APPLYING SINGLE MINUTE EXCHANGE OF DIES (SMED) AND 5S TO REDUCE SETUP TIME OF FILLING MACHINE AT PT. MNO

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THESIS ADVISOR
RECOMMENDATION LETTER

This thesis entitled “**Applying Single Minute Exchange of Dies (SMED) and 5S to Reduce Setup Time of Filling Machine AT PT. MNO**” prepared and submitted by Nathania Sembiring in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering for a thesis fit to be examined. I therefore recommend this thesis for Oral Defense.

Cikarang, Indonesia, February 6^{th} 2017

Johan Runtuk, S.T., M.T

DECLARATION OF ORIGINALITY

I declare that this thesis, entitled "**Applying Single Minute Exchange of Dies (SMED) and 5S to Reduce Setup Time of Filling Machine AT PT. MNO**" is, to the best of my knowledge and belief, an original piece of work that has not been submitted, either in whole or in part, to another university to obtain a degree.

Cikarang, Indonesia, February 6th 2017

Nathania Sembiring

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ABSTRACT

Manufacturing excellence represent as the goal for every manufacturing industry all around the world. Reducing waste could help to achieve the goal of manufacturing excellence since waste could happen in every manufacturing industry. PT. MNO as one of food and beverages industry also focusing on reducing waste in the production process, especially in filling department. Similar with other department, filling department also has planned and unplanned stoppages. As one of planned stoppages, the set-up activities represent as one of the highest contribution of waste in filling department. Therefore, PT. MNO can reduce the set-up time by using Single Minute Exchange of Dies (SMED) and 5S method. Then, overall equipment effectiveness (OEE) calculation can shows the differences between the productivity of filling machine before and after Single Minute Exchange of Dies (SMED) and 5S method. As the result, the set-up time is reduced from 34 minutes to 13 minutes by using Single Minutes Exchange of Dies (SMED) method implementation, while after 5S method implementation, the set-up time become ten minutes. The overall equipment effectiveness (OEE) calculation result shows better productivity after SMED and 5S method implementation in filling department by the increasing OEE rate from 76% to 78% in the end.

Keywords: *Set-up, waste, planned stoppages, Single Minute Exchange of Dies (SMED), 5S, Overall Equipment Effectiveness (OEE).*

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Unplanned Stoppages	: a process of machine stops because of an activity that already planned before
Planned Stoppages	: a process of machine stops because of an unexpected activity that are not planned before
Set-up	: an activity of machine preparation before the machine starts to operate
SMED	: Single Minute Exchange of Dies, which is a method to reduce changeover or set-up time
5S	: a method to reduce waster by implementing 5 cycle of SEIRI, SEITON, SEISO, SEIKETSU, and SHITSUKE
OEE	: a method used to calculate the effectiveness of the machine
Internal Activities	: activities done when the machine stops
External Activities	: activities done when the machine runs
SAP	: System Application Products which used to input the data
Shift Hand-Over	: a process of changing shift by delivering the information from previous shift to the next shift
Working Instruction (WI)	: an instruction for the operator to conduct an activity
CIL	: Cleaning Inspection Lubrication, an activity that include the inspection and lubrication to the cleaning

CHAPTER I
INTRODUCTION

1.1. Problem Background

The majority of all developing countries in the world are depending on every innovation that occur every single day. The innovation that rapidly increase makes a better change, because the future relies on every innovation and improvement that people created. A simple innovation can be in the form of product, services, or business as the root of the market industry.

People cannot become a perfect person, but people can chase the perfection while catch the excellence. This term of excellence could be implemented to the industrial section. Manufacturing excellence as one of the word that people usually used in industry which has a same meaning with innovation. Creating a continuous improvement and innovation for a better manufacturing will create a manufacturing excellence.

Manufacturing have been facing the similar problem regarding to the set-up time. People need to solve the set-up problem to achieve the manufacturing excellence. Set-up time itself is the total time of machine preparation to start the machine in the production process. Set-up time can become a problem to the company if the set-up time cause loss to the company, the set-up time is take too long time to finish the activities which actually there are several activities that can be reduce. One of the method that can be used to reduce set-up is Single Minutes Exchange of Dies.

Based on Lopes, Neto, and Pinto (2007), Single Minutes Exchange of Dies (SMED) method is a quick changeover technique. SMED method applies to set-up times, when set-up times are too high, manufacturing company need to produce more lots and stocks, which mean the production cost will increase (Shingo, 1985). SMED method have been applied all over years with several implementation studies in several different processes, such as mold industry, pharmaceutical industry, and several more manufacturing industry (Simoes & Tenera, 2010).

5S is one lean manufacturing method in reducing waste (Agrahari, Dangle, & Chandratre, 2015). 5S will organize the workplace to create a better flow of the production activities in the workplace. When the condition of workplace already cleans, and organized in the right place, it helps the worker to conduct the activities more effective.

MNO Company is one of the company that produce the food and beverage products. Based on MNO Company, stoppages are categorized into two types, which are unplanned stoppages and planned stoppages. From the word unplanned and planned, the process of waiting are differentiate with the one that occur suddenly and the other one is the waiting that already scheduled. Based on the whole company manufacturing process, the highest number of waiting waste occur in filling machine especially for the planned stoppages with the percentage of 67% compared with the 33% for the unplanned stoppages.

The high rate of planned stoppages in filling machine creates a minor loss to MNO Company. Planned stoppages that happen in filling machine are differentiate into several type of stoppages. The biggest contribution of planned stoppages which is 48% comes from setup time or line preparation time. The next is 34% of cleaning inspection and lubrication process, 19% of operational stoppages, 3% of meals or break, 2% of changeover time, and the last 1% of planned maintenance. The highest contributor which is the setup time become the most concern stoppages in this case.

As the goal of manufacturing excellence which is to create an excellence industry, there will be several obstacles that people need to face. The research conducted to focus on the current problem occurs, which is set-up time. Reducing the set-up time was the best solution to solve the current problem, but the specific method to solve the problem must be determined beforehand.

The improvement of set-up time might increase the productivity of the machine. Overall Equipment Effectiveness (OEE) calculation are the tools to calculate the productivity of the machine. There are three main rate in OEE which are availability, performance, and quality. The calculation of availability are related to set-up time, changeover time, unplanned maintenance, process failure, and etc. The calculation of performance are related with the minor stoppages, while the quality rate are related with the defect. The difference of set-up time will give impact to the productivity of the machine which shown in the calculation of the availability rate. Then, the calculation of OEE will shows the productivity difference before and after SMED and 5S method.

1.2. Problem Statement

Based on the problem happen in MNO Company, this research is conduct to answer these following questions:

- How does company reduce set-up time in filling machine by using the Single Minutes Exchange of Dies (SMED) and 5S method in PT. MNO?
- What is the difference between Overall Equipment Effectiveness (OEE) before and after Single Minutes Exchange of Dies (SMED) and 5S implementation?

1.3. Research Objectives

The main objectives of this research are as follows:

- To reduce the set-up time in filling machine by using Single Minutes Exchange of Dies (SMED) and 5S method in PT. MNO.
- To determine the difference between Overall Equipment Effectiveness (OEE) before and after Single Minutes Exchange of Dies (SMED) and 5S implementation?

1.4. Scope and Limitation

There are several scope and limitation that will give a clear boundary and the limit of this research:

- The data were taken from April until June 2016
- The data of line preparation time in filling area
- The main focus is planned stoppages of line preparation in filling area

- The defect product of filling machine only caused by sealing defect

1.5. Assumption

There are several assumption in order to support this research:

- The data of the research is accurate
- The machine is function normally
- The material handling flow is ignored

1.6. Research Outline

Chapter I Introduction

This chapter discuss about problem background, problem statement, research objectives, scope and limitation, and assumption.

Chapter II Literature Study

This chapter discuss about the theory of every method that are existed in this research. The method that is used in this research is Single Minutes Exchange of Dies (SMED) Method integrated with 5S method including several data collection and analysis tools that used in this research.

Chapter III Research Methodology

This chapter consists of the flow of this research including the explanation of each step from the beginning to the end of the research.

Chapter IV Data Collection and Analysis

This chapter discuss about the way to collect the data including the output of the data. Then, the data that has be collected will be further analyze to achieve the result regarding to problem in the research.

Chapter V Conclusion and Recommendation

This chapter consists of the conclusion and result from the research. It also contain the recommendation regarding to this research

CHAPTER II
LITERATURE STUDY

2.1 Lean Manufacturing

Lean manufacturing can describe a production method from Toyota Production System (TPS). Lean manufacturing is popularized by Womack, Jones, and Toos, in 1990. Lean manufacturing also can be defined as a process performance that happen in manufacturing company to increase competitive advantage. This system already implemented in several auto industries successfully and slowly spread to other industry sectors.

The challenge that lean manufacturing faced is to create and maintain long term commitment from top management by using the entire workforce. The main focus of lean manufacturing is to eliminate any waste in manufacturing process, which means lean manufacturing is manufacturing that run without any waste. Besides that, lean manufacturing also focus on reaching the market on time and managing manufacturing stocks that are nearly reach the customer demand while still producing products with a good quality efficiently. Lean manufacturing also aiming on produce product and service at the lowest cost in short time.

Lean manufacturing must be support by several primary element which shown in table 2.1. Lean manufacturing are divided into five primary element, which are manufacturing flow, organization, process control, metrics, and logistic. Each primary element have their own objective when dealing with the lean manufacturing implementation in the production process. (Feld, 2000)

Manufacturing flow means that the process of making a physical change and design standards that are the part of the cell, while organization the process of focusing the roles or function of people, which also include training the new working process, and communication to others. Process control is monitoring, controlling, stabilizing, and pursuing to improve the process. Metrics is the process to create a visible address, result-based performance measure, target improvement, and recognition or reward for the team. Logistic is the process to control the flow of material and create an operating rules and planning mechanism. (Feld, 2000)

Table 2.1 Five Primary Elements

No	Manufacturing Flow	No	Process Control
1	Product / quantity assessment	1	Total productive maintenance
2	Process mapping	2	Poka-yoke
3	Routing analysis	3	SMED
4	Takt calculations	4	Graphical work instructions
5	Workload balancing	5	Visual control
6	Kanban sizing	6	Continuous improvement
7	Cell layout	7	Line stop
8	Standard work	8	SPC
9	One-piece flow	9	5S housekeeping
No	Metrics	No	Logistics
1	On-time delivery	1	Forward plan
2	Process lead-time	2	Mix-model manufacturing
3	Total cost	3	Level loading
4	Quality yield	4	Workable work
5	Inventory (turns)	5	Kanban pull signal
6	Space utilization	6	A,B,C parts handling
7	Travel distance	7	Service cell agreements
8	Productivity	8	Customer/supplier alignment
		9	Operational rules
No	Organization		
1	Product-focused, multi-discipline team		
2	Lean manager development		
3	Touch labor cross-taking skill matrix		
4	Training		
5	Communication plan		
6	Roles and responsibility		

Source: (Feld, 2000)

Lean manufacturing is not a short term system, but it is a long term system. Lean manufacturing system will evaluates the whole manufacturing process step by step from beginning until the end to identify waste and inefficiency. Then, it will help people to create the new solutions to improve the manufacturing process by reduce waste, increasing the efficiency, and reduce expenses. Lean activities are assessment, improvement and performance monitoring. Lean will assess or evaluates the problem first, then improve the manufacturing system, in the end it will monitor the manufacturing performance.

2.1.1 Waste

Waste is the thing that are unnecessary or not needed to exist. Waste can in the form of object, energy, material, and many other form. Since waste is unwanted things, people will disposed the waste, people do not want the waste is exist anymore and also prevent the waste occur.

Toyota Production system (TPS) are divided into three M, which are “Muri”, “Muda”, and “Mura”. “Muri” means forcing the human or machine to the maximal limit, which can cause producing the output exceed the target. Besides that, “Muri” may cause machine breakdown and even defect products. “Muda” has the meaning of all kind of waste including non-value added activities. Based on “Muda”, the non-value added activities are include unnecessary movement of operator, high rate of inventory, and also any kind of waiting condition. “Mura” is happen because the two M, which are “Muri” and “Muda” and cause an unevenness. Breakdown and defects may cause the unstable of production schedule since the production volume is fluctuating. The unevenness also happen because of the unnecessary movement, high inventory and waiting condition that happen in “Muda”. (Liker, 2004)

As has been mention before, “Muda” is the waste that happen in lean manufacturing. Based on table 2.2, there are several types of “Muda” waste that are usually happen in production system of manufacturing company, it is called as TIMWOOD, which stands for seven waste which are Transportation, Inventory, Motion, Waiting time, Over-production, Over-processing, and Defect waste. (Arya & Choudhary, 2015)

Table 2.2 Definition of TIMWOOD

	Waste Type	Description
T	Transportation	Unnecessary movement of the components from one station to another station
I	Inventory	Stock and work in process material that are excess the necessary amount of goods and services
M	Motion	Unnecessary motion such as people, data, decisions, and information
W	Waiting	Process or machine idle that caused by waiting the material people, or equipment
O	Over Production	Producing more than the required number and may cause the excess inventory
O	Over Processing	The exceeding process of the material into finished good produce product that should not be made
D	Defects	Producing defective product because the error during the process including anything that requires rework

Source: (Arya & Choudhary, 2015)

Based on Womack and Jones in 1994, the source and cause of TIMWOOD waste are interrelated with each other. Then, if one of TIMWOOD waste is eliminated, it might also cause the elimination to the other waste.

The major source of waste comes from the inventory waste. As the root of waste, inventory means keep the items while waiting for the process runs, there would not add any value to the items. Otherwise, it causes the lost in money, time and space. Motion waste means any unnecessary motion of people, data, or information and any motion that would not add any value to the items. Over-production waste happens because the poor process management. Besides that, over-production is when the process already excesses the maximum level of resource because continuously run the machine. Waste of over-processing means the process that is unnecessary and can be removed from the process without affecting the manufacturing process. (Nicholas, 1998)

Defect is the waste of producing products that different from the real product; or producing products differently from that have been planned before. Waste of waiting is the simplest identified waste because it is too obvious when the machine stop, there are no process happen. But, it's not the true that increase the working hours of machine and worker may the best solution for waiting waste. Otherwise, it may cause another problem which is waste of over-production. One of the simple example of waste of waiting are material waiting, machine breakdowns, overlong changeover, overlong set-up time, and etc. The overlong of set-up time can be happen when the set-up activities time is take too long and make the machine stop for a long time. (Nicholas, 1998)

2.1.2 Set-up Time

Set-up time is the time spent in preparation to do a job. Besides that, set-up time also has a definition of the time between the last good products with the first good product. Set-up time includes the preparation times, which are replacements, adjustments and attachment on the machine. The count of set-up time start before the machine run until the first finish good produced. When it comes to the ineffective time, the output are the scraps or rework. (Nicholas, 1998)

When the set-up time is decrease, quality become well since there will be less mistakes done by the worker. Besides that, it also reduces cost because it will use smaller batch size and reduce work-in-process (WIP) and finished good inventory, more flexible since smaller lot size, set-up become more easy and no need to have a specialized worker for the specific set-up, capacity optimization, and process variability because the time spent for each process and step of each setup is reduce. (Nicholas, 1998)

Nicholas (1998) stated that set-up steps that conducted by all manufacturing industry have four steps, those are:

- Preparing, checking material and tools before the set-up start. Checking the condition of workplace area and machine also included
- After the process ends, changing the old tools into the new tools

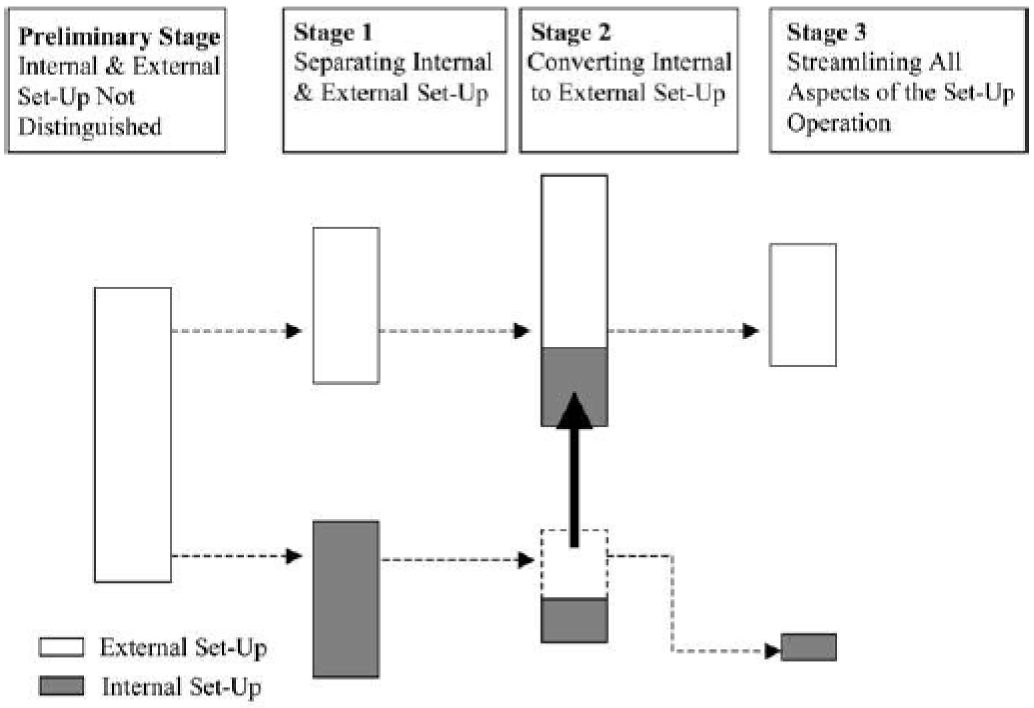
- Measuring, setting , and calibrating the machine in the right place that stated in the standard
- Test the machine until the machine runs properly and product the good finished products.

