forklift could be longer thus adding the waste of transportation. Possibility of defects in the inventory space can also happen because of the cluttered and unorganized material placement. If the operator are not carefull enough, a forklif can hit a stack of material and damaging it, making the material has defects. The event of damaging material occasionally happen when the researcher are observing the activity in the substore 2.

4.3.3. Production Rate Data

In this chapter, the production rate of the three line in PW2 factory will be displayed. The production rate of the production line is needed to calculate the actual demand for the inventory calculation. The production rate data that is displayed in this subchapter are the production data from January 2018 to May 2018. The table 4.10 will show the summary of the production rate data.

Table 4.10 Production Rate Data of PW2 Factory

Week	line 15	line 16	line 17
week 1	38,94	34,35	36,13
week 2	41,30	43,37	48,26
week 3	45,50	42,12	47,51
week 4	42,66	38,78	47,51
week 5	44,78	40,04	49,37
week 6	47,24	41,65	49,31
week 7	44,77	41,22	44,50
week 8	47,54	37,96	43,20
week 9	44,43	43,93	45,51
week 10	37,33	37,90	42,21
week 11	35,13	36,25	47,80
week 12	41,76	35,20	48,01
week 13	33,18	30,48	46,46
week 14	39,25	42,00	44,95
week 15	43,60	36,07	49,08
week 16	46,07	35,84	41,91
week 17	41,56	37,39	Abnormality
week 18	40,01	35,56	45,75
week 19	Abnormality	Abnormality	44,76
Average	41,95	38,34	45,68

A more detailed information of the production data can be seen in appendix 1. The production rate from each line vary. The variation caused by several cause, such as the product weight produced in a specific line, the machine difference in specification, and the work order given to the line at specific time. In general the three production line are capable of producing several type of product and change it production to corresponding product. The product type vary in the volume of the bar soap, starting from 80 gram, 85 gram, 110gram, and 231 gram. Each of the line produced the bar soap in cardboard measurement. The data presented are already in tonage, it has been adjusted from the raw data of production per fiberete (cardboerd) unit. For each weight, the production unit is different. For 80 gram is 144 unit per fiberete, for 85 grams is the same 144 unit per fiberete, for 110 gram is 96 unit per fiberete, and for 231 gram is 48 unit per fiberete.

From the data presented, it can be informed that the three production line able to produce soap bar with production rate average of 41,95 ton per day, 38,84 ton per day, and 45,68 ton per day, correspondingly for line 15,16, and 17. Some abnormality happen in line 17 week 17 because there are no production order for the line for two days. In week 19, abnormality occured in line 15 and 16 because the soap chip supply from drier 6 are troubled.

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CHAPTER 5
ANALYSIS AND IMPROVEMENT PLANNING

In this chapter, the two phase from DMAIC framework will be discussed, which is analyze phase and improve phase. In the analyze phase, the value stream mapping and the process activity mapping constructed before will be analyzed. After that, a root cause analysis using 5 why method will be done to analyze the root cause of the waste identified in sub chapter 4.3.2. The last analysis in the anlayze phase is the inventory calculation process, where the appropriate inventory level for the big bag in the substore will be calculated. After that, in the improve phase, the improvement alternative to the inventory problem will be given. Based on the inventory calculation, the reccomendation for layout of the substore will be given. The improvement for corresponding waste found in the material handling process will also be given. The chapter is then closed by providing comparison of improvement between the existing condition and proposed improved condition.

5.1. Analyze Phase

In this subchapter, the analayze phase of the DMAIC framework will be done. The analyze phase consists of the analysis of value stream analysis, process activity mapping. The root cause analysis of the waste happened also will be done. The analyze phase will be ended by inventory calculation analysis.

5.1.1. Value Stream Mapping Analysis

In the value stream mapping of overall process, it can be inferred that the time to process the order from to the customer in marketing department and production planning department is done twice a year because the demand is forecasted for 6 month periode and directly planned by the production planning department.

The other infomation shown by the value stream mapping is the lead time of the production. The lead time for the overall production process is 785 minutes.

The lead time consists of value added time of 185 minutes and non value added time of 600 minutes. For the material handling process, the value added time is 59 minutes, while for the non value added time is 36 minutes. In the lean manufacturing method, the non value added activity should be removed. This is because the activity takes resource such as time and money (in worker salary) but give no value to the product. While for the necessary non value added activity type, it should be reduced. The necessary non value added activity needs to be done to complete the process but it is not adding value to the product. That is why this type of activity needs to be reduced so it consumes less resource to be done. The material handling process is then anlyzed further in the process activity mapping where the activity is classified into value added activity, non value added activity, and neessary non value added activity.

5.1.2. Process Activity Mapping Analysis

In this subchapter, the process activity mapping that is constructed before will be analyzed. In the construction process, phase 1 and 2 has been done. In this subchapter, the phase 3 of analyzing will be done. The mapping is done from the process of moving big bag from the drier to the truck, until the process of moving soap chip to the Silo. After the activity has been classified, the table 5.1 will show the recapitulation of the total activity in the material handling process.

Table 5.1 Recapitulation of Activity Classification

Activity type	Total	Percentage
Operation	11	52%
Transport	7	33%
Inspection	0	0%
Delay	0	0%
Storage	3	14%

From the table 5.1 it can be inferred that the majority of activity (52%) are categorized as operation type of activity. The transport type of activity is then has 33%, and the delay type of activity has 14%. There are no activity classification for inspection, because the inspection activity only be done in the beginning of the process (the raw material arrival) and the end of the process (batch example sampled from the production result).

Although the majority of the activity is classified as operation type, the transport and delay are stil identified. This type of classification can be further analyzed in the activity classification. The summary of activity classification where the activity is classified into value added, non value added, and necessary non value added activity will be given in table 5.2 below

Table 5.2 Recapituation of Waste Identification

Activity Type	Total	Percentage
Value Added	9	53%
Non Value Added	2	12%
Neccesary non value added	6	35%

From the table 5.2, it can be informed that the value added activity is the majority in the material handling activityty with 53%. The non calue added has 12% and the neccesary non value added activity with 35%. The result almost similar to the process activity mapping percentage. This is due to that the operation activity can be classified as value added activity. Meawhile, the transport and delay type of activity are often classified also as necessary non value added activity. As stated before, this type of activity has to be minimized or reduced in order to make the material handling process more lean.

The necessary non value added activity classified in the process activity mapping are mostly related to motion and movement waste. This waste can be reduced by proposing a more lean and efficient way to the the activity. Meanwhile the non value added activity is more related to the waiting waste, especially when waiting the big bag to load, and waiting for the pump to unload the soap chip from the big bag. This needs to be removed as it is source consuming and not adding any value to the process.