2.2 Single Minute Exchange of Die (SMED)

Single Minute Exchange of Die (SMED) method was developed in 1950 by Ohno at Toyota. Toyota have a problem of the high inventory cost for the vehicle, because the way to reduce production loss was to reduce setup time. Then, Ohno want to develop a system that can exchange dies in simple way. The phrase "single minutes" does not mean all the time must become one minute, but it means that the time must become a single digit minutes or less than ten minutes. (Benjamin, Murugaiah, & Marathamuthu, 2012)

The main purpose of SMED is to reduce setup time on a machine. SMED also called as quick change over of tools. SMED can reduce or remove any non-value activities in set-up activities or changeover activities. Before the development of SMED, the best way to minimize the idle machines during the setup activities was to produce more lots, it is done to obtain the lowest percentage of idle time per unit produced. According to Min and Pheng (2007), the inventory cost must equal with the cost of idle equipment during the change over and it can become the ideal amount of production lot. Several manufacturing company already implemented SMED method to create an improvement in reducing setup time. SMED also one of lean tool that help to reduce the setup time while also eliminate waste that are identify in the changeover activities. But, SMED technique is an element of Total Productivity Maintenance (TPM) and continuous improvement process. Shingo (1985) states that, “SMED can be applied in any factory to any machine”.

Figure 2.1 shows several step of Single Minute Exchange of Die (SMED) implementation, those are internal and external setup activities are not differentiated, separate internal and external activities, convert internal to external activities, and improve all element operations. (Moxham & Greatbanks, 2000)



Source: (Moxham & Greatbanks, 2000)

Figure 2.1 SMED Step

Shingo (1985) states that there are two kinds of setup, those are internal and external setup.

- Internal setup is the activities that can be done when the machine is in idle condition or stop
- External setup is the activities that can be done when the machine is running which can be before or after the machine running

The purposes to change the internal to external setup are already applicable universally. The greatest benefit of reducing setup time is the flexibility to produce parts in smaller batches. Based on figure 2.1, SMED have four steps, every step will be further explain.

2.2.1 Internal and external setup activities not differentiated

This phase is done by gathering all the data. The data about all activities that have been classified from the beginning until the end that are related with the setup problem. Besides that, the duration of each activities from the beginning until the end also must be collected. There will be other particular factors that affect the activities that must be concerned. By observing, it can shows the critical part that reduce the efficiency of setup time. (Benjamin, Murugaiah, & Marathamuthu, 2012)

In this phase, there are several ways to collect the data, which are observe the current activities, interview with the operator of the machine, and documentation that can in the form of picture, videos, and etc.

2.2.2 Separate internal and external activities

In order to help people to separate the internal and external activities, people can try to think "Do this activities must be done when the machine is stop, can this activity done when the machine is running?" It helps to differentiate whether the activity is internal or external activity.

There are three techniques that usually used by SMED for this step, those are checklist, function checks, and improved transport dies and other parts. Checklist all the internal and external activities, explain the function for all the operator, and the improvement of the transportation tools.

2.2.3 Convert internal activities to external activities

After internal and external already divided, convert or shift internal activities to external activities must be done to achieve the goal of single minute setup time. The aim of this step in SMED is to identify whether the activities can be done during the machine running, this may lead to reduction several amount of set-up time (Benjamin, Murugaiah, & Marathamuthu, 2012). Converting internal to external activities can reduce the setup time a lot since when the several activities that all done when the machine run is convert into activities done when the machine is running. The total time of machine stop or idle is reduced. Within this step, the automation of operations is happen, and also the utilization of different tools.

2.2.4 Streamline the Remaining Internal Activities

After converting internal into external activities, this steps help to reduce more the remaining time of the internal activities which need to be done to achieve the goal of SMED which is under 10 minutes (Benjamin, Murugaiah, & Marathamuthu, 2012). The simple example to eliminate more of set-up time is relocating parts and material to reduce the distance. When the activities need to take a long walk, the position can be adjust by changing the layout of the production floor. Relocating the parts and material also means that the layout of production floor needs to be improved.

2.3 5S

5S originated from Japanese manufacturing industry from 1950. In 1980, 5S method become more famous since many manufacturing industry start to apply 5S methodology. 5S stands for SEIRI, SEITON, SEISO, SEIKETSU, and SHITSUKE (Arai & Sekine, 1998). The 5S use “Can see, Can take out, Can return” philosophy to create an improvement in the workplace (Ishijima, Eliakimu, & Mahana, 2015). 5S also becomes a simple strategy that can be done by company to clean the shop floor, but it can develop into a better standard of workplace practices.

Table 2.3 5S Explanation

	Japanese	English	Kiswahili	Meanings
S1	Seiri	Sort	Sasambua	Remove unused items from your workplace. This step will also help to identify what is missing from your workplace
S2	Seiton	Set	Seti	Organize everything needed in proper order for easier work. This step is based on finding efficient and effective storage of necessary items. Setting of necessary items can save time and energy when looking for something
S3	Seiso	Shine	Safisha	Maintain a high standard of cleanliness of the workplace, tools and equipment. This step will create ownership of infrastructure, equipment and tools, and enable identification of any abnormality of infrastructure,

				equipment or tools

Source: (Gupta & Jain, 2014)

Table 2.4 5S Explanation (Continued)

	Japanese	English	Kiswahili	Meanings
S4	Seiketsu	Standardize	Sanifisha	Maintain an environment share S1 to S3 are implemented in the same manner throughout the organization
S5	Shitsuke	Sustain	Shikilia	Maintain S1-S4 through discipline, commitment and empowerment. This step focusses on defining a new mindset and standard in the workplace

Source: (Gupta & Jain, 2014)

When 5S is integrated with management system, it will improve productivity and even quality of delivery services and safety. 5S also can integrate with other improvement method to achieve the goal of reducing waste of manufacturing industry. The successful outcome that several company already got by implementing 5S methodology, 5S becomes an effective tool to achieve the organization's goal.

2.3.1 SEIRI

The first step of 5S is SEIRI or can be called as sorting step. SERIRI step has a main purpose in eliminating the unnecessary items from the workplace area. SEIRI include the red tagging method for the items that will be removed or replaced. Red colored paper with small size known as res tagging. Any items that want to be removed or replace will be given red tagging card. Then, the unnecessary items will be removed to storage that already prepared by the company outside the workplace area, but if the items not useful anymore; the items may be disposed from the manufacturing industry. SEIRI step trigger people to evaluate the workplace area regarding to the tools or items. The result of sorting step would be the flow of items and tools become easier. (Gupta & Jain, 2014)

2.3.2 SEITON

The next process is SEITON or also can be called as set in order. SEITON will stored the items to the best place to support the production process, placed every items in the right position and right place. It is necessary to include the worker in placing the items in the workplace area, because workers play the important role in performing the activities around the workplace area. SEITON have several activities that useful for setting items in order, those are labeling each item, giving color for better identification for each item, storing the same type of item together in one place, painting floor to keep the items above stay at the right place. People become easier to find items because the items are noticeable (Gupta & Jain, 2014). SEITON creating better arrangement for the work activities, then if there is a mis-step, people can easily identify and corrected.

2.3.3 SEISO

SEISO or also can be called as shine is the next step after SEITON. SEISO will perform the cleaning and inspection through everything that exist in the workplace area (Arai & Sekine, 1998). SEISO will help to clean or sanitize everything that already stored by the previous process. Similar with SEITON step, all worker need to takes part in cleaning the workplace area. The worker needs to evaluate and know how often they must clean the workplace to create a better motivation in cleaning the workplace without feeling burden in it. A better work activities is better be done in clean workplace area, the term that worker need to believe (Gupta & Jain, 2014). All the workers also need to understand that the unclean workplace area may cause the potential hazards to human. Then, the worker must remember to keep the workplace clean as the responsibilities of their duties.

2.3.4 SEIKETSU

The next process is SEIKETSU or usually called as standardize. After organize thing in the right place, cleaning it, people need to maintain the condition of workplace area. Each worker has different daily routine that must be done every day in the workplace area, standard making people realize about the duties and responsibilities (Gupta & Jain, 2014). It is become the main reason for the company to create standardize for every workplace area. Based on Ishikawa (1986), the standard can be made by using the help of 5M to fulfill the requirement, which stands for Manpower, Methods, Materials, Machines, and Measurements representing the 5 components of making a standard.

2.3.5 SHITSUKE

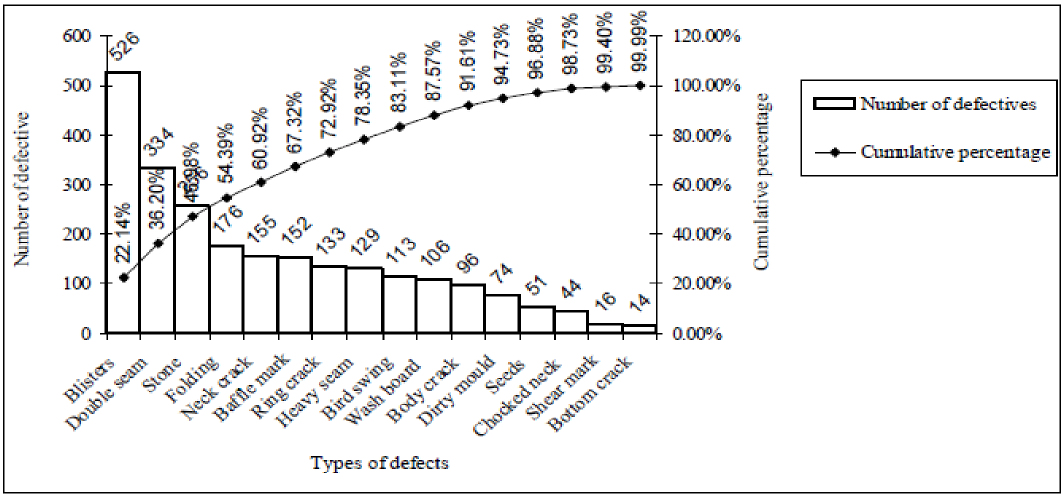
The last but not least is SHITSUKE or sustain step, after making the things set up in the right step, clean it, and create the standard, people need to maintain all the change (Arai & Sekine, 1998). People need to keep implementing everything that have been done before, which means keep the things in the right place, keep the cleanliness of the workplace area. It is easy to at the first cycle of 5S method implementation, but people tend to forget for the next cycle of 5S implementation. The hardest things to do is engaging people to understand that 5S is good for the workplace and even for them (Gupta & Jain, 2014). Changing things might be easy, but changing the habit of people might be the hardest thing to do.

2.4 Data Collection Tools

Data collection is the way that people collect the data. Data collection tools consist of several tools that used to collect the data. There are several tools to collect the data, those are Pareto chart, spaghetti diagram, Gantt chart, and Flow Process Chart.

2.4.1 Pareto Chart

Pareto also can be used as a tool to collect the necessary data that is important for the problem. Pareto chart can help to analyze the several causes or problems, it will shows the comparison between one causes with other causes. Pareto usually in the form of the bar chart combine with the line graph which shown in the figure 2.2.



Source: (Awaj, Singh, & Amedie, 2013)

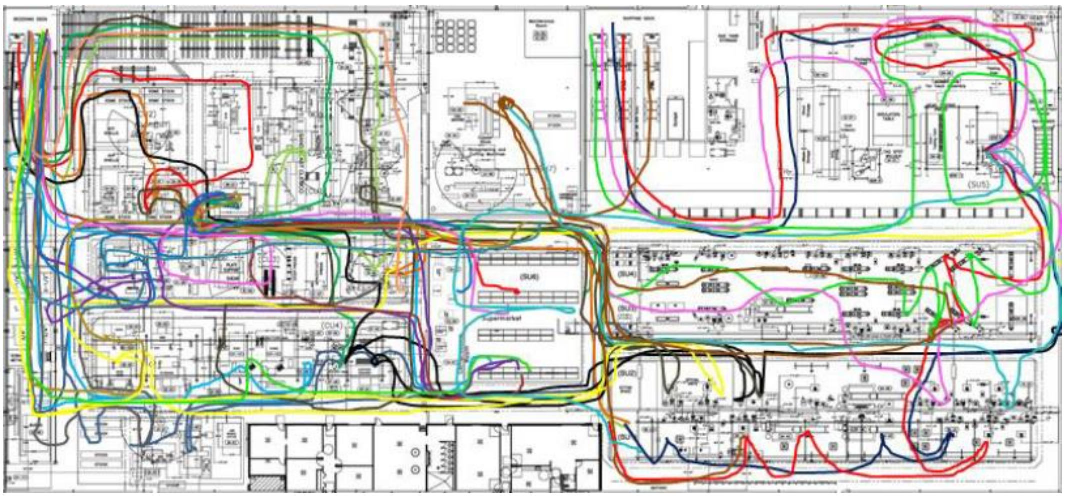
Figure 2.2 Example of Pareto Chart

The bar chart that shows the descending order will represent all the values in this problem, while the line graph show the cumulative value. The y-axis in the left of the chart represent the frequency or the unit to measure, while y-axis on the right of the chart represent the cumulative percentage of the value. The x-axis represent several different factors.

2.4.2 Spaghetti Diagram

Spaghetti diagram enable to show a clear visual representation of activity process by using continuous flow line tracing the path. Based on the example on figure 2.3, it shows clearly every movement of the activity from one place to another place. The main purpose for spaghetti diagram is to identify the activity that is unnecessary and can be removed. Besides that, spaghetti diagram can shows the movement that done repeatedly that caused delay.

There are several advantages to use Spaghetti Diagram, those are, to identify the waste of the activity flow, find the way to shorten the repeatedly movement, identify the critical part that can cause delay to the production system, and increase morale of the workforce.



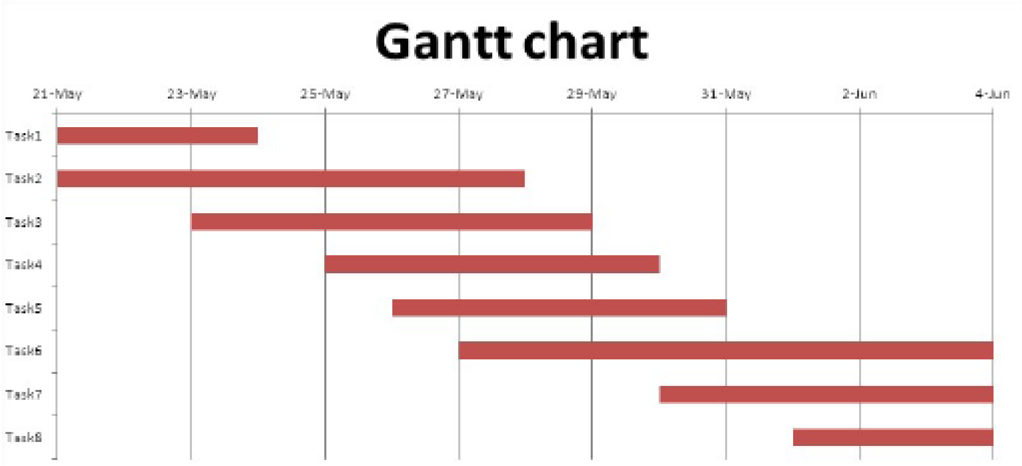
Source: (Kamne, 2016)

Figure 2.3 Example of Spaghetti Diagram

The spaghetti diagram will show the layout of the place. The place of the activities that people want to observe. For the biggest scope, it only show the name of the place, it looks like a sketch of map. For the more specific scope, it shows more detail information in it. For example, the layout of a room that consist of bathroom, closet, desk chair, bed, and etc. Then, when people want to observe the activities, it will become more detail.

2.4.3 Gantt Chart

Gantt chart is a production planning tool to manage batch production. In other words, Gantt chart also a project planning tool to represent timing task, because Gantt chart is more simple to be understand by all people and also easy to construct. Based on the example on figure 2.4, it's already used by several complex projects.



Source: (Rastogi, 2015)

Figure 2.4 Example of Gantt Chart

Gantt chart shows the items that want to be produce, the number must be done every day in total, and also the date when the production was start and finish. Even though the production sequence was not describe explicitly, but the start and end date was shown implicitly.