5.1.3. Root Cause Analysis

In this subchapter, the root cause analysis of the waste happened will be done. Based on the waste identification subchapter, several waste happened includes motion, transportation, waiting, and inventory. The root cause analysis will be using the five why's method

1. Motion waste

The root cause analysis for the motion waste are done in 2 subwaste. The 2 subwastes are the setting up motion waste in forklift and shuttle truck, and unnecessary motion while tidying up the emptied big bag. The motion waste for the setting up motion leading to more time needed to do the transportation activity. While the unnecessary motion in tidying up the big bag will make the operator travel more distance and need more time to complete. The root cause analysis for motion waste are shown in table 5.4

Based on the root cause analysis, the root cause for the 2 subwastes are no schedule and SOP for forklift operation and no place to put the tools needed to tidy up the big bag. The root cause for waste can be seen in table 5.3

Table 5.3 Root Cause of Motion Waste

Waste	Subwaste	Root cause
Motion	Long time spended setting up the forklift and shuttle truck	No schedule of operating the forklift
	Unnecessary motion while putting down used big bag from pump and tidy up	No place to put the necessary tool near the work area to tidy up big bag

Table 5.4 Five Why's Analysis on Motion Waste

Waste	Subwaste	Why 1	Why 2	Why 3	Why 4	Why 5
Motion	Long time spended setting up the forklift and shuttle truck	Forklift often low in battery due to lack of charging	No standard time of operating and charging forklift	No schedule of operating the forklift		
	Unnecessary motion while putting down used big bag from pump and tidy up	Operator need to find tools to putting down and tidy up used big bag	Tools to tidy up big bag put faraway from the work area	No place to put the necessary tool near the work area to tidy up big bag		

2. Transportation waste

The root cause analysis for transportation waste are done to the 2 subwastes. The 2 subwastes are the transportation waste happen in the transportation between drier 6 and substore 2, and the transportation waste happen inside the warehouse material handling activity. The root cause analysis can be seen in table 5.6

From the root cause analysis, it can be known that the root cause for the 2 subwastes are no maintenance schedule and backup shuttle truck available, and no schedule of processing scrap material accumulated in the warehouse. The root cause of scrap material processing resulted in many unnecessary distance transported of big bag inside the warehouse. The summary of root cause can be seen in table 5.5

Table 5.5 Root Cause of Transportation Waste

Waste	Subwaste	Root cause
Transportation	Transportation waste between drier 6 to substore 2	No maintenance schedule and backup shuttle truck
	Unnecessary transport inside warehouse	No schedule of reducing scrap material

Table 5.6 Five Why's Analysis of Transportation Waste

Waste	Subwaste	Why 1	Why 2	Why 3	Why 4	Why 5
Transportation	Transportation waste between drier 6 to substore 2	Shuttle truck needed to transport big bag	Shuttle truck is very old	No maintenance schedule and backup shuttle truck		
	Unnecessary transport inside warehouse	No specific place to put the big bag	Space to put big bag occupied with scrap material	Scrap material stacked too much	No schedule of reducing scrap material	

3. Waiting waste

The root cause analysis for te waiting waste are done to 3 subwastes. The 3 subwastes related to the waiting waste are the waiting time waste in between bigbag supply, waiting time when unloading the big bag to substore 2, and waiting time when the big bag is being emptied. The root cause analysis for the three subwastes can be seen in table 5.8

From the table 5.7, the root cause for the three subawastes can be seen. The root causes are drier 6 need to reach the shuttle truck capacity before transported to substore 2, no designated unloading loading bay for the trucks, and no standard schedule of using pump or lift. Beside of that, the root cause of different time emptying big bag using pump and lift can be the major cuase of long waiting time of emptying big bag.

Table 5.7 Root Cause of Waiting Waste

Waste	Subwaste	Root cause
Waiting	Waiting time accross material handling activity between drier 6 and substore 2	Production of soap chip from drier 6 transported with no schedule.
		No designated unloading loading bay
		No standard schedule of using pump or using lift

Table 5.8 Five Why's Analysis of Waiting Waste

Waste	Subwaste	Why 1	Why 2	Why 3	Why 4	Why 5
Waiting	Waiting time accross material handling activity between drier 6 and substore 2	Waiting time between big bag supply	Shuttle truck operating in interval of time	Production of soap chip from drier 6 transported with no schedule.		
		Waiting time to unload the big bag to substore 2	Only 2 unloading bay in the warehouse	Loading activity of finished product often delay the unloading process of big bag	No designated unloading loading bay	
		Waiting time when big bag is being emptied	Different time of empting big bag between pumping and using lift	Pumping require longer time then using lift	No standard schedule of using pump or using lift	

4. Inventory waste

The root cause analysis for inventory waste will include the analysis for 3 subwastes. The 3 subwastes are items put in passage way, unused space in racking system, and operator don't know where to put the material. The root cause analysis for the three subwastes can be seen in table 5.10

From the root cause analysis, the root cause for the three subwastes can be found. The root causes are no calculation ever done to determine the needed capacity in the warehouse, no updated plan for the unused space in the racking system, and no genba activity are scheduled or planned. The root cause that is the main problem for messy placement are that the placement of item no longer follow the layout planned before. The absence of genba activity from the management also make the operator freely put the inventory in messy place. The summary of the root causes can be seen in table 5.9

Table 5.9 Root Cause of Inventory Waste

Waste	Subwaste	Root cause
Inventory	Messy inventory placement in warehouse	No calculation of needed inventory in warehouse
		No new plan for the unused space
		Genba is not scheduled or planned

Table 5.10 Five Why's Analysis of Inventory Waste

Waste	Subwaste	Why 1	Why 2	Why 3	Why 4	Why 5
Inventory	Messy inventory placement in warehouse	Many item put in passage way	Over inventory happen in warehouse	No calculation of needed inventory in warehouse		
		Unused space in the racking system	Unused space initially prepared for the stopped production product	No new plan for the unused space		
		Operator dont know where to put material	Management don't know about the problem	No genba is ever done to inventory space	Genba is not scheduled or planned	

5.1.4. Inventory Calculation Analysis

In this subchapter the calculation of suitable inventory in substore 2 will be conducted. After in subchapter 4.3.2 the production rate data has been provided, the calculation for optimum inventory level will be done. Based on table 4.10 the total soap chip needed to keep the production process going have average of 125,96 ton/day. It means, the soap chip production on PW1 must be able to supply 125,96 ton of soap chip per day to PW2 substorage.

Next, safety stock need to be calculated. This is to overcome the possibility of the drier stopping production due to problems. Based on the interview with the team leader, Mr. Sulaiman, several condition can halt the production or the transportation process of soap chip from PW1 to PW2. The condition that has been occured before were the shuttle truck went broke, the absence of the shuttle operator, and disruption in drier 6 itself due to problem in the soapchip making process. To calculate safety stock, several variable are needed, such as the desired service level, the demand standard deviation, and the delivery lead time. In this calculation, the service level are using 95% based on the interview with the production manager. The demand standard deviation are using the standard deviation from the production rate in the three production line as the production from the production line are considered as the demand. For the delivery lead time factor are ignored because the intermediary material can be directly transported from PW1 to PW2. The safety stock are calculated for each line of production, considering for different production rate capability of each line. An example for safety stock calculation based on equation 1 for line 15 are presented below:

$$SS = Z \times \sigma \times \sqrt{LT}$$

$$SS = 1.96 \times 4.06$$

$$SS = 7.95$$

From the calculation, it is shown that the safety stock for the production of line 15 require 7,95 ton soap chip per day. For other line, line 16 is 3,59 ton per day, and for line 17 is 3,33 ton per day. So, the total safety stock for the three production line is 21,51 ton per day.

After safety stock has been calculated, it can be informed that the total soap chip demand for the three production line to run every day would be 125,96 ton + 21,51 ton = 147,48 ton per day. According to the inteview conducted to the leader in the soap chip drier (drier 6 for supplying demand in substore 2) the production capacity of the drier is 8 ton per hour. This means, the drier are capable of producing 8 x 24 = 184 ton per day. This means, the demand and supply has gap of 36,52 ton per day. With sufficient capacity, the demand can be safely fulfilled.

There are two possibility of improvement that can be implemented using the result of the calculation provided above. For the current condition, the soap chip are transported from drier 6 to PW2 substore using big bag that weigh of 800kg per big bag. For the current condition, the calculation of how many big bag are needed is provided in the table 5.11

Table 5.11 Big bag needed in 800 kg capacity

800 kg big bag					
	line 15	line 16	line 17		
bigbag/day	52	48	57	total big bag per day	184
safety stock	10	9	8	total big bag per shift	61
Big bag	62	57	65	total bigbag per hour	8

In this scenario, the total big bag per day needed are 184 big bag. The total big bag per shift needed are 61 big bag per shift. For this condition, in order to be able to implement the 4-8 hour storing time a space for 122 big bag are needed in the inventory slot. The space is to store the big bag for two shifts. However, other scenario are available. The big bag maximum capacity is 1.000 kg or 1 ton per big bag. The table 5.12 will show how the big bag inventory needed if the big bag is 1.000 kg per big bag.