2.4.4 Flow Process Chart

A flow process chart is a chart that used for mapping the activities of that happen during the production process. The event that shows in the flow process chart is the sub-activity done by the operator to conduct the production process, while the symbols will shows classification of the operation for each event. There are several information provided by flow process chart, which are the type of operation, the detail activity of the process, time needed to perform the activity, distance needed to perform the activity, total time and total distance for the overall activity. Table 2.5 shows the example of flow process chart. (Niebel & Freivalds, 2009)

Table 2.5 Example of Flow Process Chart

Flow Process Chart Page 1 of 1

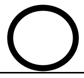
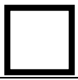
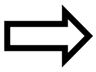
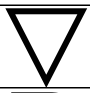
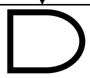
Location: Dorben Ad Agency		Summary			
Activity: Preparing Direct Mail Ads		**Event**	**Present**	**Proposed**	**Savings**
Date: 1-26-98		Operation	4		
Operator:J.S.	Analyst:A.F.	Transport	4		
Circle appropriate Method and Type:		Delay	4		
Method: *(Present)* *Proposed*		Inspection	0		
Type: *Worker* *(Material)* *Machine*		Storage	2		
Remarks:		Time (min)			
		Distance (ft)	340		
		Cost			

Event Description	Symbol	Time (In Minutes)	Distance (In Feet)	Method Recommendation
stock room	○ ◇ D □ ▼			
to collating room	○ ◆ D □ ▽		100	
in collating rack by type	○ ◇ ● □ ▽			
collate 4 sheets	● ◇ D □ ▽			
in stack	○ ◇ ● □ ▽			
to folding room	○ ◆ D □ ▽		20	
in stack	○ ◇ ● □ ▽			
jog, fold, crease	● ◇ D □ ▽			
in stack	○ ◇ ● □ ▽			
to angle stapler	○ ◆ D □ ▽		20	
in stack	○ ◇ ● □ ▽			
staple	● ◇ D □ ▽			
in stack	○ ◇ ● □ ▽			
to mail room	○ ◆ D □ ▽		200	
in stack	○ ◇ ● □ ▽			
addressing	● ◇ D □ ▽			
in stack	○ ◇ ● □ ▽			
mailbag	○ ◇ D □ ▼			
	○ ◇ D □ ▽			

Source: (Niebel & Freivalds, 2009)

Flow process chart will shows every that happen in the activity. For example, the flow process chart of the milling process, event is the sub activity that done by the operator to complete the milling process from the beginning until the end. Then, every event or sub-activity will be differentiate based on the type of operation which shows in table 2.6. The link arrows shows the direction of flow process chart. Inside the table of flow process chart, the analyst that fill the flow process chart must fill the time needed to complete every event, and also the distance needed by the operator to conduct the event. The total time total distance also input inside the flow process chart. Flow process chart will show the information and short overview about the whole process. (Niebel & Freivalds, 2009)

Table 2.6 Type of Operation

	Process	Process or activity that happen
	Inspection	Compare the items due to the standard
	Transport	Movement of operator, material, or equipment
	Storage	The material, item or product are stored at the certain place
	Delay	Process of waiting, which means idle

Source: (Simoes & Tenera, 2010)

Table 2.6 shows five types of operation, which are process, inspection, transport, storage, and delay. The activity that can be categorized as process are assembly, dis-assembly, and change in shape or quality. The inspection represent the activity to compare the items with the standard that already made. If the items is not fulfilled the standard it become a defect or rework. Transport is the change of location due to the operator, tools and equipment, and material. Storage is store the item into a certain place. The item might be a Work In Process (WIP), finished product, material, defect, rework, and other item. Delay is the idle process that happen because of the interruption of certain process. (Simoes & Tenera, 2010)

2.4.5 Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness or can be called as OEE proposed by Nakajima in late 1980. OEE is a method used for measuring the performance of equipment or machine as part of Total Productive Maintenance (TPM) implementation. The objective of Overall Equipment Effectiveness (OEE) is to measure and investigate the overall performance which might be a disturbance in the manufacturing process. (Jonsson & Lesshammar, 1999)

OEE have three factors of performance measurement which are availability, performance, and quality which will be used for OEE calculation in rating the effectiveness of the machine or equipment. (Jonsson & Lesshammar, 1999)

- ✓ **Availability rate** shows the availability of the machine during the production process. Loss in availability means the downtime loss of a machine which inlude breakdowns, and set-up time and adjustment.
- ✓ **Performance rate** shows the performance of the machine in performing the production process. Speed loss is the OEE loss category in the performance rate and include small stops and speed reduce.
- ✓ **Quality rate** shows the quality related due to the result of production process. Quality loss includes the start-up rejects and production rejects.

Table 2.7 Characteristics of Overall Equipment Effectiveness (OEE)

OEE Factor	Six Big Losses Category	OEE Loss Category	Event Examples
Availability	Breakdowns	Downtime loss	Tooling Failures Unplanned Maintenance General Breakdown Equipment failure
	Set-up and Adjustments	Downtime loss	Set-up/ Changeover Material Shortages Operator Shortages Major Adjustment Warm-up Time
Performance	Small Stops	Speed Loss	Obstructed Product Flow Component Jams Misfeeds Sensor Blocked Lubricant top-up Delivery blocked Cleaning/ Checking

Source: (Benjamin, Murugaiah, & Marathamuthu, 2012)

Table 2.8 Characteristics of Overall Equipment Effectiveness (OEE) (Continued)

OEE Factor	Six Big Losses	OEE Loss	Event Examples

	Category	Category	
Performance	Reduced Speed	Speed Loss	Rough Running Under Nameplate Capacity Equipment Wear Tool Wear Operator Inefficiency
Quality	Startup Rejects	Quality Loss	Scrap Rework In-process Damage In-process Expiration Incorrect Assembly
	Production Rejects	Quality Loss	Scrap Rework In-process Damage In-process Expiration Incorrect Assembly

Source: (Benjamin, Murugaiah, & Marathamuthu, 2012)

Based on table 2.7 and table 2.8, there are "six big losses" category that become the major objectives in OEE methodology. The six big losses are (Wudhikarn, 2013);

- Equipment failure or breakdown losses, as one of downtime loss; means the losses that will decrease the productivity of the machine which comes from the stops of the machine in more than ten minutes.
- Set-up and adjustments losses, also one of downtime loss; have a meaning of losses that happen when set-up the machine that usually happen before running the machine or also can be happen before and after starting the machine.
- Minor stoppages or small stops, as one of speed loss; happens when the machine is interrupted by a small malfunction or machine in idle condition in less than ten minutes time.
- Reduces speed losses, also one of speed loss; happens when the speed of machine is not the same as been desired and become slower than the real speed of the machine.

- Defect and rework loss, as one of quality loss; happens when the losses that caused by repairing the rework or defect product into a good products, which include the time and financial losses.
- Startup loss, also one of quality loss; the losses that happen when start-up the machine or production process, which also include time and volume lsses.

2.4.5.1 Overall Equipment Effectiveness (OEE) Calculation

Overall Equipment Effectiveness (OEE) calculation are differentiate into three, which are availability rate, performance rate, and quality rate. The multiplication od availability, performance, and quality rate become the Overall Equipment Effectiveness (OEE) rate. All the result of availability, performance, quality, and OEE rate are in the form of percentage. (Wudhikarn, 2013)

a) Availability Rate

Availability rate is related with unplanned stoppages and planned stoppages. Planned stoppages for this calculation include the set-up or line preparation time, and also the changover time. Unplanned stoppages comes from the breakdown time.

$$Availability\ rate = \frac{Operating\ Time}{Loading\ Time} \times 100\% \qquad \textbf{(2.1)}$$

$$Availability\ rate = \frac{Loading\ Time - Downtime}{Loading\ Time} \times 100\% \qquad \textbf{(2.2)}$$

Loading time is can be calculated by the total time of the machine can operates or runs during the certain time. For example, if the OEE calculation in one month, the loading time is the total machine time can run in a month. The calculation of operating time is loading time minus downtime loss. Downtime loss can be calculated from the total unplanned and planned stoppages that have been mention before, which are set-up or line preparation time, changover time, and breakdown time. Then, the calculation for availability rate is operating time divided with loading time.

b) Performance Rate

Performance rate is related with minor stoppages happen during the production process and the operating time that same with previous discusion.

$$Performance\ rate\ = \frac{Net\ Operating\ Time}{Operating\ Time} \times 100\% \quad \textbf{(2.3)}$$

Performance loss is can be taken from the sum of minor stoppages happen during the production process. Net operating time is obtained by subtracting loading time with performance loss. The result of performance rate is comes from the net operating time divided with operating time.

c) Quality Rate

The quality rate is related with the defect and the number of items can be produce during the production process.

$$Quality\ rate = \frac{Processed\ Amount - Defect\ Amount}{Processed\ Amount} \times 100\% \quad \textbf{(2.4)}$$

Processed amount the the total amount can be produce during the production process, while the defect amount is the total number of defect occur during the production process. Then, quality rate is processed amount minus defect amount and the result will be divided with the processed amount.

d) Overall Equipment Effectiveness (OEE) Rate

Overall Equipment Effectiveness (OEE) rate is the overall rate calculation that shows the effectiveness of the machine. Overall Equipment Effectiveness (OEE) rate is related with availability, performance, and quality rate.

$$OEE\ Rate\ = (A \times P \times Q) \times 100\% \quad \textbf{(2.5)}$$

Overall Equipment Effectiveness (OEE) rate can be calculted by multiply availability, performance, and quality rate and the result is in percentage. The higher the OEE rate, the management of the production process in the manufacturing process is already effective and efficient. The smaller OEE rate, the production process is not effective and need several improvements to increase the OEE rate.

2.5 Previous Research

SMED approach applied to a press line in automotive industry. SMED method proposes waste elimination by reducing non-production time in each machine, especially the time needed for set-up machine time. Gantt chart and time study will be used to support the SMED implementation in this research. In the end, the set-up time of press line in automotive industry has been reduce from 6 minutes and 47 seconds become 5 minutes and 23 seconds, with one minute and 24 seconds reduction in total. SMED implementation is successful in reducing set-up time of press line in automotive industry with 47.5% reduction of set-up time. This research is done by Andreia Simoes and Alexandra Tenera in 2010 with the title "Improving Set-up Time in a Press Line – Application of the SMED Methodology", from IFAC, from page 297 until page 302.

Another SMED implementation happens in punch press operation in the fabrication department at Krueger International's (KI) Manitowoc manufacturing facility. Reduction of set-up time might be helpful to support KI's marketing strategy in fulfill customer's needs. After conducting all the step of SMED, the set-up time is reduced by the overall set-up time reduction rate at 68%. The SMED implementation is successful in reducing set-up time in punch press operation at Krueger International's (KI) Manitowoc manufacturing. This research is done by Brian T. Michels in 2007 with title of "Application of Shingo's Single Minute Exchange of Dies (SMED) Methodology to Punch Press Changeover Times at Krueger International, 5^{th} ed, American Psychological Association in Washington DC.

A study case held in a small scale industry of one of automotive manufacturing industry to reduce set-up time by using SMED implementation. In order to achieve the excellence, manufacturing industry need to reduce production time and cost to improve production performance and product quality. After implementation of SMED, the set-up time is reduce from 480 second become 385 seconds with a total 85 seconds. Another achievement by using SMED implementation is 30% cost reduction while the productivity and product output is increased. This research is held by Mr. Rahul R Joshi and Prof G R Naik in 2012 with title of “Application of SMED Methodology – A Case Study in Small Scale Industry”, International Journal of Scientific and Research Publications in Kolhapur, India.

A study case happens in Tanzania hospital that has the main purpose in reducing waiting time of patient of hospital. The method used for reducing waiting time is 5S methodology by the help of Design of Experiment method of Randomized Block Design. After implementation 5S (SEIRI-SEITON-SEISO-SEIKETSU-SHITSUKE) and randomized block design, the outcome shows a good result which means a successful research. This research held by Hisahiro Ishijima, Eliudi Eliakimu, and Jonathan Mcharo Mshana, with ttile of “The 5S Approach to Improve a Working Environment can Reduce Waiting Time”, The TQM Journal from page 664 until page 680.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Framework

Research framework shows the step or guideline to conduct the research. Based on figure 3.1, steps of this research are initial observation, problem identification, literature study, data collection and analysis, and conclusion and recommendation.

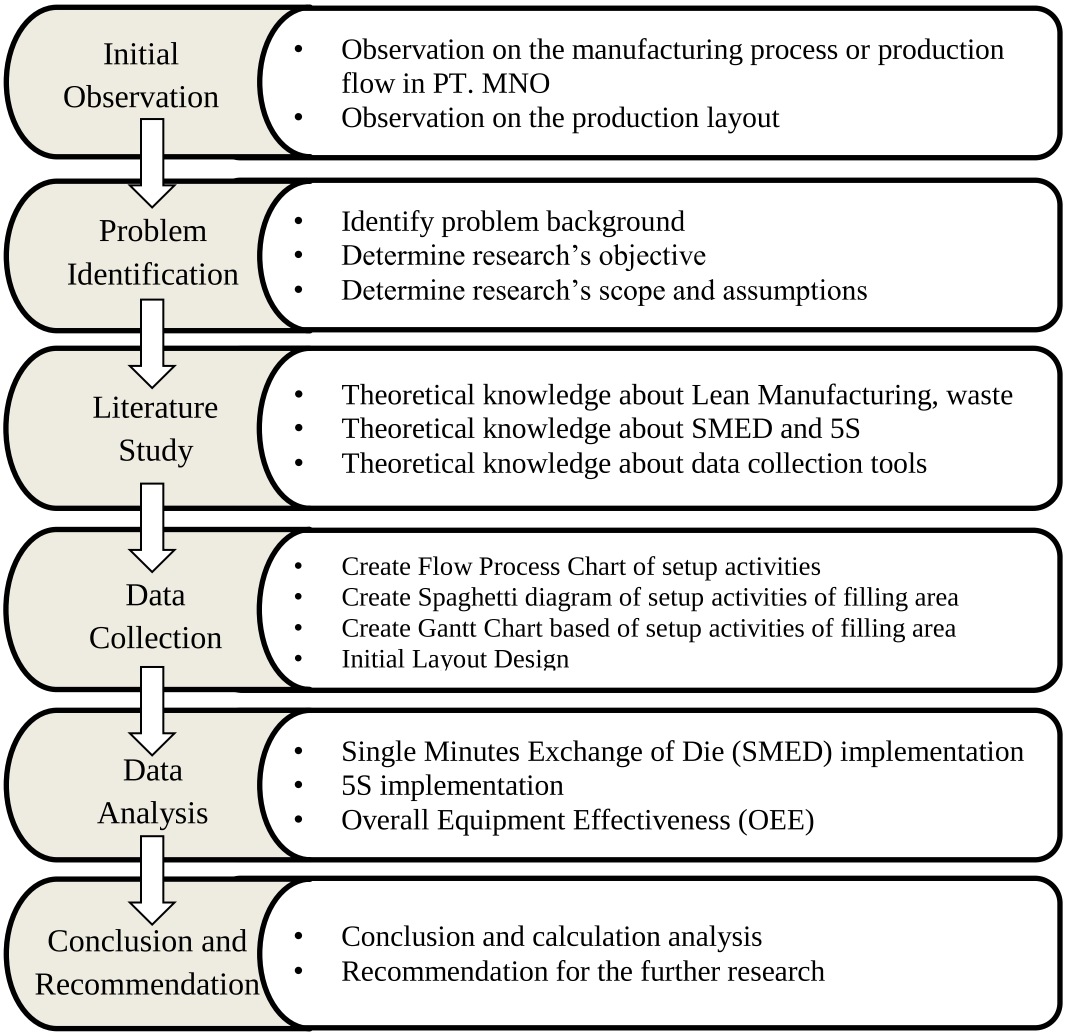


Figure 3.1 Research Methodology

3.1.1 Initial Observation

The initial observation is analyzing the line preparation process from the beginning until the end in filling machine area in PT. MNO. It observes the detail activities of line preparation or set-up time in filling area. Besides that, it observe the filling production layout that include the surrounding environment of filling machine. From the observation the research can gather some important data that can be used for this research.

3.1.2 Problem Identification

After observing the line preparation of filling area, there is a problem regarding to the line preparation or set-up time. There will be problem background that explains about the problem of planned stoppages of line preparation in filling machine area. Problem statement also can be determined by focusing to the main problem about reducing planned stoppages in line preparation of filling area. The research objective is the answer of the problem statement that already stated which are reducing the planned stoppages in line preparation of filling area by using Single Minute Exchange of Dies (SMED) and 5S method implementation.

3.1.3 Literature Study

The literature study will clearly explain about every method that will be used in this research based on several journals and books. There will be theoretical knowledge regarding to SMED and 5S method. Besides that, there are theoretical knowledge about the lean manufacturing, waste, and set-up time that related with the problem in this research. There will be several data collection and analysis tools which are, Flow Process Chart, Gantt Chart, Spaghetti Diagram, Pareto Chart, and Overall Equipment Effectiveness (OEE).

3.1.4 Data Collection

All the data is originally taken from PT. MNO by individual observation and also the data that already record by the company. There will be four data that will be collected which are Flow Process Chart that explain the activities, time and distance of set-up activities, Spaghetti Diagram that shows the movement of operator during the set-up activities, Gantt Chart that explain the time lap of set-up activities, layout design that shows the overall layout of filling machine area.

3.1.5 Data Analysis

After the data is gathered, the data will be further analyze in this section. First of all, there will be OEE calculation that will be used at the end of this research to compare the effectiveness of the machine before and after SMED and 5S implementation. OEE calculation will help this research to know the difference from the effectiveness of production process before and after SMED and 5S method implementation. The data that will be used in this calculation are based on the monthly data regarding to unplanned and planned stoppages that taken from the PT.MNO

Then, the analysis is done by using the Single Minutes Exchange of Dies (SMED) method at first. Then, it is continued by 5S method after SMED method, Single Minutes Exchange of Dies (SMED) method consist of four steps which are internal and external activities are not differentiated, separate internal and external activities, convert internal and external activities, and streamline internal activities. 5S method help to streamline the remaining internal activities to make the internal activities more effective than before. The data of conduct the analysis is taken from the data collection in this research.