Table 5.12 Big Bag Needed in 1000kg Capacity

1000 kg big bag					
	line 15	line 16	line 17		
bigbag/day	42	38	46	total big bag per day	147
safety stock	8	7	7	total big bag per shift	49
Bigbag	50	45	52	total bigbag per hour	6

In the table, it can be shown that the total big bag needed per day is 147, and 49 per shifit. This means that the space needed in the inventory will be 98 big bag. As stated before the 98 big bag inventory are for two shift for each shift 49 big bag are needed.

5.2. Improve Phase

After the analyze phase has been done, the next phase in the DMAIC framework is the Improve phase. In the improve phase, several alternatives and recomendation related to the problem happened will be discussed and displayed. The subchapter consisted of improvement alternatives and improved condition comparison.

5.2.1. Improvement Alternative

In this subchapter several improvement suggestion will be discussed and described. It consists of the relayout of substore 2, motion waste improvement, transportation waste improvement, waiting waste improvement, and inventory waste improvement.

5.2.1.1. Motion Waste

From the root cause analysis done in chapter 5.1.3, the root cause for the motion wastes are:

- No schedule for operating of the forklift
- No place to put the necessary tool near the work area to tidy up big bag

Based on the root causes, the improvement recommendation for the waste are:

1. Give designated space or tool bucket for tidying up big bag

The first recommendation to reduce the motion waste in the tidying up big bag activity is by assign a space or specia tool box to store the tools needed to do the tidying up activity. This is due to unplanned and messy tool put everywhere in the substore will cause the operator to search the tool first in order to do the activity. By giving designated space or tool box, the operator doesn’t need to search for the tool before using it.

The tools needed to tidy up the used big bag are clear tape, scissor, and rope. The clear tape, scissor and rope often used by various activity in the warehouse, such as wrapping the scrap material after being crushed, cutting raw material container before being used, and other activity too. The tools can be anywhere in the warehouse after other operator used it. The bucket will be placed near the unpacking area of big bag, which is near the Silo in 4th floor. This is because in the recommendation, the big bag emptying only done using lift.

The tool box or space can be using the scrap or waste of production, which is the scrap wrapper. The bar soap that is defected or scrapped with wrapper normally will be torn apart and sold in kilo to a plastic recycling company. Using some of the scrap to make a tool bucket is free, no costs needed and eliminte the search activity. The illustration of the tool bucket will be shown in figure 5.1

Figure 5.1 Illustration of tool box for the tidying up big bag activity

2. Assign schedule of forklift usage based on the new layout and operating schedule

In the new layout reccomendation in chapter 5.2.1.1 , the total big bag transported each shift will be 49. The big bag transported will be in 1 ton each big bag. The 49 big bag will be transported in 3 waves of transporting from drier 6. Each waves of big bag have interval of 2 to 2,5 hours. This is because, the capacity of drier 6 is 8 ton per hour. That mean 8 big bag per hour (1 ton each big bag). From this information, the schedule of forklift can be constructed.

The schedule of the forklift will ease the operator of forklift to decide what to do in particular time. In the existing condition, the activity of forklift only based on the current situation and doesn't have any schedule. This means, many idle time are created, because bassically the forklift only doing the unloading activity of big bag. The schedule of the forklift presented can be used in the 3 shift of operation. The schedule will be presented in table 5.13

Table 5.13 Schedule Recommendation for Forklift Usage

<table>
<tr><th>Time</th><th>Activity</th></tr>
<tr><td>00.00-00.30</td><td>Unloading 16 big bag</td></tr>
<tr><td>00.30-01.00</td><td>Tidy up inventory space</td></tr>
<tr><td>01.00-01.30</td><td rowspan="2">Charging</td></tr>
<tr><td>01.30-02.00</td></tr>
<tr><td>02.00-02.30</td><td>Unloading 16 big bag</td></tr>
<tr><td>02.30-03.00</td><td>Picking up used big bag</td></tr>
<tr><td>03.00-03.30</td><td rowspan="2">Charging</td></tr>
<tr><td>03.30-04.00</td></tr>
<tr><td>04.00-04.30</td><td>Unloading 16 big bag</td></tr>
<tr><td>04.30-05.00</td><td rowspan="2">Charging</td></tr>
<tr><td>05.00-05.30</td></tr>
<tr><td>05.30-06.00</td><td>Stacking the used big bag</td></tr>
<tr><td>06.00-06.30</td><td>Tidy up inventory space</td></tr>
<tr><td>06.30-07.00</td><td rowspan="3">Charging</td></tr>
<tr><td>07.00-07.30</td></tr>
<tr><td>07.30-08.00</td></tr>
</table>

From the table, there are roughly 3 activity done by the forklift, which are unloading the big bag from the shuttle truck, picking up the used big bag and scrapped material, and tidy up inventory space. With the schedule, now the idle time because of operator not knowing what to do can be reduced. The charging time is needed to keep the forklift can be operated.

5.2.1.2. Relayout of Substore 2

First, the improvement suggestion related to the inventory problem will be given. Based on the calculation of chapter 5.1.4, two possibilities can be implemented, based on the big bag capacity. For the 800 kg big bag capacity, the needed inventory for each shift will be 61 big bags, while for the 1 ton big bag capacity, the needed inventory for each shift will be 49 big bags.

In the background, the problem stated that it repuire a mandatory 4 – 8 hours store time be implemented. This is because to harden the soap chip freshly produced from the drier 6 facilities. The soap chip that is freshly produced from the drier still has a little moisture in it. The moisture can decrease the efficiency of the mixer, plodder and the machine processes after the Silo. The moisture in the soap chip that is not completely gone can also damage the machines and make maintenance cost rising to fix the machines.

To achieve the 4 – 8 hours store time, the inventory space will be be prepared to be able to hold 2 times the capacity for each shift. With this method, the big bag can be stored for more than 8 hours (drastically reduce the moisture in the soap chip) before it is moved in to the Silo. To achieve more efficiency while maintaining low level of space needed for inventory, the calculation of 1 ton soap chip in each big bag will be choosen. The inventory space needed then will be 100 big bags (49 big bags each shift x 2). Figure 5.1 will show how the inventory space will be arranged in the substore 2.

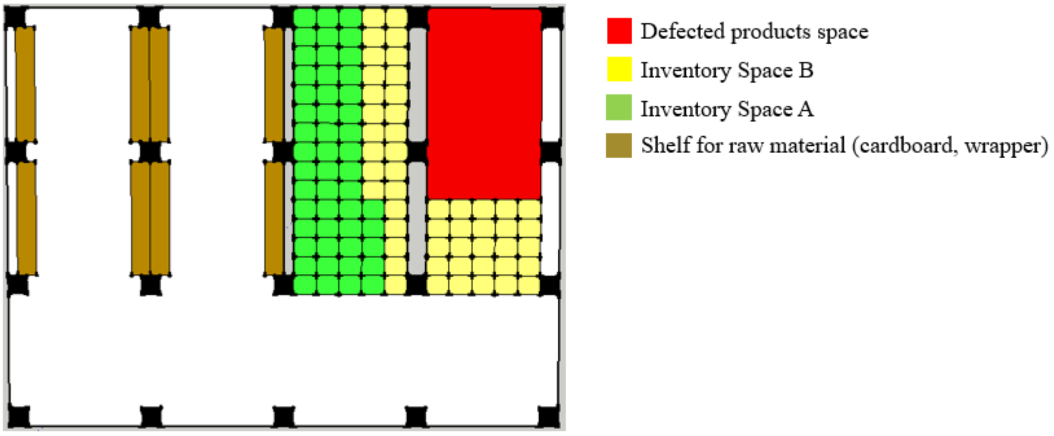

Figure 5.2 Improvement Recommendation of Subsotre 2 Layout

To better understand the concept of two inventory space, the inventory space will be named, the diagram shown in figure 5.2 will show the name of each inventory space. In the diagram, space F,G,H,I,J 6 to 15 are coloured red, this is to show that the space are allocated for defects and scrap products. The yellow coloured space, which are F,G,H,I,J 1 to 5, E column, and D 15 to 6 are named inventory space B, while the rest, the green coloured are named inventory space A. For each inventory space, number has been given to identify each individual space.