3.1.6 Conclusion and Recommendation

This section contains the summary of all the feedback that already done including the main result. The result will be answering the problem of reducing the planned stoppages of filling area in PT. MNO which comes from set-up activities. There are also the differences of OEE rate before and after SMED and 5S method implementation. In this section also include the advice to the further research.

3.2 Detail Framework

Based on figure 3.2 and figure 3.3 there are four phase in total, those are define problem, data collection, data analysis, execute the action, and conclusion and recommendation. Each phase will further explain in this section.

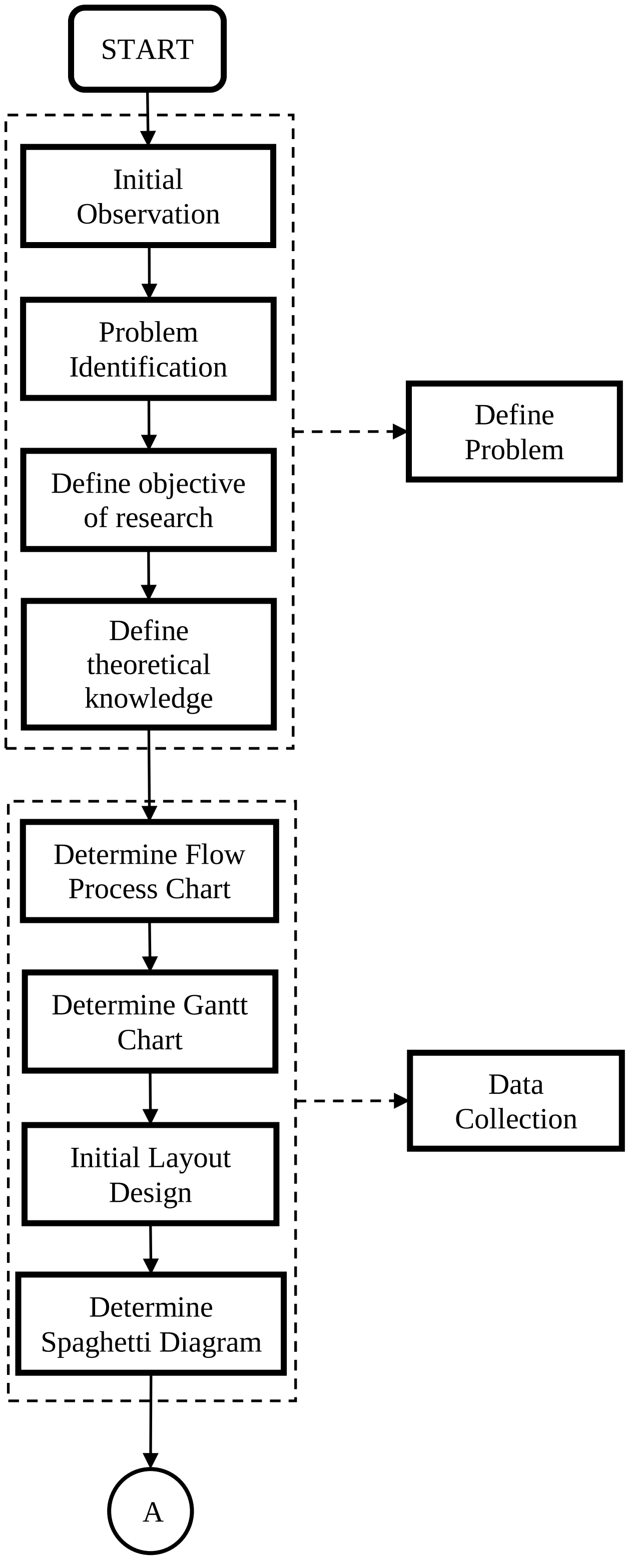


Figure 3.2 Detail Framework

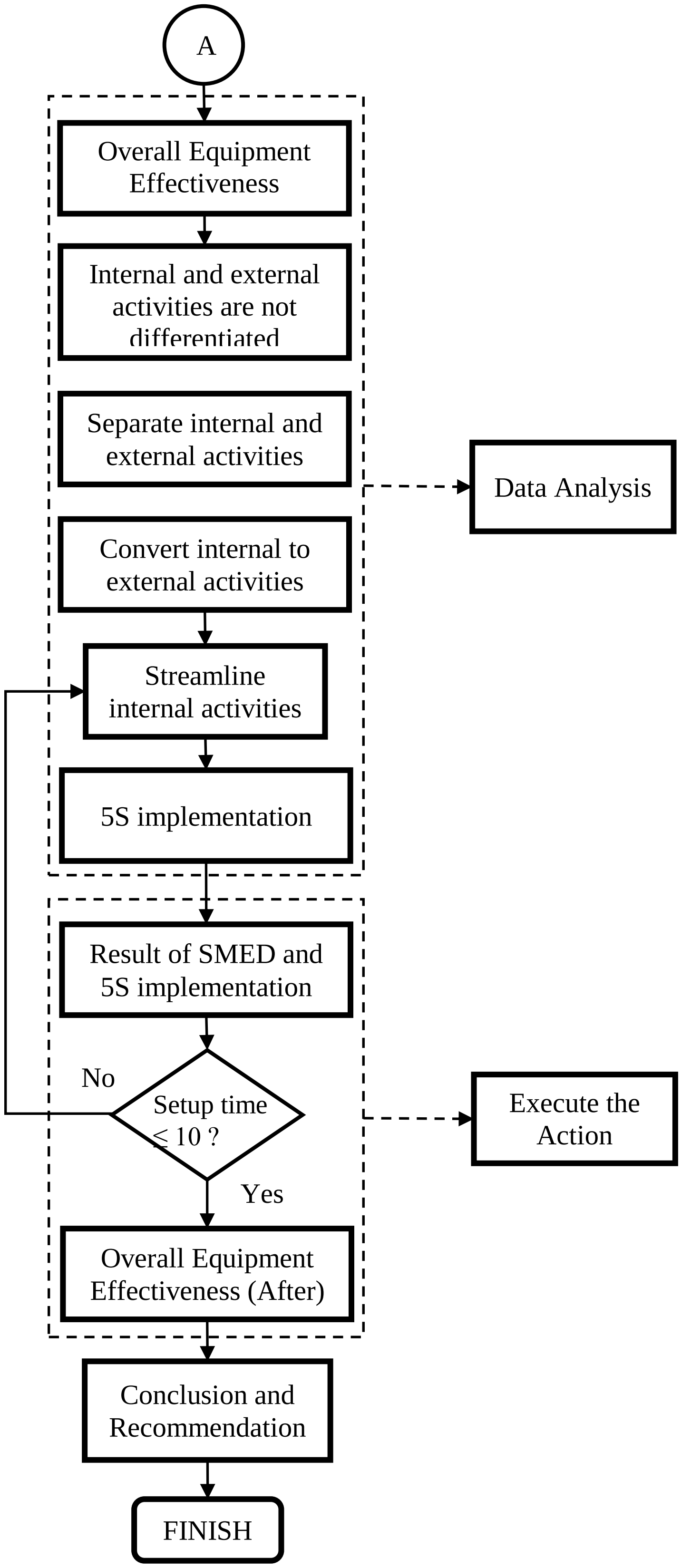


Figure 3.3 Detail Framework (continued)

3.2.1 Define Problem

Based on figure 3.2, define problem is differentiated into four steps, which are initial observation, problem identification, define objective of research, define theoretical knowledge regarding to the problem. Initial observation can be done by observing the production process in filling machine area and find is there any problem happen. Problem identification means identified the problem and also the causes of the problem which comes from set-up activities. Define the objective of research means identify the objective to held the research and the way to solve the problem. In this research, set-up time can be reduce by using Single Minutes Exchange of Dies (SMED) integrated with 5S method. The last steps is defining theoretical knowledge regarding to the SMED, 5S, set-up and other data collection and analysis tools based on several journals and books.

3.2.2 Data Collection

All the data that have been collected from PT. MNO will support the analysis in this research. The data that are needed for this research are all activities regarding to the problem in line preparation or set-up time of filling area. The activities including the duration, movement, distance, steps of activities, etc.

- Flow Process Chart will shows the main activities including the sub-activities, including the time and distance. The data for Flow Process Chart is obtain from individual observation during the set-up activities.

- Gantt chart will show the clear step of activity and the time lap for each activity. Similar with Flow Process Chart and Spaghetti Diagram, data of Gantt Chart is obtain by observation and data from PT. MNO.

- Observation also held to gather the data of layout design. The layout design will shows the specific location of the machine and surrounding environment of the filling machine area.
- The observation of the operator movement to conduct the set-up activities will become the data of spaghetti diagram. Spaghetti diagram shows the detail movement of the operator during the line preparation from the beginning until the end with the movement from one place to another place.

3.2.3 Data Analysis

After the data is gathered, the data will be further analyze in this section which shown in figure 3.3. Overall Equipment Effectiveness is used to analyze the effectiveness of the machine before SMED and 5S implementation. The data that will be used for OEE calculation are obtained from the PT. MNO in filling machine. The data might be the planned maintenance time, breakdown time, line preparation time, changeover time, and other production time from the month of April until June 2016.

The first step of Single Minutes Exchange of Dies (SMED) method is stated internal and external activities that are not differentiated which contain the entire activities of set-up. Then, separate the internal and external activities from the result of previous step. The internal and external activities must be separate according to the activities that the operator done in real life. If there any internal activities that can be done during the machine run, the internal activities can be convert to external activities to reduce internal activities. Next, streamline the remaining internal activities by using 5S implementation.

SEIRI (Sorting) will be the first step, observing the surrounding area and determine unnecessary item in the filling machine area and removed, re-place, or re-stored unnecessary item. Then, SEITON (Set) will set the all the remaining item in the right place to reduce the repetition and far movement of the operator. The implementation of SEISO (Shining) step is done by creating a schedule to clean the filling machine area environment together with the operator and achieve the standard condition. The cleaning time can be done during the planned maintenance time in the beginning of June 2016. SEIKETSU (Standardizing) step will help to create the standard of new set-up activities in filling machine area, while SHITSUKE (Sustaining) keeping the implementation stay running as it is can be done by train the operator the new set-up activities and keep monitoring them when performing the new standard of set-up activities.

3.2.4 Execute the Action

The result of analysis from Single Minutes Exchange of Dies (SMED) was implemented in the real production process on May 2016, while 5S implementation was started on June 2016. The setup activities time before and after Single Minutes Exchange of Dies (SMED) and 5S method will be compared with one another. If the setup time after SMED and 5S method implementation is less than ten minutes, overall equipment effectiveness can be calculated to compare the OEE rate before and after SMED and 5S implementation. If the set-up time is still more than ten minutes, the research must do the re-analyze of the streamline of the internal activities. Then, if the OEE rating is greater than the previous calculation, SMED and 5S implementation is successful help the reduce setup activities while increase the productivity. The research that use SMED method can be categorized as success when the set-up time is ten or less than ten minutes, which means in single minutes of set-up time (Benjamin, 2012).

CHAPTER IV

DATA COLLECTION AND ANALYSIS

PT. MNO is one of the biggest food and beverage industry in Indonesia. PT. MNO has 447 factories in 86 different countries all around the world. PT. MNO also manufactures around ten thousands different products and employs around 250 thousand people. PT. MNO already market products in 130 different countries which can sell around a billion products each day. PT. MNO product are milk, chocolate, snacks, and other product.

PT. MNO still need to face the problem of planned and unplanned stoppages. Planned and unplanned stoppages also happen in filling machine area. One of PT. MNO product is milk powder which become the main focus of filling machine area in this research. The filling process is the process of input the milk powder to sachet which is the last process before packaging process. Then, all the product that come to filing machine is already in good condition. The defect in filling process only include the sealing of sachet product. The rate of planned and unplanned stoppages happen in filling machine are shown in figure 4.1. The data was obtain from original data of PT. MNO for filling machine area from February until March 2016.

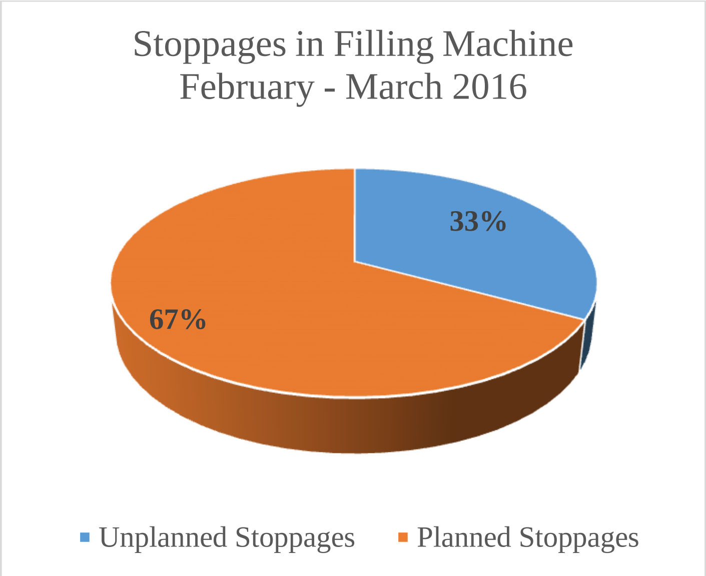


Figure 4.1 Stoppages in Filling Machine (February – March 2016)

Planned stoppages and unplanned stoppages become the problem that must be face by PT. MNO. Based on figure 4.1, filling machine shows the appearance of both stoppages. But, the highest contribution goes to planned stoppages with 67%, while the unplanned stoppages only contributes 33%. Then, the company focus on the planned stoppages happen in filling machine. The planned stoppages itself can be divided into four major stoppages happen in filling machine, which are set-up activities, cleaning inspection lubrication (CIL), operation stoppages, and planned maintenance. The data of planned stoppages are shown in figure 4.2 that are obtain from the data of PT. MNO from February until March 2016 in filling machine.

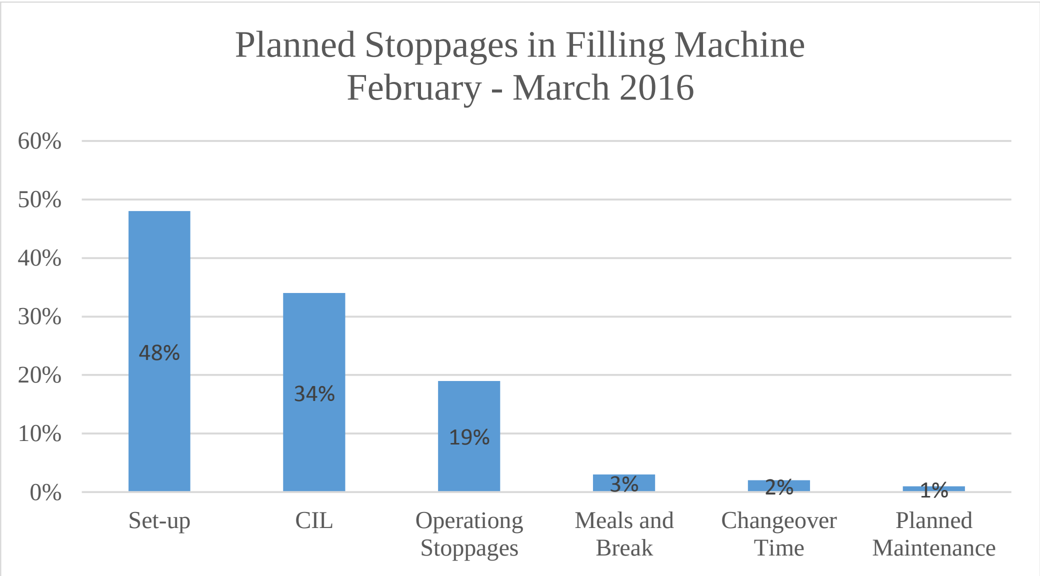


Figure 4.2 Planned Stoppages in Filling Machine (February – March 2016)

Based on figure 4.2, the highest contribution goes to set-up activities with 48% from February until March 2016. Cleaning Inspection Lubrication (CIL) shows 34%, while operation stoppages 19%, meals and break 3%, changeover time 2%, and planned maintenance only 1%. Then, the main focus in this research goes to set-up activities of filling machine area.

PT. MNO still has to face a problem in manufacturing industry regarding to planned stoppages especially in set-up activities. The time needed to conduct set-up activities is taking too long which actually the set-up time still can be reduce by using Single Minutes Exchange of Dies (SMED) method. 5S method will be used to streamline the remaining internal activities to reduce more set-up time. Then, PT. MNO can reduce the impact of losses to the company.

The productivity of machine can be calculated by using Overall Equipment Effectiveness (OEE). There are three different rate, which are availability, performance, and quality. In this research, the availability calculation will use the set-up time, changeover time, and process failure, while performance rate will use the minor stoppages, and quality will use the defect of the filling machine product.

The defect happen in filling machine product only caused by the sealing of product sachet, since the output of filling machine is milk powder in sachet product. The milk powder that come to filling machine are already in the good condition since filling machine is the last production process before the packaging process.

4.1 Data Collection

Data collection can be obtained by initial observation to the condition of filling machine area. The data are original from PT.MNO particularly in filling machine area. The data that need to be collected are flow process chart, Gantt chart, initial layout design, and spaghetti diagram. All the data will be collected and used for data analysis in the next discussion.