To implement the concept, first, the inventory space will be marked with two different color to differentiate where to put big bag from the drier 6, and where to take from the inventory space. The space will be named by inventory space A and B. For example, for the morning shift (6 a.m to 2 p.m) the big bag to be supplied taken from inventory space A, while when the big bag arrive from drier 6, it will be stored in inventory space B.

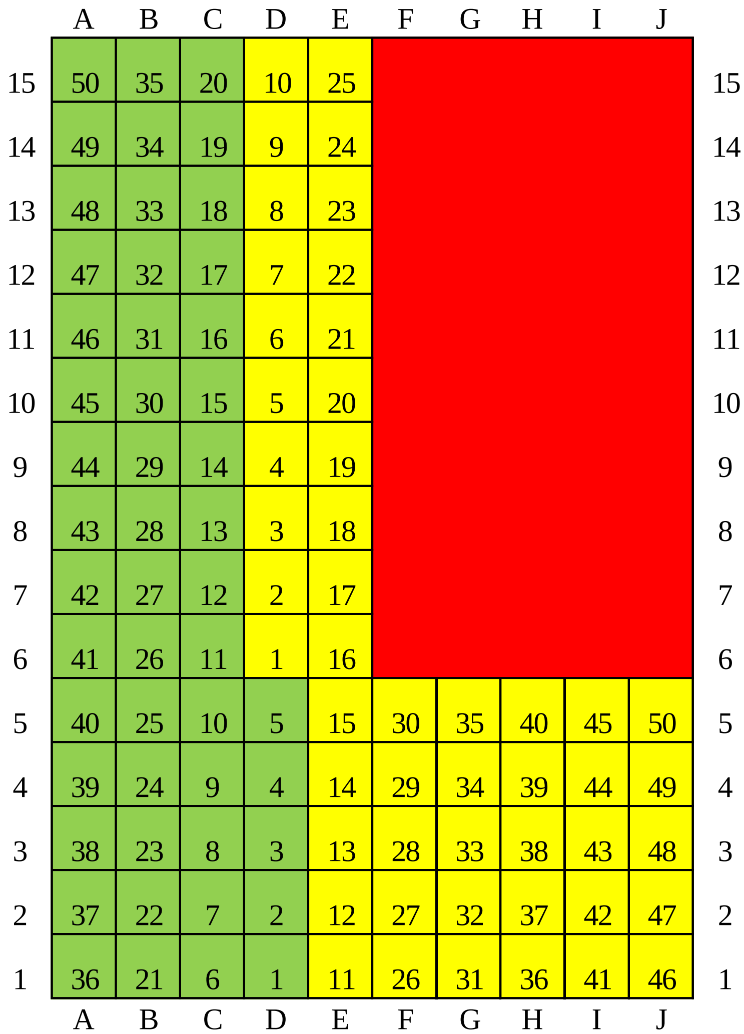

Figure 5.3 Inventory Space Notation

In figure 5.3, the notation for inventory space can be seen. The notation and space numbering is shown for each inventory space A and B from 1 to 50. The number representing the sequence of inflow as well as outflow of the big bag into the inventory space. This means, if from the shift before the big bag is from inventory space A, then the first big bag for the production is from the space number 1 (grid D-1) and so on.

For each shift, the inflow of big bag will be 49 big bags. In the inflow, a safety stock of 7 big bag. This may cause cumulation of unused safety stock big bag. But the safety stock are calculated to anticipate any uncertainty of continuous soap making process. Should any cummulation of big bag happen in the substore 2, the drier 6 can reduce the production rate to wait until the safety stock are used.

5.2.1.3. Transportation Waste

From the root cause analysis done in chapter 5.1.3, the root cause for the transportation wastes are:

- No maintenance schedule and backup shuttle truck
- No schedule of reducing scrap material

Based on the root causes, the improvement recommendation for the waste are constructing schedule for both maintenance of the shuttle truck, and schedule to recycle the scrap material.

1. Truck maintenance schedule

The shuttle truck used to transport the big bag are very old and outdated. This need a serious attention to maintain and conduct maintenance activity so that the truck can be used reliably. Based on the interview with the team leader (Mr. Sulaiman) the shuttle truck can stop operating just because of the flood inside the factory. If flood happen, the truck can be stalled and it hold the big bag material handling activity.

A simple twice a week maintenance can be done to prevent the breakdown and stall of the truck. But a very thorough research about the truck reliability and capability of carrying 16 ton of big bag need to be done. It is reccomended to continue the research to determine whether it is beneficial or not to keep or maintenance the current truck. The shuuttle truck used to transport material can be seen in figure 5.4.

Figure 5.4 Shuttle Truck Used to Transport Big Bag

2. Scrap material recycle schedule

In the current condition, the number of scrap material that can be stocked in the substore 2 are 60 pallets of scrap material. But in the new reccomended layout, the scrap material allowed in the substore 2 are only 40 pallets. In the current condition also there are no schedule of emptying the scrap material in the substore 2.

The schedule of emptying the scrap material will be determine by the volume of the scrap material in the substore. It is known that the maximum capacity of scrap material is 40 pallets. The scrap emptying process then should be done when the volume of scrap material are 30 or beyond. The 10 pallet reserve are planned to avoid any over volume in the scrap material inventory.

Not only the schedule to empty the scrap material is needed, but also prioritization of scrapping scrap material is needed. . The cardboard and plastic material can be directly scrapped and shipped to a recycling company, while the bar soap need to be crushed in pieces before it can be remanufactured. This way, the plastic and cardboard scrap material need to be prioritized so that the inventory doesn’t stack up in substore 2.

5.2.1.4. Waiting Waste

From the root cause analysis in chapter 5.1.3, the root causes for waiting wastes are:

- Production of soap chip from drier 6 transported with no schedule.
- No designated loading unloading deck
- No standard schedule of using pump or using lift

Based on the root causes, the improvement recommendation for the waiting waste are:

1. Schedule of transporting bigbag from drier 6

The schedule of transporting bigbag from drier 6 can be made following the schedule of unloading activity stated in subchapter 5.2.1.2

2. Assignment of loading unloading deck

In the substore 2, there are 2 unloading deck. The unloading deck are used for two activities, which are the activity from the substore 2 and the finished good storage. Although there are 2 loading unloading deck, the loading activity from the finished storage often used the two space of loading unloading deck. This lead to delay of unloading activity of big bag. The delay caused by this activity is then classified as waiting waste.

On the schedule proposed in 5.2.1.2 where the big bag will be transported in interval of 2 hours, it can be used for the assignment of loading unloading deck. In the schedule, the unloading activity will happen in the start of the shift (time 00.00), time 02.00, and time 04.00. Every shift will apply the same schedule. This means, one unloading deck must be available in this unloading schedule. Aside of those schedule, the two loading unloading deck can be used for the finished product. The unloading deck that must be made available should be the one that near the substore 2 location, which in figure 5.5 is the dock A

Figure 5.5 Two Loading Unloading Dock.

3. Lift of pump usage determination

The waiting waste also caused by the unmatched time of emptying big bag by using pump or by directly moving the big bag to Silo. From the Process Activity Mapping it can be shown that longer time are required when using the pump to empty the big bag into the Silo then directly move the big bag to the Silo in the 4th floor.

Using the pump may be slower than using lift directly to 4th floor, but using pump is easier to be done because it doesn't require additional worker on the 4th floor to move the big bag to the silo using the hoist. But by using the lift to directly pour and empty the big bag to the silo are more efficient because it need less time than using the pump.

The lift maximum capacity to transport big bag to 4th floor is 4 pallet, which is 4 ton. To construct schedule, the supply to the silo must be matched with the consumption of each line. The conversion of soap chip consumption per line per hour can be seen in table 5.14

Table 5.14 Soap Chip Consumption per Line

	bigbag/day	bigbag/hour	bigbag/2 hour
line 15	42	1,7	3
line 16	38	1,6	3
line 17	46	1,9	4

From table 5.14 it can infered that the demand for each line is 3 big bag for line 15 and 16 and 4 big bag for line 17 per 2 hour. The total big bag needed per 2 hour is 10 big bag. After the demand is known, the schedule can be determine, which is by constantly transporting 10 big bag every 2 hour to the top floor. From the process activity mapping, it can be known that for a cycle of transporting big bag to 4th floor require 1 minute, while to unload the big bag require 45 second each bigbag, so in total is 3 min, and going down is 1 minute. The total time for a batch to be transported using lift is 5 minutes. To transport 10 big bag, 3 batch of transportation is needed, so the total time will be 15 minutes. This means, every 2 hours, 15 minutes of transporting big bag to the 4th floor is needed.

5.2.1.5. Inventory Waste

From the root cause analysis in chapter 5.1.3, the root causes for inventory wastes are:

- No calculation of actual demand of big bag inventory ever done in warehouse
- No new plan for the unused space
- Genba activity is not scheduled or planned

The first and second root cause of the inventory waste has already given recommendation. The actual demand of big bag inventory has been given in subchapter 5.1.4. While the new plan for the unused place is given in the new layout recommendation in chapter 5.2.1.1. For the third root cause the recommendation will be a schedule for gemba walk activity

In the inventory problem, operator often place material or item recklessly. Many item placed in racking aisle, on the forklift way, and near the column. This may lead to many waste. The illustration of cluttered and unorganized substore 2 inventory space can be seen in figure 5.6

Figure 5.6 Cluttered and Messy Inventory Placement in Substore 2

Genba or gemba (現場) is a Japanese term with meaning of “the actual place”. In lean methodology concept, genba simply refers to the location where value is created. The location where the value is created is not only creating value, but also creating the most problem.

Gemba walk, is a term that define the action of walking around the factor floor with the goal to identify problem and improvement ideas. In fact, the benefits of conducting gemba walk is not only identifying problem but also it may increase productivity, reduce health and safety hazards, and prevent issues to happen.

After knowing it benefits, and because the problem is the lack of discipline of the operator, by doing gemba walk activity can reduce the waste of inventory. Implementing strong gemba walk can be achieved by doing the following steps:

1. Determining the responsible person to carry out the gemba walk activity

This step can be done by looking at the organizational chart of the responsible person in the material handling activity. A team leader or production manager can be assigned the duty of gemba walk activity as it is the responsible person in the material handling activity in substore 2.

2. Set up a gemba walk checklist

The checklist made will consists of several verification points that must be validated with every aspects while conducting the gemba activity. When constructing the checklist all member of the material handling activity must be involved, from the operator to the manager. It is important that the operator and worker know that the checklist and the gemba walk activity is done to improve and make sure the productivity target are achieved. An example of gemba walk checklist will be presented in table 5.15

3. Set up a standard gemba walk schedule

Gemba walk should be done regularly to identify issues imidiately. Without regular gemba walk, gemba walk just become a regular inspection. A regular schedule of gemba walk will also make the relation between the manager or person responsible and the operator better and a better relation will result in faster response and prevent issues more effectively. A twice a week schedule is appropriate to be implemented because the process to check in material handling is not immense or too complicated.

Table 5.15 Gemba Walk Checklist Recommended

Category	Subcategory	Checkpoints
Inventory	Tidyness	The cardboard raw material are placed into place
		The wrapper are placed in corresponding place
		The big bag are stored in the corresponding place
		The scrap material are placed in corresponding place
		The tools and forklift are placed in corresponding place
	Quantity	The number of cardboard and wrapper in the inventory space is sufficient
		The number of big bag are suit the schedule of inflow and outflow
Productivity	Equipment	The operator are using appropriate safety tools
		The forklift are in good condition
		The hand truck are in good condition
	Quality	The soap chip in the big bag are in good quality
		The wrapper stored are in good quality
		The cardboard stored are in good quality

4. Schedule gemba walk improvement meetings

After the gemba walk activity is regularly done and the checklist is filled up, a regular meeting about the gemba result should be done. The meeting will discuss about the result of the gemba walk and how the current condition of the “place where value (and problem) is created” is. Because the gemba walk activities is done twice a week, the meeting will be suited if scheduled once in two weeks. The meeting should discuss a bigger scope problem as the small issues and problem can be directly tackled in the routing gemba walk activities. The goal of the meeting is to keep up with the actual condition and tackle a possibility of bigger problem before occuring, or evaluate the big problem or issues happen in the last gemba activity done.

5.2.2. Improved Condition Comparison

In this subchapter a comparison of the current condition of the material handling and inventory activity will be done. The comparison is done on the current performance of material handling activity and inventory level to the possible improvement performance. Based on the chapter 5.2.1, there are several improvement reccomendation. The improvements can be summarized into (1) inventory relayout, (2) schedule of forklift, shuttle truck usage, big bag transportation frequency, (3) Gemba walk and tool box storage, and (4) lift only usage of soap chip pouring into silo. Each of the improvement recommendation will be compared below:

1. Inventory relayout

The inventory relayout are an effect of the new inventory calculation. The relayout aims to make room for the 100 big bag calculated in the new plan of inventory. Several benefits that is caused by the new inventory and relayout are the probability of production loss can be reduced. For example, throughout the production rate data (January to May 2018), several production loss happened because there are no soap chip big bag in the inventory to supply the production process. The revenue loss estimation are calculated in table 5.16

Table 5.16 Revenue Loss Calculation

	Line 15	Line 16	Line 17
Maximum output (ton)	47,53584	43,92936	49,37004
Total of 80 bar soap produced	594198	549117	617125,5
Revenue lost per day	Rp 2.376.792.000	Rp 2.196.468.000	Rp 2.468.502.000

In the table, the maximum possible revenue lost per line are Rp 2.468.502.000. The revenue loss happen because the production loss in a day. By implementing the relayout and inventory level recommendation, such loss can be hindered

2. Schedule of forklift, shuttle truck usage, big bag transportation frequency

The schedule of the activity given in the chapter 5.2.1 use for reducing set up time of various thing needed in the material handling process. In the current condition, long setup time happen because the usage and the activity are not planned. Rather the activity is directly done, without no schedule. This lead to uncertainty and unstandaradize setup time

To compare the condition before and after the improvement recommendation, table 5.17 are given. In the table, it is shown more than 50% of the process time can be reduced.

Table 5.17 Improvement from Schedule Construction

Improvement recommendation	Activities improved	Current time	Estimated improved time
Schedule of forklift, shuttle truck usage, big bag transportation frequency	Setting up the forklift	1 min	30 sec
	Setting up the shuttle truck	5 min	2 min
	Operator setting up forklift	1 min	30 sec

3. Gemba walk and tool box storage

The gemba walk activity and tool box storage tackle the issues in motion and inventory waste. The advantages of the recommendation is that it require minimum to none cost to implement. The gemba walk activities will only need cost to print the checklist, which can be included in the printing budget of the company. While the tool box storage are using the leftover wrapper or plastic material from the production process which means it doesn't require any cost.