There are also several data that can be obtain originally from the company. The data of several planned and unplanned stoppages that will be used for Overall Equipment Effectiveness (OEE) calculation in the next chapter which is data analysis. The data of changeover time, set-up time and process failure will be used for calculating availability. Minor stoppages data will be used for performance calculation, and the data of defect will be used for calculating the quality. All the data are from the filling machine are from April to June 2016 which shown in the appendices.

4.1.1 Flow Process Chart

The whole activities of line preparation in filling machine area are shown in flow process chart in table 4.1 and table 4.2. The data for flow of set-up process are obtain from the observation to the area of filling machine when set-up activities are take place. The flow process chart also shows the symbols of activity that clearly identified what type of activity that happen, it can be operation, transport, delay, inspection, or storage. Besides that, the time of each activities are stated including the distance that the operator take, in order to perform the activity in the filling machine area. Based on table 4.1, there are eight main activities in total which are checking metal detector, cleaning environment, cleaning machine, input data SAM/ SAP, take sample bubble test, take sample of carbon test, cut open rework, and Shift Hand-Over (SHO) update. There are 25 activities happen during the setup or line preparation in filling machine.

Table 4.1 Flow Process Chart

Location : Filling Machine Area			Summary		
Activity : Line Preparation / Set-up			Event		Present
			Operation		16
Time (in minute) : 34 minutes			Transport		5
Distance : 92 meters			Delay		3
			Inspection		0
			Storage		2
NO	Event Description	Symbol	Time Start	Time Stop	Distance (meter)
	Checking Metal Detector				
1	Record Counter Metal Detector	● ⇨ D □ ▽	0:00:00	0:01:00	1
2	Verified positive sample metal detector	○ ⇨ ◗ □ ▽	0:01:00	0:02:00	4
	Cleaning Environment				
3	Take Cleaning Tools	○ ➡ D □ ▽	0:02:00	0:04:00	7
4	Cleaning floor below the machine	● ⇨ D □ ▽	0:04:00	0:07:00	1
5	Tidy Up Cleaning Tools	○ ⇨ D □ ▼	0:07:00	0:09:00	7
	Cleaning Machine				
6	Take Cleaning Tools	○ ➡ D □ ▽	0:07:00	0:11:00	0
7	Cleaning Horizontal Seal Bar	● ⇨ D □ ▽	0:11:00	0:11:30	7
8	Cleaning Vertical Seal Bar	● ⇨ D □ ▽	0:11:30	0:12:00	0
9	Cleaning Colar	● ⇨ D □ ▽	0:12:00	0:12:20	2
10	Cleaning Knife Jaw	● ⇨ D □ ▽	0:12:20	0:12:40	0
11	Cleaning Cover Acrylic	● ⇨ D □ ▽	0:12:40	0:13:00	1
12	Cleaning Conveyor Plat	● ⇨ D □ ▽	0:13:00	0:13:30	1
13	Cleaning Conveyor Belt	● ⇨ D □ ▽	0:13:30	0:14:00	0
14	Tidy Up Cleaning Tools	○ ⇨ D □ ▼	0:14:00	0:16:00	7
	Input Data SAM				
15	Pre-input data SAM	● ⇨ D □ ▽	0:16:00	0:18:30	10
16	Collect sheet report	○ ➡ D □ ▽	0:18:30	0:19:00	0
17	Input to computer	● ⇨ D □ ▽	0:19:00	0:24:00	10

Table 4.2 Flow Process Chart (Continued)

NO	Event Description	Symbol	Time Start	Time Stop	Distance (meter)
	Take Sample for Bubble Test				
18	Take Sample for Bubble Test	● ➡ D □ ▽	0:00:00	0:25:00	4
19	Waiting sampling result	● ➡ ◗ □ ▽	0:25:00	0:25:40	0
20	Report sampling	● ⇨ D □ ▽	0:25:40	0:26:00	4
	Take Sample for Carbon Test	● ⇨ D □ ▽			
21	Take Sample for Carbon Test	● ➡ D □ ▽	0:25:40	0:27:00	4
22	Waiting sampling result	● ⇨ ◗ □ ▽	0:27:00	0:27:40	0
23	Report sampling	● ⇨ D □ ▽	0:27:40	0:28:00	4
24	Cut Open Rework	● ⇨ D □ ▽	0:27:00	0:31:00	10
25	SHO Update	● ➡ D □ ▼	0:27:40	0:34:00	8

The whole activity shows 16 operation event, five transport events, three delay events, no inspection event, and two storage events. There are several activities that have a zero distance, this means that the operator does not require any movement for the current activities, which means the operator is not moving to any other place. Based on the flow process chart in table 4.1 and table 4.2, time required to complete setup activity is 34 minutes in total, while the movement done by the operator is 92 meter of distance in total.

4.1.2 Gantt Chart

Gantt Chart displays the set-up activities against the time taken for the activities. Based on table 4.3, the number stated in horizontal area means the time of activities in minutes from one until 34 minutes, while the vertical area shows the all activities.

Table 4.3 Gantt Chart

No	Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	Checking Metal Detector																																		
	Record Counter Metal Detector	■																																	
	Verified positive sample metal detector		■																																
2	Cleaning Environment																																		
	Take Cleaning Tools			■	■																														
	Cleaning floor below the machine					■	■	■																											
	Tidy Up Cleaning Tools								■	■																									
3	Cleaning Machine																																		
	Take Cleaning Tools										■	■																							
	Cleaning Horizontal Seal Bar												■																						
	Cleaning Vertical Seal Bar												■																						
	Cleaning Colar													■																					
	Cleaning Knife Jaw													■																					
	Cleaning Cover Acrylic													■																					
	Cleaning Conveyor Plat														■																				
	Cleaning Conveyor Belt														■																				
	Tidy Up Cleaning Tools															■	■																		
4	Input Data SAM																																		
	Pre-input data SAM																	■	■	■															
	Collect sheet report																			■															
	Input to computer																				■	■	■	■	■										
5	Take Sample for Bubble Test																																		
	Take Sample for Bubble Test																									■									
	Waiting sampling result																										■								
	Report sampling																										■								
6	Take Sample for Carbon Test																																		
	Take Sample for Carbon Test																											■							
	Waiting sampling result																												■						
	Report sampling																												■						
7	Cut Open Rework																													■	■	■			
8	SHO Update																																■	■	■

The activities are stated same with flow process chart but the difference only comes from the table shows the time lap from current activities the next activities until the set-up activities are finished. Gantt chart shows the activities start in minute one until minutes 34.

4.1.3 Initial Layout Design

Layout design can be created by observing the real layout design of filling machine area. Based on figure 4.3 there are seven items in filling machine area that used for set-up activities and one filling machine. The seven items are SAM/ SAP table, cleaning tools for (red) for cleaning environment, cleaning tools (blue) for cleaning machine, Shift Hand-Over board, metal detector, sampling test table, tip table, and cut open rework table. The distance shown in figure 4.3 are drawn by scale of 1:100.

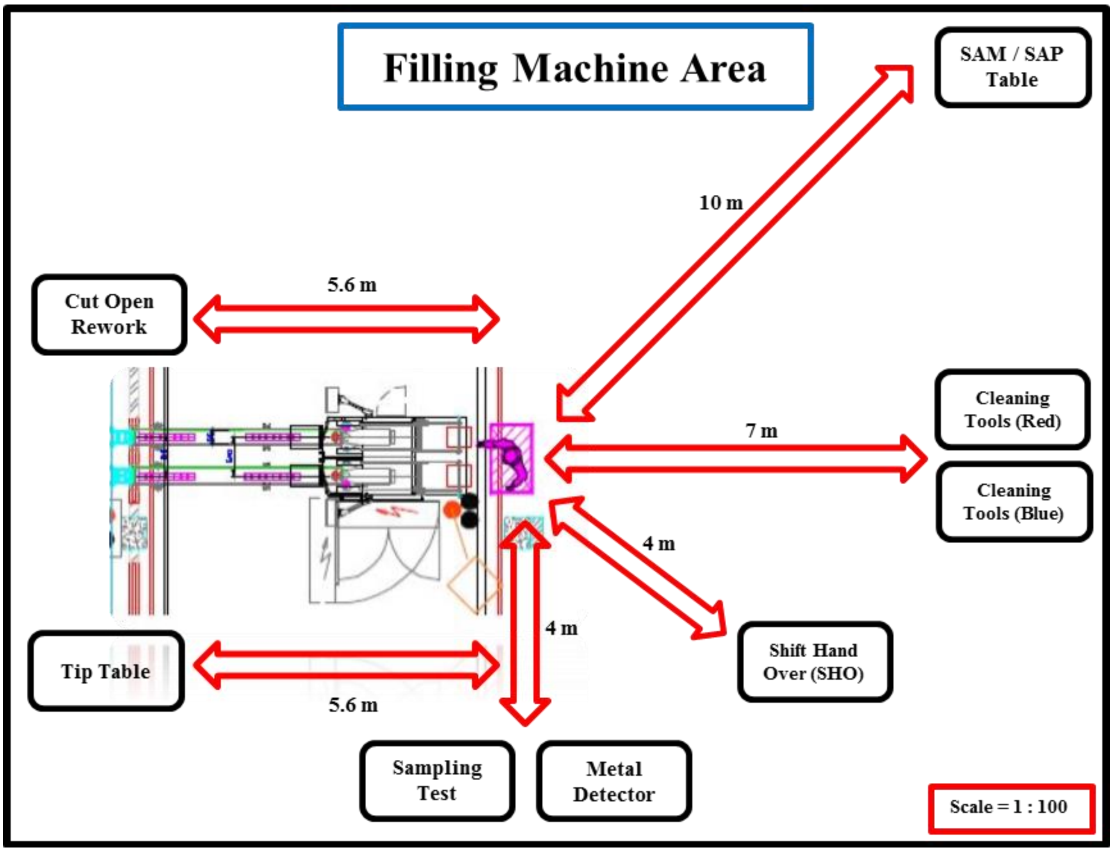


Figure 4.3 Initial Layout Design of Filling Machine

The length of machine is 5.6 meters in total. SAM/ SAP table is ten meters away from the machine. There are two types of cleaning tools, cleaning tools with red mark and blue mark which are 7 meters away from the machine. Shift Hand-Over (SHO) board is located 4 meters from the machine. The metal detector and sampling test are located 4 meters from left of the machine. Cut open rework places and tip table are located 5.6 meter from the machine which means in front section of the machine. The longest items that placed in filling machine area is

SAM / SAP table with ten meters distance, while the shortest items places in filling machine area are Shift hand-Over board, metal detector, and sampling test table with four meters in distance.

4.1.4 Spaghetti Diagram

Spaghetti diagram shows the movement of the operator during the set up activities in filling machine area. Figure 4.4 shows the spaghetti diagram that has been used during the observation of the operator's movement during set-up activities. The total number of 25 means the total activities conduct by the operator which same with that have been stated in table 4.1 Flow Process Chart beforehand.

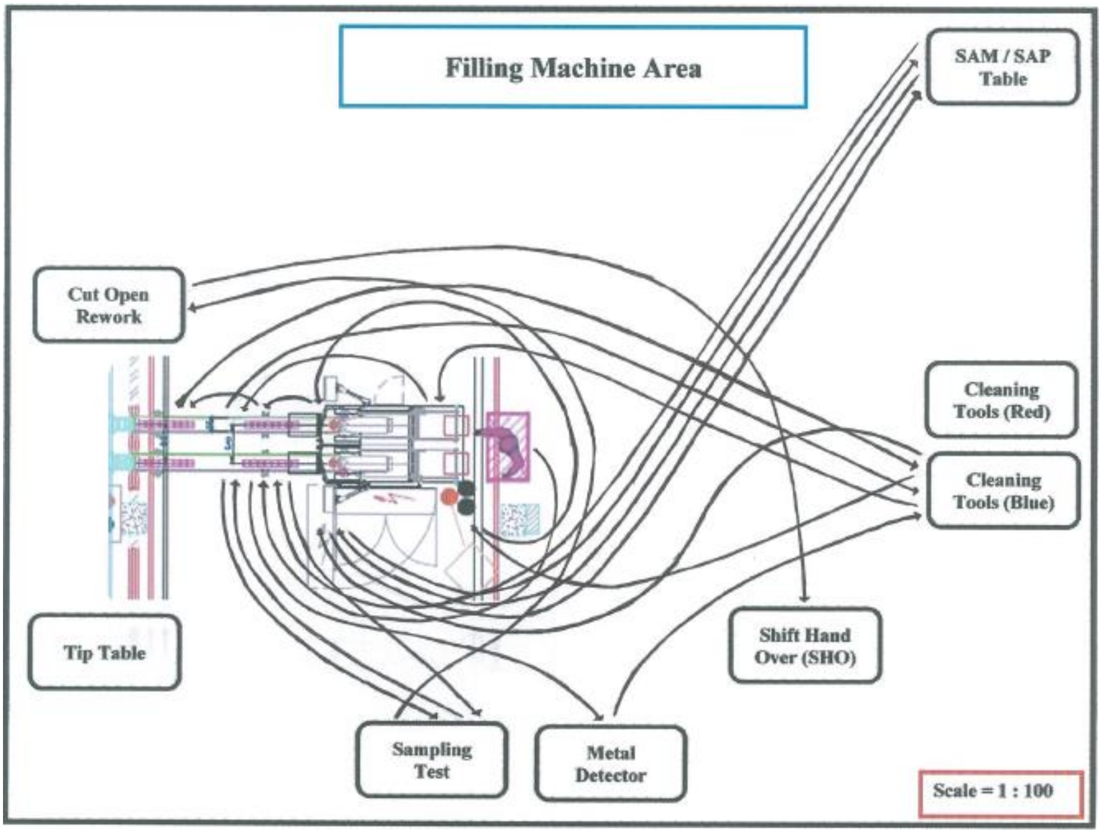


Figure 4.4 Spaghetti Diagram

Figure 4.4 shows the movement of the operator step by step from the beginning until the end of set-up activities. The flow of set-up activities process based on the spaghetti diagram are explained more below.

a. The operator starts the operation from the middle of filling machine area that mark with purple color.

b. Then, the operator will go to the center point of machine to check the metal and go to metal detector equipment to check the condition of metal detector
c. The operator needs to take the cleaning tools with the red mark and move to the machine to clean the floor and surrounding environment of the machine that are dirty and need to be cleaned.
d. Next, the operator needs to clean several internal part of filling machine. The operator needs to take cleaning tools with blue mark to clean several internal parts of the machine.
e. The operator is going back and forth to the machine and SAM/SAP table to finished inputting SAM/ SAP data to the computer.
f. Next activities are sampling test for bubble and carbon. The operator needs to take the filling machine output or product to be test in the bubble test and carbon test. After the operator take the output or product, the operator will go to sample test table that already provide the equipment for bubble and carbon sample test.
g. The operator needs to do the cut open rework in order to help the rework department in making the rework of the defect product from filling machine.
h. The last activity is the operator need to fill up the shift hand-over board. The chart in shift hand-over board will summarize all situation that happen during the current shift and the information will be delivered to the next shift.

Based on the analysis of spaghetti diagram that already shown in figure 4.4, there are several repetition movement that done by the operator. In order to reduce the time of set-up activities, the research may consider reducing distance of the items also may help to decrease the set-up time.

4.2 Data Analysis

The data that were collected in previous section, will be further analyzed by using Overall Equipment Effectiveness (OEE), Single Minute Exchange of Dies (SMED), and 5S method. The analysis are related with the problem in this research which is set-up time. Then, the analysis will help to reduce the number of set-up time in filling machine area.

4.2.1 Overall Equipment Effectiveness (OEE) Before Implementation

Single Minutes Exchange of Dies (SMED) implementation is done in the beginning of May 2016, April 2016 will become the data for OEE calculation before SMED implementation. All the data is originally obtained from PT. MNO which include planned and unplanned stoppages. Planned stoppages data are changeover product and line preparation or set-up time, and etc. Unplanned stoppages data are minor stoppages, breakdown, and etc.

Based on figure 4.5 that visualized by Pareto chart, there are several calculation that will be used to calculate the availability, performance, and quality. The calculation includes down time loss, performance loss, loading time, operating time and net operating time. Besides that, figure 4.6 shows the Pareto Chart of the availability, performance, quality rate and the Overall Equipment Effectiveness (OEE) rating in April 2016. The result shown in figure 4.5 and 4.6 are shown in minute.