The gemba walk and tool box storage recommendation are analysed together because both of them improve the time aspect of the process.The improvement of the recommendation can be measured in time improvement made possible. The table 5.18 will show the effect of the recommendation and the improvement made by the recommendation.

Table 5.18 Improvement Comparison from Gemba Walk and Tool Box Storage

Improvement recommendation	Activities improved	Current time	Estimated improved time
Gemba Walk activities	Lifting big bag from unloading dock to inventory	30 sec	30 sec
	Moving big bag from inventory point to lift	30 sec	30 sec
	Moving big bag from lift to temporary place	45 sec	30 sec
Tool box storage	Putting big bag back and tidy up	1,2 min	45 sec

From the table, it can be shown that two activities, moving big bag from lift to temporary place and putting big back and tidy up can be reduced 15 second and 35 second sequencely. While for the other two, the cycle team remains the same. Although remains the same, the gemba activities prevent the cycle time of those two activities to be longer than the standard. In current condition, they have tendency to become longer because without gemba walk, the inventory space become clutered, thus making the process longer.

4. Lift only usage of soap chip transfer into Silo

In the current condition, there are two ways to transfer the soap chip in big bag to the silo, which are using pump or directly using lift. Based on the recommendation given, it is better to only use the direct lift to transfer the soap chip. When compared, there is a major time difference between the two method. Table 5.19 show the comparison between current and improved condition relating to the loft

Table 5.19 Comparison of Only Using Lift to Transfer Soap Chip

Activity	Current	Improved
Transfer soap chip by pump	31 min	0 (eliminated)
Transfer soap chip by lift	7,2 min	7,2 min
Overal lead time	102 min	71 min

The pump using method require 31 minutes to completely transfer a bag of soap chip, while using lift only require 7,2 minutes to completely transfer a bag of soap. By eliminating the pump method, the overal lead time is reduced from 102 minutes to only 71 minutes.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

In this chapter, the conclusion and the recommendation regarding of the research will be discussed. The conclusion given is the respond from the objective of the research, while the recommendation given is for further research.

6.1. Conclusion

The conclusion of the research are:

1. The wastes of the material handling process are identified using Value Stream Mapping and Process Activity Mapping. From the 7 type of wastes, the wastes that are defined are motion waste, inventory waste, transportation waste and waiting waste.
2. The root cause of the waste are identified and analyzed using five why's tool. For the motion waste, the root cause are no schedule of operating the forklift and no place to put the needed tool. For the inventory waste, the root causes are no calculation ever did on the actual inventory in the warehouse, no new plan for the unused space, and no gemba walk are planned. For the transportation waste, the root causes are no maintenance are scheduled for the shuttle truck and no schedule for reducing scrap material. For the waiting waste, the root cause are the wait for the drier 6 to reach shuttle truck capacity, no designated loading or unloading bay, and no standard schedule of using pump or lift.
3. After calculating the safety stock and the actual production rate of the three line in the production line, the optimal inventory in PW2 substore is decided. The optimal inventory are using big bag that is 1000kg capacity each big bag, and the inventory space are set to be able to hold 100 pallet of big bag.
4. After knowing the waste, the root cause of the waste, and the inventory calculation several improvement suggestion has been given. To summarize, the improvements are : (1) inventory relayout, (2) schedule of

forklift, shuttle truck usage, big bag transportation frequency, (3) Gemba walk and tool box storage, and (4) lift only usage of soap chip pouring into silo.

6.2. Recommendation

The recommendation for further research are:

1. The calculation of inventory level in this research are using fix value based on the history of production. In the future research, it is recommended to use simulation approach to calculate and decide the inventory level so it can accomodate the possibility of fluxtuation in the production level
2. The shuttle truck maintenance schedule recommended in chapter 5.2.1 can be further research by using RCM (Reliability Centered Maintenance) to construct a comprehensive maintenance schedule for the shuttle truck.

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APPENDIX

Appendix 1 Summarized Daily Production Rate Data

Week	Day	Line	15		16		17
		Product	110	85	231	85	85
		Weight	10560	12240	11088	12240	12240
1	Monday	FIB					
		Weight (ton)	0	0	0	0	0
	Tuesday	FIB	4168			1881	1336
		Weight (ton)	44,01	0,00	0,00	23,02	16,35
	Wednesday	FIB	4051			2243	1862
		Weight (ton)	42,78	0,00	0,00	27,45	22,79
	Thursday	FIB	4147			1698	3112
		Weight (ton)	43,79	0,00	0,00	20,78	38,09
	Friday	FIB	2899			2853	3314
		Weight (ton)	30,61	0,00	0,00	34,92	40,56
	Saturday	FIB	3699			3322	2893
		Weight (ton)	39,06	0,00	0,00	40,66	35,41
	Sunday	FIB	3162			2050	2487
		Weight (ton)	33,39	0,00	0,00	25,09	30,44
2	Monday	FIB	4060			3477	1658
		Weight (ton)	42,87	0,00	0,00	42,56	20,29
	Tuesday	FIB	2654			3573	3744
		Weight (ton)	28,03	0,00	0,00	43,73	45,83
	Wednesday	FIB	3701			3476	4253
		Weight (ton)	39,08	0,00	0,00	42,55	52,06
	Thursday	FIB	4120			3384	1991
		Weight (ton)	43,51	0,00	0,00	41,42	24,37
	Friday	FIB	3186			3572	3731
		Weight (ton)	33,64	0,00	0,00	43,72	45,67
	Saturday	FIB	3763			3777	4043
		Weight (ton)	39,74	0,00	0,00	46,23	49,49
	Sunday	FIB					
		Weight (ton)	0,00	0,00	0,00	0,00	0,00
3	Monday	FIB	1484			3325	3642
		Weight (ton)	15,67	0,00	0,00	40,70	44,58
	Tuesday	FIB	4565			3571	3612
		Weight (ton)	48,21	0,00	0,00	43,71	44,21
	Wednesday	FIB	3611			3272	3903
		Weight (ton)	38,13	0,00	0,00	40,05	47,77
	Thursday	FIB	4498			3597	4369
		Weight (ton)	47,50	0,00	0,00	44,03	53,48

	Friday	FIB	3312			2610	1382
		Weight (ton)	34,97	0,00	0,00	31,95	16,92
	Saturday	FIB	4562		1910	316	2322
		Weight (ton)	48,17	0,00	21,18	3,87	28,42
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
4	Monday	FIB	3416		2804		3870
		Weight (ton)	36,07	0,00	31,09	0,00	47,37
	Tuesday	FIB	3946		300	2778	4421
		Weight (ton)	41,67	0,00	3,33	34,00	54,11
	Wednesday	FIB	2534			3444	4176
		Weight (ton)	26,76	0,00	0,00	42,15	51,11
	Thursday	FIB	4184			3095	3769
		Weight (ton)	44,18	0,00	0,00	37,88	46,13
	Friday	FIB	3247			33	3312
		Weight (ton)	34,29	0,00	0,00	0,40	40,54
	Saturday	FIB	4613			3712	4063
		Weight (ton)	48,71	0,00	0,00	45,43	49,73
	Sunday	FIB					
		Weight (ton)	0,00	0,00	0,00	0,00	0,00
5	Monday	FIB	3300			3206	
		Weight (ton)	34,85	0,00	0,00	39,24	0,00
	Tuesday	FIB	4096			2161	
		Weight (ton)	43,25	0,00	0,00	26,45	0,00
	Wednesday	FIB	4095			3371	
		Weight (ton)	43,24	0,00	0,00	41,26	0,00
	Thursday	FIB	4766			1174	1942
		Weight (ton)	50,33	0,00	0,00	14,37	23,77
	Friday	FIB	3504			3237	3837
		Weight (ton)	37,00	0,00	0,00	39,62	46,96
	Saturday	FIB	4742			2720	4230
		Weight (ton)	50,08	0,00	0,00	33,29	51,78
	Sunday	FIB					
		Weight (ton)	0,00	0,00	0,00	0,00	0,00
6	Monday	FIB	4539			3504	3933
		Weight (ton)	47,93	0,00	0,00	42,89	48,14
	Tuesday	FIB	4271			3382	4301
		Weight (ton)	45,10	0,00	0,00	41,40	52,64
	Wednesday	FIB	3406			3901	4160
		Weight (ton)	35,97	0,00	0,00	47,75	50,92
	Thursday	FIB	4489			3235	2235
		Weight (ton)	47,40	0,00	0,00	39,60	27,36

	Friday	FIB	3169			3125	3866
		Weight (ton)	33,46	0,00	0,00	38,25	47,32
	Saturday	FIB	4594			3269	3883
		Weight (ton)	48,51	0,00	0,00	40,01	47,53
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
7	Monday	FIB	3078			1462	3594
		Weight (ton)	32,50	0,00	0,00	17,89	43,99
	Tuesday	FIB	3898			3057	4026
		Weight (ton)	41,16	0,00	0,00	37,42	49,28
	Wednesday	FIB	4967			3713	4219
		Weight (ton)	52,45	0,00	0,00	45,45	51,64
	Thursday	FIB	3853			3333	3181
		Weight (ton)	40,69	0,00	0,00	40,80	38,94
	Friday	FIB					
		Weight (ton)	0	0	0	0	0
	Saturday	FIB	3205			2332	3158
		Weight (ton)	33,84	0,00	0,00	28,54	38,65
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
8	Monday	FIB	3188			2485	2391
		Weight (ton)	33,67	0,00	0,00	30,42	29,27
	Tuesday	FIB	5040		2190	660	504
		Weight (ton)	53,22	0,00	24,28	8,08	6,17
	Wednesday	FIB	5038		845	2370	3659
		Weight (ton)	53,20	0,00	9,37	29,01	44,79
	Thursday	FIB	2878			3198	4004
		Weight (ton)	30,39	0,00	0,00	39,14	49,01
	Friday	FIB	4166			3400	3034
		Weight (ton)	43,99	0,00	0,00	41,62	37,14
	Saturday	FIB	3762			3290	3420
		Weight (ton)	39,73	0,00	0,00	40,27	41,86
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
9	Monday	FIB	4083			2819	3193
		Weight (ton)	43,12	0,00	0,00	34,50	39,08
	Tuesday	FIB	4304			4171	4115
		Weight (ton)	45,45	0,00	0,00	51,05	50,37
	Wednesday	FIB	4714			3652	3773
		Weight (ton)	49,78	0,00	0,00	44,70	46,18
	Thursday	FIB	4239			1916	4023
		Weight (ton)	44,76	0,00	0,00	23,45	49,24

	Friday	FIB	4012			2517	2565
		Weight (ton)	42,37	0,00	0,00	30,81	31,40
	Saturday	FIB	3895			2944	3487
		Weight (ton)	41,13	0,00	0,00	36,03	42,68
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
10	Monday	FIB	3380			3007	3485
		Weight (ton)	35,69	0,00	0,00	36,81	42,66
	Tuesday	FIB	3403			2449	3356
		Weight (ton)	35,94	0,00	0,00	29,98	41,08
	Wednesday	FIB	3713			2940	3215
		Weight (ton)	39,21	0,00	0,00	35,99	39,35
	Thursday	FIB	3644			3370	1791
		Weight (ton)	38,48	0,00	0,00	41,25	21,92
	Friday	FIB	387			3379	3545
		Weight (ton)	4,09	0,00	0,00	41,36	43,39
	Saturday	FIB	3535			2787	3643
		Weight (ton)	37,33	0,00	0,00	34,11	44,59
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
11	Monday	FIB	2058			1535	2384
		Weight (ton)	21,73	0,00	0,00	18,79	29,18
	Tuesday	FIB	3451		804	2072	4073
		Weight (ton)	36,44	0,00	8,91	25,36	49,85
	Wednesday	FIB	3763		3315		4266
		Weight (ton)	39,74	0,00	36,76	0,00	52,22
	Thursday	FIB	3033		956	1649	2637
		Weight (ton)	32,03	0,00	10,60	20,18	32,28
	Friday	FIB	3059			3528	3376
		Weight (ton)	32,30	0,00	0,00	43,18	41,32
	Saturday	FIB					
		Weight (ton)	0	0	0	0	0
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
12	Monday	FIB	3520			3123	2600
		Weight (ton)	37,17	0,00	0,00	38,23	31,82
	Tuesday	FIB	3628			2946	3740
		Weight (ton)	38,31	0,00	0,00	36,06	45,78
	Wednesday	FIB	4715			3044	4365
		Weight (ton)	49,79	0,00	0,00	37,26	53,43
	Thursday	FIB	3610		2420	460	3473
		Weight (ton)	38,12	0,00	26,83	5,63	42,51

	Friday	FIB	2518		2121		3881
		Weight (ton)	26,59	0,00	23,52	0,00	47,50
	Saturday	FIB	4298		2884		4151
		Weight (ton)	45,39	0,00	31,98	0,00	50,81
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
13	Monday	FIB	2876		2681		3671
		Weight (ton)	30,37	0,00	29,73	0,00	44,93
	Tuesday	FIB			624	1274	3736
		Weight (ton)	0,00	0,00	6,92	15,59	45,73
	Wednesday	FIB				2212	2235
		Weight (ton)	0,00	0,00	0,00	27,07	27,36
	Thursday	FIB	343			2444	3932
		Weight (ton)	3,62	0,00	0,00	29,91	48,13
	Friday	FIB					
		Weight (ton)	0	0	0	0	0
	Saturday	FIB	3408			2875	3845
		Weight (ton)	35,99	0,00	0,00	35,19	47,06
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
14	Monday	FIB	3017			3194	3340
		Weight (ton)	31,86	0,00	0,00	39,09	40,88
	Tuesday	FIB	3921			3656	2508
		Weight (ton)	41,41	0,00	0,00	44,75	30,70
	Wednesday	FIB	3563			3147	3670
		Weight (ton)	37,63	0,00	0,00	38,52	44,92
	Thursday	FIB	3885			3728	3803
		Weight (ton)	41,03	0,00	0,00	45,63	46,55
	Friday	FIB	3071		976	1769	3676
		Weight (ton)	32,43	0,00	10,82	21,65	44,99
	Saturday	FIB	3497		2516		3874
		Weight (ton)	36,93	0,00	27,90	0,00	47,42
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
15	Monday	FIB	3594			2853	3341
		Weight (ton)	37,95	0,00	0,00	34,92	40,89
	Tuesday	FIB	4629			3430	4172
		Weight (ton)	48,88	0,00	0,00	41,98	51,07
	Wednesday	FIB	4366			1786	4236
		Weight (ton)	46,10	0,00	0,00	21,86	51,85
	Thursday	FIB	4487			833	4289
		Weight (ton)	47,38	0,00	0,00	9,71	52,50