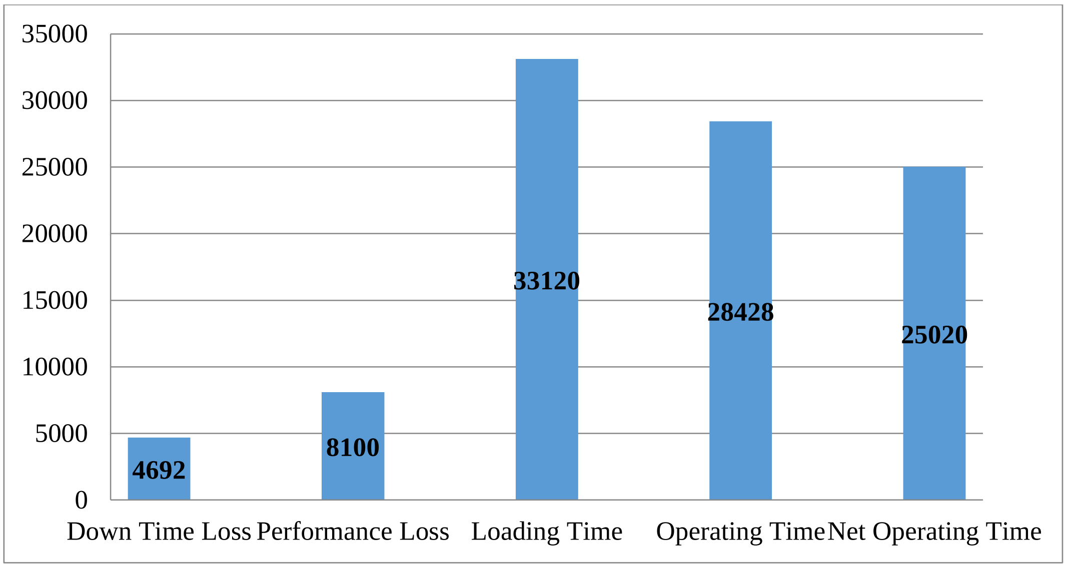


Figure 4.5 Overall Equipment Effectiveness Calculation (April 2016)

Downtime loss can be calculated from the changeover, line preparation or set-up time, and also breakdown time happen in filling machine during April 2016 which results 4692 minutes in total, the data are shown in the appendices. On the other hand, performance loss can be calculated from the minor stoppages happen in filling machine and the total performance loss is 8100 minutes in total. Loading time calculated based on the total time when machine can run. There are seven days for planned maintenance, which means seven days of idle production process and 33120 minutes is total time of machine can run in April 2016. Operating time can be calculated by the subtracting loading time with down time loss that result 28428 minutes. Net operating time also got from the calculation of the difference between loading time and performance loss which result 25020 minutes in total. All the data and the OEE calculation are shown more clearly in the last chapter of appendices.

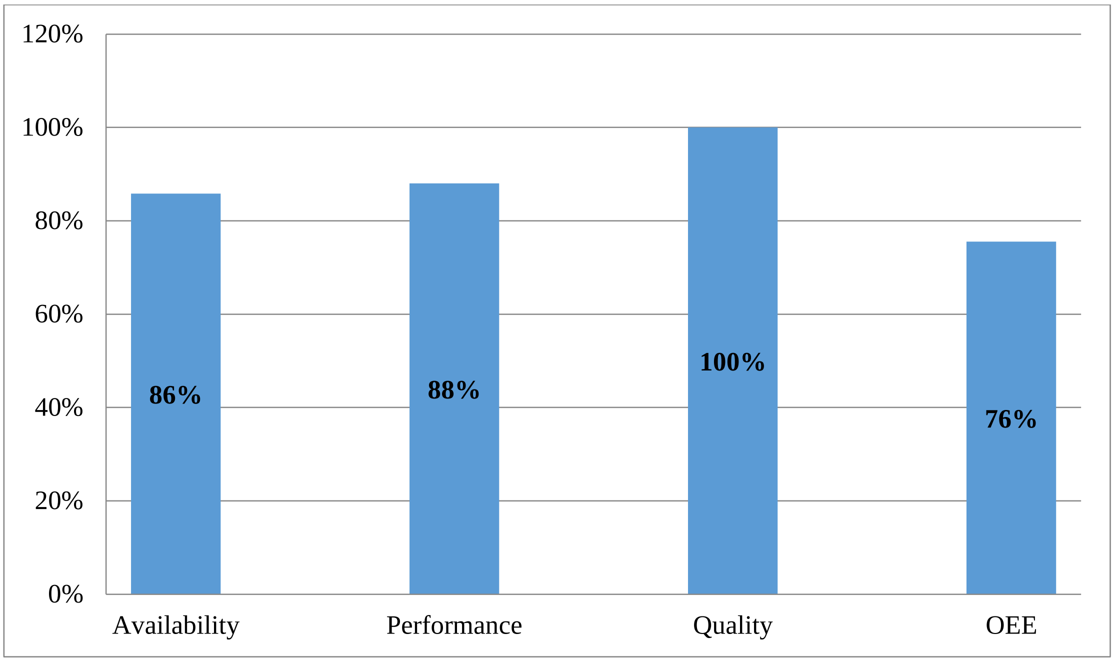


Figure 4.6 Overall Equipment Effectiveness (April 2016)

There are four data shown in figure 4.6 which are availability, performance, quality and OEE rate in April 2016. The calculation of availability rate use the equation 2.1, and the calculation are shown as follows:

$$Availability\ Rate = \frac{Operating\ Time}{Loading\ Time} = \frac{28428}{33120} x\ 100\% = 85.83\% \approx 86\%$$

Availability rate can be calculated by dividing operating time by loading time which result 86%. The calculation of performance rate is based on dividing the net operating time with the operating time which shown in the equation 2.2 and the result for performance calculation is 88%. The detail calculation are stated in the appendices

Quality rate can be calculated by the total product amount that produce in April 2016 except the defect product and divided by the total product amount should be produce in April 2016, the calculation are based on equation 2.3. There are 130 defect product occur in April 2016 caused by the sealing while the demand is 39000, and the result of quality rate is 100% which calculated by subtracting processed amount with defect amount, and the result will be divided with processed amount. OEE rating can be calculated by multiply availability, performance, and quality rate which result 76%. For the further calculation are shown more clearly in the last chapter of appendices.

4.2.2 Single Minutes Exchange of Dies (SMED) Implementation

Single Minutes Exchange of Dies (SMED) implementation differentiates into four steps, those are internal and external setup activities are not differentiated, separate internal and external activities, convert internal into external activities, and streamline the remaining internal activities. Streamlining the remaining internal activities will be done using 5S implementation to reduce the movement of the operator.

4.2.2.1 Internal and External Setup Activities are not differentiated

The set-up activity in filling machine area based on individual observation are shown in table 4.4 and table 4.5. Setup activities has already stated more detail before in flow process chart in table 4.1. Similar with the flow process chart, there are eight main activities which represent by alphabet of A until H, while the sub-activities are represent with number one until 25. Table 4.4 and table 4.5 also shows the time to start each activities with the time when each activity stops, the total time represent the time needed to conduct each activities.

Table 4.4 Setup Activity of Filling Machine Area

NO	Activity	Time Start	Time Stop	Total Time
A	**Checking Metal Detector**			
1	Record Counter Metal Detector	0:00:00	0:01:00	0:01:00
2	Verified positive sample metal detector	0:01:00	0:02:00	0:01:00
				2 minutes
B	**Cleaning Environment**			

3	Take Cleaning Tools	0:02:00	0:04:00	0:02:00
4	Cleaning floor below the machine	0:04:00	0:07:00	0:03:00
5	Tidy Up Cleaning Tools	0:07:00	0:09:00	0:02:00
				7 minutes
C	**Cleaning Machine**			
6	Take Cleaning Tools	0:09:00	0:11:00	0:02:00
7	Cleaning Horizontal Seal Bar	0:11:00	0:11:30	0:00:30

Table 4.5 Setup Activity of Filling Machine Area (Continued)

NO	Activity	Time Start	Time Stop	Total Time
C	**Cleaning Machine**			
8	Cleaning Vertical Seal Bar	0:00:00	0:12:00	0:00:30
9	Cleaning Colar	0:12:00	0:12:20	0:00:20
10	Cleaning Knife Jaw	0:12:20	0:12:40	0:00:20
11	Cleaning Cover Acrylic	0:12:40	0:13:00	0:00:20
12	Cleaning Conveyor Plat	0:13:00	0:13:30	0:00:30
13	Cleaning Conveyor Belt	0:13:30	0:14:00	0:00:30
14	Tidy Up Cleaning Tools	0:14:00	0:16:00	0:02:00
				7 minutes
D	**Input Data SAM**			
15	Pre-input data SAM	0:16:00	0:18:30	0:02:30
16	Collect sheet report	0:18:30	0:19:00	0:00:30
17	Input to computer	0:19:00	0:24:00	0:05:00
				8 minutes
E	**Take Sample for Bubble Test**			
18	Take Sample for Bubble Test	0:24:00	0:25:00	0:01:00
19	Waiting sampling result	0:25:00	0:25:40	0:00:40
20	Report sampling	0:25:40	0:26:00	0:00:20
				2 minutes
F	**Take Sample for Carbon Test**			
21	Take Sample for Carbon Test	0:26:00	0:27:00	0:01:00
22	Waiting sampling result	0:27:00	0:27:40	0:00:40
23	Report sampling	0:27:40	0:28:00	0:00:20
				2 minutes
G	**Cut Open Rework**			
24	Cut Open Rework	0:28:00	0:31:00	0:03:00
				3 minutes
H	**SHO Update**			
25	SHO Update	0:31:00	0:34:00	0:03:00
				3 minutes
TOTAL				**34 minutes**

Total time for setup activity for filling machine area is 34 minutes. Table 4.4 and table 4.5 shows the whole activity which include and internal activities in the correct order. Checking metal detector activities require two minutes in total. Cleaning environment also needs seven minutes to finish the activities, while the cleaning machine also needs seven minutes to finish the entire cleaning machine. The activities of input data SAM/ SAP take eight minutes in total. There are two sample test in set-up activities, which are bubble test and carbon test. Each test needs two minutes to complete the sample test. Cut open rework can be done in three minutes, while fill the Shift Hand-Over (SHO) board requires three minutes to finish the activities.

4.2.2.2 Separated Internal and External Activities

Setup activity that already stated in table 4.4 and table 4.5 only shows the whole activities in detail and correct order. Then, those activities need to separate into two activities category, which are internal and external activities. The internal activities that need to be done when the machine stops and cannot be convert into external activities will be mark with red color, while the rest can be convert into external activities. Table 4.6 and 4.7 shows the set-up activities that already separated.

Table 4.6 Internal and External Activities of Set-up Activities in Filling Machine Area

NO	Activity	Time (minute)		Explanation
		Internal	External	
A	**Checking Metal Detector**			
1	Record Counter Metal Detector	1		metal detector test in metal detector equipment
2	Verified positive sample metal detector	1		verified the result of metal detector
B	**Cleaning Environment**			
3	Take Cleaning Tools	2		take red cleaning tools to clean the environment of machine
4	Cleaning floor below the machine	3		cleaning the machine environment
5	Tidy Up Cleaning Tools	2		re-store red cleaning tools to the previous place
C	**Cleaning Machine**			

6	Take Cleaning Tools	2		take blue cleaning tools
7	Cleaning Horizontal Seal Bar	1		clean horizontal and vertical seal bar
8	Cleaning Vertical Seal Bar			
9	Cleaning Colar	1		clean colar, knife jaw, cover acrylic
10	Cleaning Knife Jaw			
11	Cleaning Cover Acrylic			
12	Cleaning Conveyor Plat	1		clean conveyor plat and belt
13	Cleaning Conveyor Belt			
14	Tidy Up Cleaning Tools	2		re-store blue cleaning tools

Table 4.7 Internal and External Activities of Set-up Activities in Filling Machine Area (Continued)

NO	Activity	Time (minute)		Explanation
		Internal	External	
D	**Input Data SAM**			
15	Pre-input data SAM	2.5		pre-input SAM/SAP data
16	Collect sheet report	0.5		collect sheet report for SAM/SAP data
17	Input to computer	5		input whole SAM/SAP data
E	**Take Sample for Bubble Test**			
18	Take Sample for Bubble Test	1		take the product of filling machine to bubble sample test equipment
19	Waiting sampling result	1		wait the result of bubble test and record the result
20	Report sampling			
F	**Take Sample for Carbon Test**			
21	Take Sample for Carbon Test	1		take the product of filling machine to carbon sample test equipment
22	Waiting sampling result	1		wait the result of carbon test and record the result
23	Report sampling			
G	**Cut Open Rework**			
24	Cut Open Rework	3		re-open the defect product manually to be transferred to rework department
H	**SHO Update**			
25	SHO Update		3	fill the shift hand-over board that happen in current shift after set-up activities end
TOTAL		**31**	**3**	

The internal and external activities must be separate based on the real activities that operator done during the line preparation or setup time. Based on table 4.6 and table 4.7, there are eight main activities those are checking metal detector, cleaning environment, cleaning machine, input data SAM, take sample for bubble test, take sample for carbon test, check nitrogen, and cut open rework. There is one external activity which is SHO update. The operator performs the eight internal activities during the machine stops, while the external activities during the machine run. Internal activities time required in setup activities are 31 minutes in total, while the external activities requires three minutes in total. The internal activities that cannot be removed or replaced are to record counter of metal detector to check metal detector, cleaning horizontal and vertical seal bar, cleaning colar and knife jaw, cleaning cover acrylic, cleaning conveyor plat and belt, and take sample for bubble test and carbon test. The rest activities still can be removed or replace to external activities.

4.2.2.3 Convert Internal to External Activities

The internal and external activities that are mention in table 4.6 and 4.7 are a real implementation by the operator during the setup activities. Based on the previous analysis, there are internal activities that cannot be convert to external activities which mark with red mark. The rest internal activities that are not mark with red can be convert to external activities. The reason of internal activities that convert to external activities are shown in table 4.8 and table 4.9 below.

Table 4.8 Converting Internal Activities into External Activities

NO	Activity	Internal	External
B	**Cleaning Environment**		
3	Take Cleaning Tools	take red cleaning tools to clean the environment of machine	take red cleaning tools to clean machine environment after set-up activities end
4	Cleaning floor below the machine	cleaning the machine environment	cleaning the machine environment set-up activities end
5	Tidy Up Cleaning Tools	re-store red cleaning tools to the previous place	re-store red cleaning tools to the previous place set-up activities end
D	**Input Data SAM**		
15	Pre-input data SAM	pre-input SAM/SAP data	pre-input SAM/SAP data after set-up activities end
16	Collect sheet report	collect sheet report for SAM/SAP data	collect sheet report for SAM/SAP data after set-up activities end
17	Input to computer	input whole SAM/SAP data	input whole SAM/SAP data after set-up activities end

G	**Cut Open Rework**		
24	Cut Open Rework	re-open the defect product manually to be transferred to rework department	re-open the defect product manually after set-up activities end
H	**SHO Update**		
25	SHO Update	fill the shift hand-over board that happen in current shift	fill the shift hand-over board that happen in current shift after set-up activities end

Based on table 4.8, there are four internal activities that can be convert to external activities are cleaning environment, input data SAM, cut open rework, and fill up shift hand-over board. The replacement of internal activities to external activities may be caused by:

- Cleaning environment is the activities to clean the surrounding area of filling machine. The operator clean only the environment of the machine, not the machine, the operator may clean the floor below the machine, and other place that are dirty. Cleaning environment can be done when the machine runs since it does not affect the machine, but only the surrounding. Then, the cleaning environment activities can be replace into external activities.
- Input data SAM/SAP is another activities that can be done when machine is running. The operator input the data SAM or SAP without interrupting the machine, because the operator input the data SAM or SAP to the computer that are different part with the machine. The operator only need to gather the SAM/SAP data from the machine without interrupting the machine operation and input those data to the computer. Then, the input SAM/SAP data activities will be replace into external activities.
- This activity is done when there are defect or rework output or product from the filling machine. If there are any defect or rework, it must be cut open manually in the cut open rework place. All the defect or rework will be all gather and will be transferred to rework department to be rework again.
- The activity of fill up the shift hand-over board is the last set-up activity. Shift Hand Over board contain several chart that shows the condition of filling machine. The operator must fill up this shift hand-over board to shows

the condition of filling machine during the current set-up activities. Then, the next shift of operator will know the condition of the machine before start the machine in the next shift.

The rest internal activities are remain the same in the internal activities. The remaining internal activities are checking metal detector, cleaning machine, and sample test for bubble test and carbon test.

4.2.2.4 Current Internal and External Activities in Filling Machine Area

The time of set-up activities will be differentiate into internal and external activities. Table 4.9 and table 4.10 will shows the total internal time and external time for whole set-up activities. There are four internal activities and four external activities. Internal activities are differentiate into checking metal detector, cleaning machine, bubble sampling test and carbon sampling test. External activities are differentiate into cleaning environment, input data SAM/SAP, cut open rework, and fill up shift hand-over board.

Table 4.9 Current Internal Activities for Set-up Activities in Filling Machine Area

NO	Activity	Time (minute)	Explanation
A	**Checking Metal Detector**		
1	Record Counter Metal Detector	1	metal detector test in metal detector equipment
2	Verified positive sample metal detector	1	verified the result of metal detector
C	**Cleaning Machine**		
6	Take Cleaning Tools	2	take blue cleaning tools to clean the machine
7	Cleaning Horizontal Seal Bar	1	clean horizontal and vertical seal bar
8	Cleaning Vertical Seal Bar		
9	Cleaning Colar	1	clean colar, knife jaw, cover acrylic
10	Cleaning Knife Jaw		
11	Cleaning Cover Acrylic		
12	Cleaning Conveyor Plat	1	clean conveyor plat and belt
13	Cleaning Conveyor Belt		
14	Tidy Up Cleaning Tools	2	re-store blue cleaning tools to previous place
E	**Take Sample for Bubble Test**		

18	Take Sample for Bubble Test	1	take the product of filling machine to bubble sample test equipment
19	Waiting sampling result	1	wait the result of bubble test and record the result
20	Report sampling		
F	**Take Sample for Carbon Test**		
21	Take Sample for Carbon Test	1	take the product of filling machine to carbon sample test equipment
22	Waiting sampling result	1	wait the result of carbon test and record the result
23	Report sampling		
TOTAL		**13**	

Based on table 4.9, the total internal time in set-up activities are 13 minutes. Checking metal detector require two minutes to complete the activities, while cleaning machine require seven minutes, bubble and carbon sampling test require two minutes for each sampling test to complete the action. Based on table 4.9, there are several internal activities that are not mark with red color which means actually it can be convert to external activities, but it's not convert to external activities. Those activities are not convert to external activities because it is related to the internal activities.