	Friday	FIB	3567			2718	1610
		Weight (ton)	37,67	0,00	0,00	31,31	19,71
	Saturday	FIB					
		Weight (ton)	0	0	0	0	0
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
16	Monday	FIB	4482			2723	
		Weight (ton)	47,33	0,00	0,00	31,37	0,00
	Tuesday	FIB	4450			2456	581
		Weight (ton)	46,99	0,00	0,00	28,29	7,11
	Wednesday	FIB	4156			3136	3821
		Weight (ton)	43,89	0,00	0,00	36,13	46,77
	Thursday	FIB	1709			2227	3618
		Weight (ton)	18,05	0,00	0,00	25,66	44,28
	Friday	FIB				2843	2653
		Weight (ton)	0,00	0,00	0,00	32,75	32,47
	Saturday	FIB	2930			3355	2833
		Weight (ton)	30,94	0,00	0,00	38,65	34,68
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
17	Monday	FIB	2709			3195	2535
		Weight (ton)	28,61	0,00	0,00	36,81	31,03
	Tuesday	FIB	2940			3297	3625
		Weight (ton)	31,05	0,00	0,00	37,98	44,37
	Wednesday	FIB	4075			2943	2159
		Weight (ton)	43,03	0,00	0,00	33,90	26,43
	Thursday	FIB	3917			3244	
		Weight (ton)	41,36	0,00	0,00	37,37	0,00
	Friday	FIB	3814			1196	1804
		Weight (ton)	40,28	0,00	0,00	13,78	20,78
	Saturday	FIB					
		Weight (ton)	0,00	0,00	0,00	0,00	0,00
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
18	Monday	FIB					
		Weight (ton)	0	0	0	0	0
	Tuesday	FIB					
		Weight (ton)	0	0	0	0	0
	Wednesday	FIB	3079			2657	1877
		Weight (ton)	32,51	0,00	0,00	30,61	21,62
	Thursday	FIB	3806			2913	2108
		Weight (ton)	40,19	0,00	0,00	33,56	24,28

	Friday	FIB	3451			3296	3674
		Weight (ton)	36,44	0,00	0,00	40,34	42,32
	Saturday	FIB	4110			3275	4268
		Weight (ton)	43,40	0,00	0,00	37,73	49,17
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0
19	Monday	FIB	1961			715	2395
		Weight (ton)	20,71	0,00	0,00	8,75	27,59
	Tuesday	FIB	1613			3278	3463
		Weight (ton)	17,03	0,00	0,00	40,12	39,89
	Wednesday	FIB	2886			2619	4097
		Weight (ton)	30,48	0,00	0,00	32,06	47,20
	Thursday	FIB					
		Weight (ton)	0	0	0	0	0
	Friday	FIB	675			2127	2713
		Weight (ton)	7,13	0,00	0,00	26,03	31,25
	Saturday	FIB		517		2325	4097
		Weight (ton)	0,00	5,96	0,00	28,46	47,20
	Sunday	FIB					
		Weight (ton)	0	0	0	0	0

Appendix 2 Checklist for Gemba Walk Activities

In this appendix, the checklist form for gemba walk activities will be given

PT. X (Logo of company)	Checklist of Gemba Walk Activities	No. : Date : Checklist version A
Substore 2 Area		

Checkpoint	Checker	Remarks
The cardboard raw material are placed into place		
The wrapper are placed in corresponding place		
The big bag are stored in the corresponding place		
The scrap material are placed in corresponding place		
The tools and forklift are placed in corresponding place		
The number of cardboard and wrapper in the inventory space is sufficient		
The number of big bag are suit the schedule of inflow and outflow		
The operator are using appropriate safety tools		
The forklift are in good condition		
The hand truck are in good condition		
The soap chip in the big bag are in good quality		
The wrapper stored are in good quality		
The cardboard stored are in good quality		

Checked		
Observer	Observer 2	Observer 3

Appendix 3 Schedule for Forklift Usage

In this appendix, a schedule form for the usage of forklift will be given. The form is a standard form so that it can be used directly by the company.

PT. X (Logo of company)	Schedule of Forklift	No. : Issued date: Prepared by :
Substore 2 Area		

Shift 1	Shift 2	Shift 3	Activity
02.00-02.30	10.00-10.30	18.00-18.30	Unloading 16 big bag
02.30-03.00	10.30-11.00	18.30-19.00	Tidy up inventory space
03.00-03.30	11.00-11.30	19.00-19.30	Charging
03.30-04.00	11.30-12.00	19.30-20.00	
04.00-04.30	12.00-12.30	20.00-20.30	Unloading 16 big bag
04.30-05.00	12.30-13.00	20.30-21.00	Picking up used big bag
05.00-05.30	13.00-13.30	21.00-21.30	Charging
05.30-06.00	13.30-14.00	21.30-22.00	
06.00-06.30	14.00-14.30	22.00-22.30	Unloading 16 big bag
06.30-07.00	14.30-15.00	22.30-23.00	Charging
07.00-07.30	15.00-15.30	23.00-23.30	
07.30-08.00	15.30-16.00	23.30-00.00	Stacking the used big bag
08.00-08.30	16.00-16.30	00.00-00.30	Tidy up inventory space
08.30-09.00	16.30-17.00	00.30-01.00	Charging
09.00-09.30	17.00-17.30	01.00-01.30	
09.30-10.00	17.30-18.00	01.30-02.00	

Approved

Hermi Sri Witarsih

Valid until:

Appendix 4 Process Activity Mapping Comparison

In this appendix, the comparison of improved activity based on chapter 5.2.2 will be given.

No	Flow Process	Time	Improved time
	Moving big bag from drier to truck		
1	Setting up the forklift	1 min	30 sec
2	Going to drier 6	2,5 min	2,5 min
3	Putting the big bag in the shuttle truck	15 min	15 min
4	Return journey to the PW2	2,5 min	2,5 min
5	Moving the big bag from truck to the loading bay	15 min	15 min
	Transporting big bag from drier 6 to substore 2		
6	Setting up the shuttle truck	5 min	2 min
7	Going to drier 6	3 min	3 min
8	Waiting for loading process	15 min	15 min
9	Return journey to the PW2	3 min	3 min
	Moving big bag from truck to substore 2		
10	Operator setting up forklift	1 min	30 sec
11	Forklift going to unloading dock	30 sec	30 sec
12	Lifting big bag from unloading dock to inventory	30 sec	30 sec
	Moving big bag to Silo (a)		
13	Moving big bag from inventory point to hoist place	45 sec	0 sec
14	Putting down used big bag from pump	77 sec	0 sec
15	Lifting the big bag to place of the pump	60 sec	0 sec
16	Opening and waiting for the big bag to be emptied	28 min	0 sec
	Moving big bag to Silo (b)		
17	Moving big bag from inventory point to lift	30 sec	30 sec
18	Lift moving up	1 min	1 min
19	Moving big bag from lift to temporary place	45 sec	30 sec
20	Lifting big bag with hoist	45 sec	45 sec
21	Opening and waiting for the big bag to be emptied	3 min	3 min
22	Putting big bag back and tidy up	1,2 min	45 sec

BIOGRAPHY

Winahyu Tyas Wicaksana is the first child of Pambudi Tyas Martopo and Anna Slamet Setiyowati. Born in Jakarta, July 4th 1996, the author started his formal education in SDK Samaria Kudus for elementary school. Then, the author continued to SMP N 75 Jakarta Barat for junior high school, and SMA N 78 Jakarta Barat for Senior High School. Graduated from high school at 2014, the author continued to Industrial Engineering Department of ITS Surabaya.

During the university years, the author joined several organization. The first organization was the ITS Student Choir as head of competition department (2015-2016). The next year as staff of student resources department (2016-2017). The author then joined Himpunan Mahasiswa Teknik Industri ITS (HMTI ITS) as member of student senate (2017-2018). During the 5th semester of his study, the author joined student exchange program for one semester to Universiti Teknikal Melaka Malaysia (UTeM).With the interest in manufacturing system field, the author had several internship experiences. The first internship was at PT. Isuzu Astra Motor Indonesia where the author was placed in paintshop division (2017). The second was in PT. Unilever Indonesia Rungkut Factory, where the author was placed in production division (2018). The author can be reached through email: winahyutyas@gmail.com