- Verified positive sample metal detector in checking metal detector activities are not convert to external activities because the machine must be verified first to know whether the metal detector function normally in the filling machine. If the verification activities are happen in external activities when the machine runs, the operator already start the machine without knowing the result of metal detector condition.
- Take cleaning tools for cleaning the machine also not convert to external activities, but it cannot be convert to external activities. The reason is because the operator cannot conduct the cleaning machine activities if the operator do not take the cleaning tools beforehand. Imagine that the activities of take the cleaning tools for cleaning machine are happen in external activities. Then, the cleaning machine are happen in external activities when the machine stops. It is also happen to tidy up the cleaning tools for cleaning machine. Tidy up the cleaning tools are related with cleaning machine, which means

every activities that related to cleaning machine cannot be separated to the external activities.

- Waiting sample test for bubble and carbon test are the same activities but only different in the type of sample test. As has been mention before, bubble test are used to test the condition of filling output or product. The output or product must not leaking. If the output or product is leaking, the set-up activities cannot be started. The waiting activities cannot be done in external activities when the machine runs because the result of sample test are needed to be verified first before the machine runs.
- Similar with bubble test, carbon test is done to test the condition of filling output or product sealing. Then, if the sealing is not proper the operator cannot start the machine. The result of bubble and carbon sample test are used to know the condition of the filling output or product. All the activities are done to reduce the number of defects or rework for the filling output or product.

Previous table are explaining the internal activities, while table 4.10 will explain the external activities. Based on previous discussion already stated the reason of converting internal activities to external activities. Table 4.10 will shows the time needed to conduct each external activities.

Table 4.10 Current External Activities for Set-up Activities in Filling Machine Area

NO	Activity	Time (minute)	Explanation
B	**Cleaning Environment**		
3	Take Cleaning Tools	2	take red cleaning tools to clean the environment of machine
4	Cleaning floor below the machine	3	cleaning the machine environment
5	Tidy Up Cleaning Tools	2	re-store red cleaning tools to the previous place
D	**Input Data SAM**		
15	Pre-input data SAM	2.5	pre-input SAM/SAP data
16	Collect sheet report	0.5	collect sheet report for SAM/SAP data
17	Input to computer	5	input whole SAM/SAP data
G	**Cut Open Rework**		

24	Cut Open Rework	3	re-open the defect product manually to be transferred to rework department
H	**SHO Update**		
25	SHO Update	3	fill the shift hand-over board that happen in current shift after set-up activities end
TOTAL		**21**	

Based on table 4.10 cleaning environment require seven minutes, input data SAM/SAP require eight minutes, cut open rework and SHO update require three minutes for each to complete each activities. Then, the total time needed to conduct the external activities in set-up activities of filling machine are 21 minutes.

4.2.2.5 Streamline the Remaining Internal Activities

After the previous step of SMED method, the result of analysis is the internal activities time become 14 minutes. The internal activities need to be streamline again to achieve the goal of single minutes which means ten minutes or less than ten minutes. The streamline method for the rest of internal activities is by using 5S method.

4.2.3 5S Implementation for Set-up Activities in Filling Machine

After conducting the analysis using Single Minute Exchange of Dies (SMED) method, 5S method will be implemented to reduce more the internal activities time. Then, the set-up time also will be reduce when the internal activities time is reduced. There are five steps of 5S that will be done in this chapter, which are SEIRI (Sorting), SEITON (Setting), SEISO (Shining), SEIKETSU (Standardizing), and SHITSUKE (Sustaining).

4.2.3.1 SEIRI (Sorting)

Based on the layout stated in previous discussion, the filling machine area consist of several items, those are SAM/ SAP table, red and blue cleaning tools, Shift Hand-Over Board, Metal Detector, Sampling test, Tip Table, and Cut Open Rework. SAM/ SAP table is used to input the data into SAM/SAP. On the SAM/SAP table, there are a computer that will be used to input the SAM/SAP data. Blue and red cleaning tools are two different cleaning tools with two different uses. The blue cleaning tools will be used for cleaning the internal parts of the machine, while red cleaning tools will be used for cleaning the environment of the machine. The blue cleaning tools consist of small size of brush with different shape to cleaning the internal parts. The red cleaning tools consist of the bigger size of brush or also can be called as a broom. The cleaning tools are hang on the iron stools.

Shift Hand-Over (SHO) board are contain several chart that must be filled by the operator. The chart will represent everything that happen during the current shift. Then, the operator on the next shift will know the situation that have been happen before. Metal detector is the tools to use to check the metal in the machine. Sampling test is located on the table, which contain a sampling device for testing the sample of bubble and nitrogen. Tip table contains the telephone, several paper and stationary, and etc. Cut open rework is the place to open the rework product that produce on the previous shift. The product are already inside the sachet, the operator need to open the rework product manually and stored to rework department. Then, sorting the item in filling machine layout can be shown in figure 4.7.

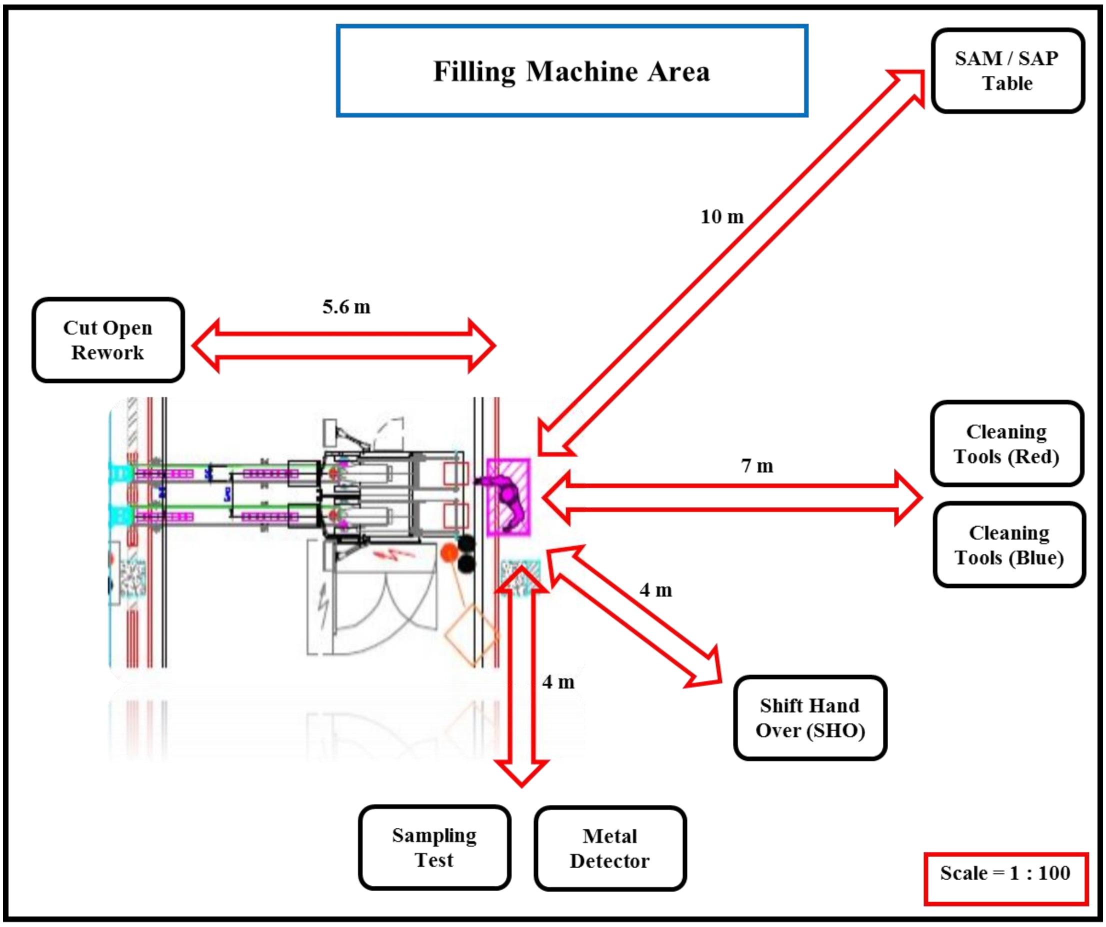


Figure 4 7 Removing Unnecessary Item

Based on the spaghetti diagram, all the set-up activities done in filling machine are used the items that have been mentioned in the previous paragraph. But, there is one items that not used by the operator, which is the tip table. The tip table can be removed or combine with other table to reduce the movement of the operator in performing the set-up activities in filling machine area. Based on figure 4.7, the tip table is removed from the filling machine layout.

4.2.3.2 SEITON (Setting)

Based on previous data of spaghetti diagram, there are several movement of operator in performing set-up activities that are too far away. The operator needs to take a lot of time to reach the destination. The most visible place that have the most far distance are SAM/ SAP table with ten meters away from the machine and cleaning tools red and blue with seven meters far away from the machine. Based on figure 4.8, two items have been replaced to another place that are close by the machine.

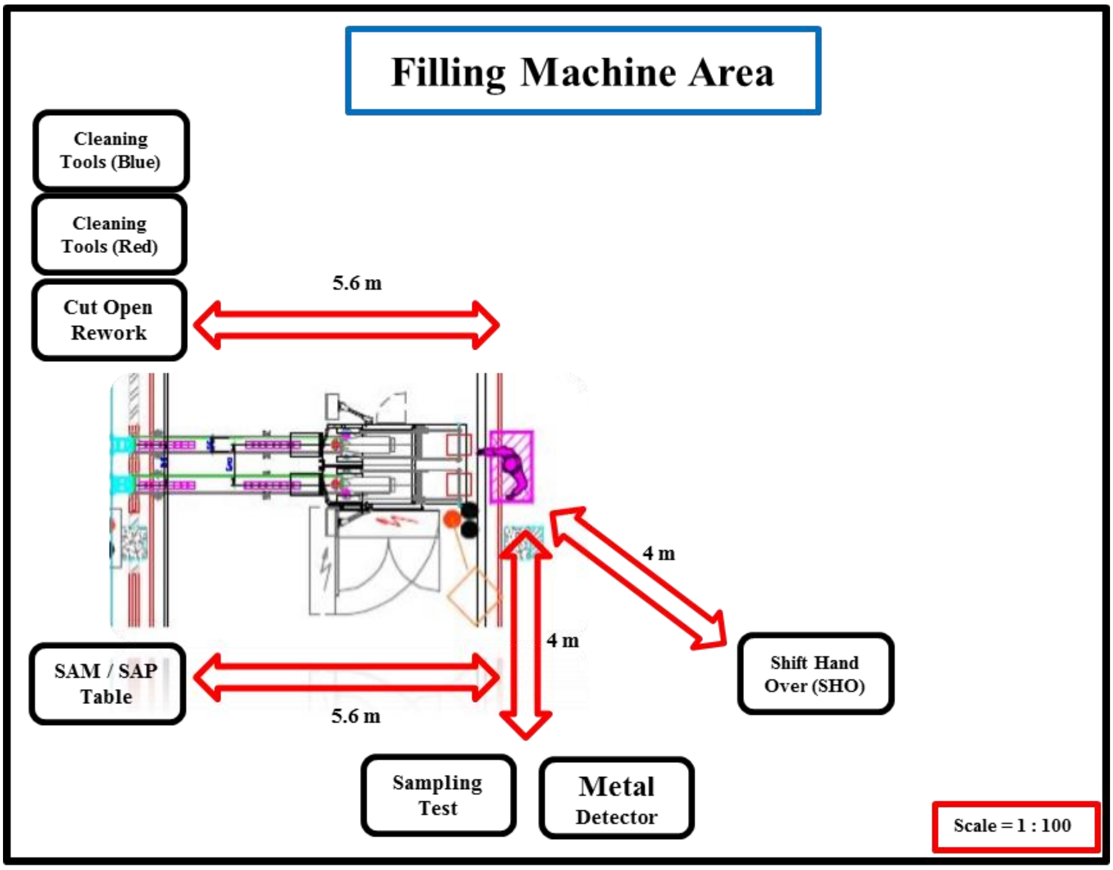


Figure 4.8 New Design Layout

Figure 4.8 shown that SAM/ SAP table replaced or combined with the tip table that located 5.6 meters from the machine and on the left side of the filling machine. The computer for input the data SAM/SAP will be replace into tip table. The red and blue cleaning tools also replace to near cut open rework place which located also 5.6 meters from the machine, but on the right side of the machine. The rest items are not replaced and stay in the original place.

4.2.3.3 SEISO (Shining)

The layout of filling machine area has been improved with several change. Then, the filling machine are need to be clean, which means the items that are located in filling machine must be clean. The items including the SAM/SAP table, red and cleaning tolls, Shift Hand-Over (SHO) board, metal detector, sampling test, tip table, and cut open rework. The cleaning is done during the planned maintenance time when the machine is not run. All of the operator will help the cleaning activities in filling machine area. The cleaning time is done in beginning of May 2016.

4.3 Single Minute Exchange of Dies (SMED) and 5S Method Implementation

The method that used in this research are Single Minutes Exchange of Dies (SMED) and 5S method. The time for set-up activities are different before and after SMED and 5S method implementation. Before SMED method implementation is the data from April 2016, while result of SMED analysis are implemented on May 2016, the result of 5S analysis are implemented on June 2016. The data of set-up time are from April until June 2016.

4.3.1 New Improvement Result of Set-up Activities

After Single Minute Exchange of Dies (SMED) and 5S implementation, the internal and external time are decreased. Table 4.11 and 4.12 shows the differences before and after SMED and 5S implementation for whole set-up activities. The table will differentiate between before and after for internal activities, and before and after for external activities. The method stated in table 4.11 and table 4.12 are method that make the change between set-up activities before and after.

Table 4.11 New Improvement Result of Set-up Activities

NO	Activity	Time (minute)				Tools / Method
		Internal		External		
		Before	After	Before	After	
A	**Checking Metal Detector**					
1	Record Counter Metal Detector	1	1			SMED
2	Verified positive sample metal detector	1	1			
B	**Cleaning Environment**					
3	Take Cleaning Tools			2	0.5	SMED & 5S
4	Cleaning floor below the machine			3	3	
5	Tidy Up Cleaning Tools			2	0.5	

Table 4.12 New Improvement Result of Set-up Activities (Continued)

NO	Activity	Time (minute)				Tools / Method
		Internal		External		
		Before	After	Before	After	
C	**Cleaning Machine**					
6	Take Cleaning Tools	2	0.5			SMED & 5S
7	Cleaning Horizontal Seal Bar	1	1			
8	Cleaning Vertical Seal Bar					
9	Cleaning Colar	1	1			
10	Cleaning Knife Jaw					
11	Cleaning Cover Acrylic					
12	Cleaning Conveyor Plat	1	1			
13	Cleaning Conveyor Belt					
14	Tidy Up Cleaning Tools	2	0.5			
D	**Input Data SAM**					
15	Pre-input data SAM			2.5	1.5	SMED & 5S
16	Collect sheet report			0.5	0.5	
17	Input to computer			5	5	
E	**Take Sample for Bubble Test**					
18	Take Sample for Bubble Test	1	1			SMED
19	Waiting sampling result	1	1			
20	Report sampling					
F	**Take Sample for Carbon Test**					
21	Take Sample for Carbon Test	1	1			SMED
22	Waiting sampling result	1	1			
23	Report sampling					
G	**Cut Open Rework**					
7	Cut Open Rework			3	3	SMED
H	**SHO Update**					
8	SHO Update			3	3	SMED
TOTAL		**13**	**10**	**21**	**17**	

Based on table 4.11 and table 4.12 there are several time of activities that reduced. The reduction happen because of the 5S method implementation that discussed before. The 5S implementation change the layout of filling machine area. The replacement of SAM/SAP table to the tip table which is from ten meters to only 5.6 meters away from the machine. The red and blue cleaning tools are also replace from seven meter away to 5.6 meter away which located near the cut open rework places. Then, the result of several replacement cause the reduction time for the related activities. The activity of taking and tidy up the cleaning tools are reduce from 2 minutes into 0.5 minutes, while the activity of pre-input data SAM/SAP are reduce from 2.5 into 1.5 because the distance for input the SAM/SAP data are reduce from ten meters into 5.6 meters. The computer to input SAM/SAP data are replace to the tip table location.

The time for internal activities before and after SMED and 5S method implementation are reduced three minutes from 13 minutes into 10 minutes. The time for external activities are reduced five minutes, from 21 minutes into 17 minutes. Based on table 4.14 and table 4.15, current internal and external time for set-up activities are ten minutes and 17 minutes. But, the total set-up time can be taken from internal activities, which means the total set-up time for current set-up activities is only ten minutes.

4.3.2 Before Single Minute Exchange of Dies (SMED) Method Implementation

Single Minute Exchange of Dies (SMED) result has been implemented start in May 2016. Before May 2016, the set-up time is still the same with the original set-up activities. As has been mention before, the total time needed for set-up activities is 40 minutes. The data set-up time in filling machine during April 2016 are shown in table 4.13 and 4.14. The data is originally taken from PT. MNO and also individual observation to set-up activities in filling machine are started in 1 April 2016 until 31 April 2016 There are seven days of maintenance that has been planned by the company for one month in April 2016.

Table 4.13 Set-up time before Single Minute Exchange of Dies (SMED) Implementation

April		Time (minute)
Friday	1-Apr-16	35
Saturday	2-Apr-16	-
Sunday	3-Apr-16	-
Monday	4-Apr-16	30
Tuesday	5-Apr-16	25
Wednesday	6-Apr-16	40

Thursday	7-Apr-16	34
Friday	8-Apr-16	39
Saturday	9-Apr-16	-

Table 4.14 Set-up time before Single Minute Exchange of Dies (SMED) Implementation (Continued)

April		Time (minute)
Sunday	10-Apr-16	-
Monday	11-Apr-16	40
Tuesday	12-Apr-16	34
Wednesday	13-Apr-16	27
Thursday	14-Apr-16	32
Friday	15-Apr-16	35
Saturday	16-Apr-16	34
Sunday	17-Apr-16	-
Monday	18-Apr-16	38
Tuesday	19-Apr-16	38
Wednesday	20-Apr-16	30
Thursday	21-Apr-16	40
Friday	22-Apr-16	30
Saturday	23-Apr-16	-
Sunday	24-Apr-16	-
Monday	25-Apr-16	37
Tuesday	26-Apr-16	30
Wednesday	27-Apr-16	33
Thursday	28-Apr-16	36
Friday	29-Apr-16	40
Saturday	30-Apr-16	35
TOTAL		**792**
Average		**34**

Based on table 4.13 and table 4.14, there are seven days that shows the set-up time is equal to zero, which means that the machine is not running on entire day in seven days for planned maintenance. The planned maintenance happen in 2 - 3 April 2016, 9 - 10 April 2016, 17 April 2016, and 23 - 24 April 2016. The total time needed for set-up time in filling machine is 792 minutes, while the average set-up time for the entire month of April 2016 is 34 minutes.

4.3.3 After Single Minute Exchange of Dies (SMED) Method Implementation

Single Minute Exchange of Dies (SMED) result has been implemented in May 2016 after the analysis that has been done in this research. The data of set-up time after SMED implementation is shown in table 4.15 below. The data is original and taken from PT. MNO and individual observation to set-up activities in filling machine area. Planned maintenance that scheduled by the company is 11 days in total of May 2016. Then, there are 20 days for calculate the average set-up time in May 2016 from filling machine.

Table 4.15 Set-up time after Single Minute Exchange of Dies (SMED) Implementation

May		Time (minute)
Sunday	1-May-16	-
Monday	2-May-16	-
Tuesday	3-May-16	-
Wednesday	4-May-16	-
Thursday	5-May-16	-
Friday	6-May-16	-
Saturday	7-May-16	-
Sunday	8-May-16	-
Monday	9-May-16	15
Tuesday	10-May-16	12
Wednesday	11-May-16	13
Thursday	12-May-16	15
Friday	13-May-16	13
Saturday	14-May-16	15
Sunday	15-May-16	-
Monday	16-May-16	13
Tuesday	17-May-16	15
Wednesday	18-May-16	16
Thursday	19-May-16	10
Friday	20-May-16	10
Saturday	21-May-16	15
Sunday	22-May-16	-
Monday	23-May-16	10
Tuesday	24-May-16	10
Wednesday	25-May-16	15
Thursday	26-May-16	8
Friday	27-May-16	15

Saturday	28-May-16	15
Sunday	29-May-16	-
Monday	30-May-16	11
Tuesday	31-May-16	10
TOTAL		**256**
Average		**13**

As has been mention before, planned maintenance has been scheduled in 11 days which are 1 – 8 May 2016, 15 May 2016, 22 May 2016, and 29 May 2016. The analysis that already done in this research, the set-up time is reduces from 40 minutes into 13 minutes. The reduction of set-up time is 27 minutes in total. The total set-up time requires for the month of May 2016 is 256 minutes, while the average set-up time is 13 minutes.

4.3.4 After Single Minute Exchange of Dies (SMED) and 5S Method Implementation

Internal activities are streamline again by using 5S implementation since the set-up time is still 13 minutes, not ten or less than ten minutes. 5S implementation is started in the beginning of June 2016. Then, the data of set-up time after SMED and 5S result implementation are shown in table 4.20 and table 4.21 below. Similar with previous month, the company also already schedule planned maintenance for filling machine for 13 days in a month of June 2016 which means there are only 17 days of filling operation in June 2016 that can be used to calculated the average set-up time after SMED and 5S implementation.

Table 4.16 Set-up time after Single Minute Exchange of Dies (SMED) and 5S Implementation

June		Time (minute)
Wednesday	1-Jun-16	15
Thursday	2-Jun-16	11
Friday	3-Jun-16	14
Saturday	4-Jun-16	-
Sunday	5-Jun-16	-
Monday	6-Jun-16	-
Tuesday	7-Jun-16	11
Wednesday	8-Jun-16	12
Thursday	9-Jun-16	10

Friday	10-Jun-16	6
Saturday	11-Jun-16	-
Sunday	12-Jun-16	-
Monday	13-Jun-16	10
Tuesday	14-Jun-16	10
Wednesday	15-Jun-16	10

Table 4.17 Set-up time after Single Minute Exchange of Dies (SMED) and 5S Implementation (Continued)

June		Time (minute)
Thursday	16-Jun-16	10
Friday	17-Jun-16	9
Saturday	18-Jun-16	-
Sunday	19-Jun-16	-
Monday	20-Jun-16	10
Tuesday	21-Jun-16	8
Wednesday	22-Jun-16	10
Thursday	23-Jun-16	9
Friday	24-Jun-16	10
Saturday	25-Jun-16	-
Sunday	26-Jun-16	-
Monday	27-Jun-16	-
Tuesday	28-Jun-16	-
Wednesday	29-Jun-16	-
Thursday	30-Jun-16	-
TOTAL		**175**
Average		**10**

The planned maintenance happened in 4 – 6 June 2016, 11 – 12 June 2016, 18 – 19 June 2016, and 25 – 30 June 2016, the total of 13 days in a month. Then, the total time shown in table 4.19 and table 4.20 is 175 minutes, while the average time is 10 minutes.

4.3.5 Set-up time April until June 2016

All of the data for set-up time from April until June 2016 in filling machine are shown on figure 4.9. Based on previous discussion the average set-up time on April 2016 is 34 minutes, while on May 2016 the average set-up time is 13 minutes, on June 2016, the average set-up time is ten minutes. The data on figure 4.9 are shows in minute.

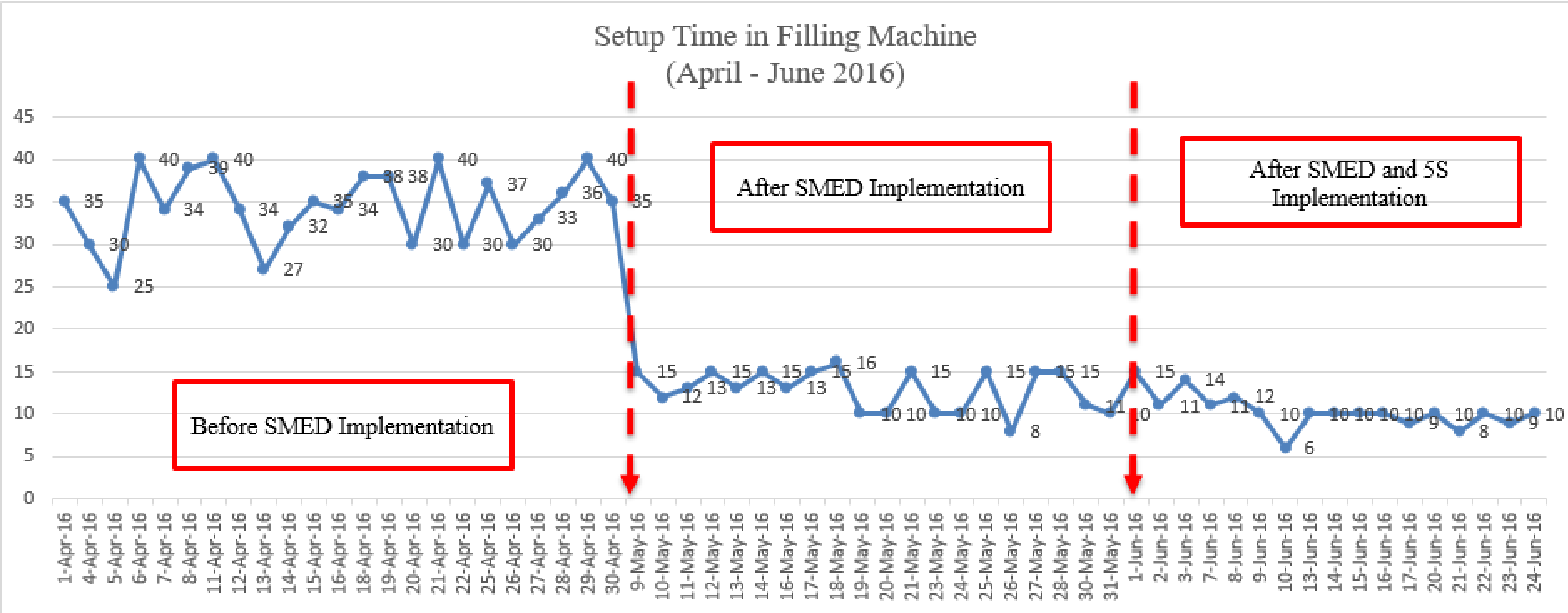


Figure 4 9 Set-up time April – June 2016

There are three different part that seen in figure 4.9. The first part is before SMED method implementation. The time of set-up activities are quite high which all above 35 minutes and below 45 minutes. But, the average of the set-up time on April 2016 is 34 minutes. Then, after SMED implementation, the set-up time shown in figure 4.8 are decreasing drastically into below 16 minutes and higher than eight minutes. The average time on May 2016 in filling machine is 13 minutes. Last part is on June 2016 where 5S result analysis are implemented, the set-up time decreasing a little bit with the range of set-up time from six minutes until 15 minutes, and the average of set-up time in June 2016 is ten minutes.

4.4 Summary of the Implementation Overall Equipment Effectiveness (OEE) after Single Minute Exchange of Dies (SMED) and 5S Implementation

Overall Equipment Effectiveness (OEE) used to shows the difference of the effectiveness of machine before and after new improvement by using SMED and 5S implementation. OEE rate include the line preparation or set-up time into the calculation. This means that, the effectiveness of the machine are related with set-up time. In this research, the beginning set-up time is 34 minutes. But, after SMED implementation, the set-up time decrease to 13 minutes. Then, 5S method also implemented in this research. The set-up is decrease more become only ten minutes in total. The decreasing of set-up time will create a difference between OEE before and after SMED and 5S implementation.

4.4.1 Overall Equipment Effectiveness (OEE) after Single Minutes Exchange of Dies (SMED) and 5S implementation

5S method implementation is done after SMED method implementation in May 2016. Then, 5S method starts to be implemented in June 2016. The data are taken originally from PT. MNO in June 2016, which include the same unplanned and planned stoppages happen in filling machine in previous month.

Figure 4.10 shows the result of calculation for down time loss, performance loss, loading time, operating time and net operating time, while figure 4.11 shows the calculation for Overall Equipment Effectiveness (OEE) rate which include availability, performance, quality, and also OEE rate. All the result shown in figure 4.10 and 4.11 are calculated in minute.

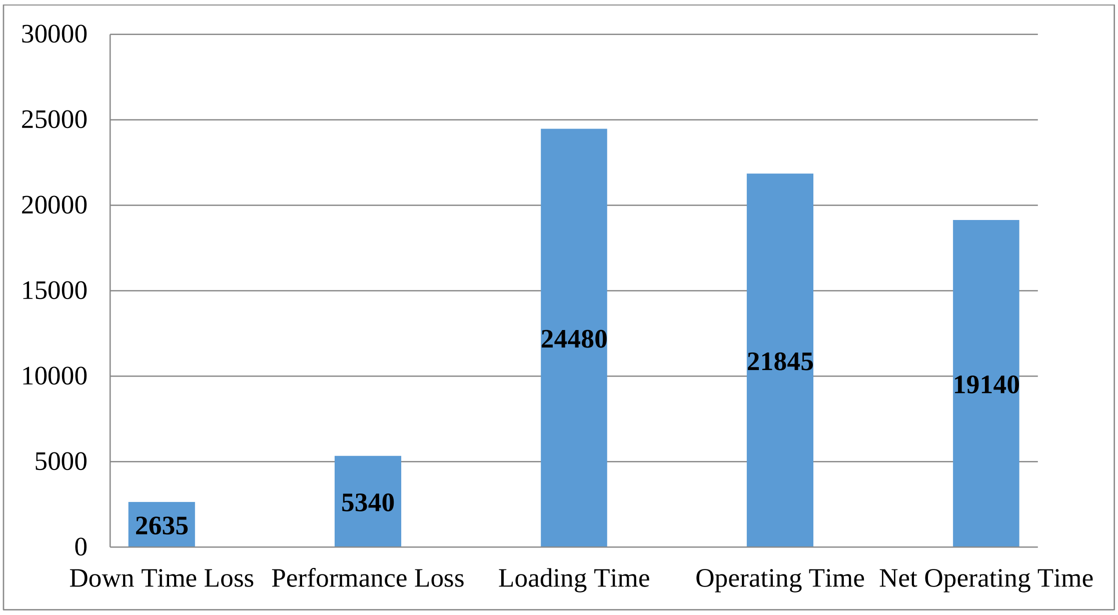


Figure 4.10 Overall Equipment Effectiveness (June 2016)

Based on figure 4.10, there are five calculation that shown, those are downtime loss, performance loss, loading time, operating time, and net operating time. Downtime loss is taken from the sum of changeover time, line preparation or set-up time, and breakdown time happen in filling machine on June 2016. The result of downtime loss happen in June 2016 is 2635 minutes. Performance loss are the sum of minor stoppages occur in filling machine during a month of June 2016. The result of performance loss is 5340 minutes. For the result of loading time is 24480 minutes, which can be calculated from the total time of machine can runs in one month of June 2016 minus the planned maintenance that have been scheduled by PT. MNO. Based on previous data, the planned maintenance in June 2016 is 13 days in total. Then, there are only 17 days the filling machine can runs in June 2016. Operating time can be calculated by subtracting loading time with downtime loss. The result of operating time of filling machine in June 2016 is 21845 minutes. Besides that, net operating time can be calculated by subtracting loading time with performance loss. The result of net operating time is 19140 in June 2016.

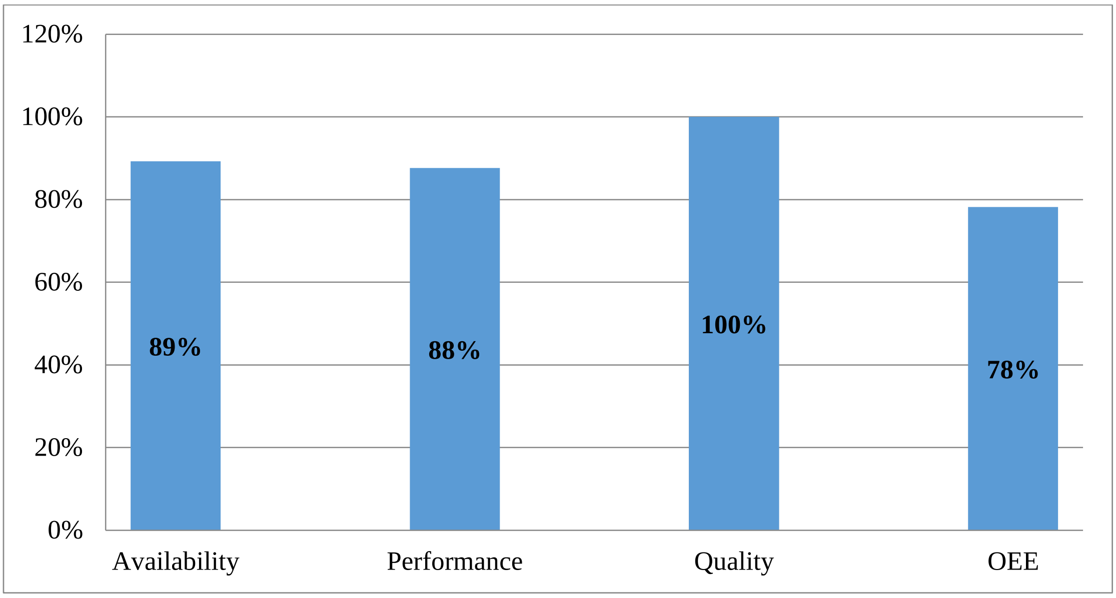


Figure 4.11 Overall Equipment Effectiveness (June 2016)

There are four result of calculation that shown in figure 4.11, those are availability, performance, quality and OEE rate. The calculation is the same with previous discussion of OEE calculation shown in equation 2.1, but the difference is in the result.

$$Availability\ Rate = \frac{Operating\ Time}{Loading\ Time} = \frac{21845}{24480} x\ 100\% = 89.23\% \approx 89\%$$

The result of availability rate is 89% in June 2016. The calculation can be done by dividing operating time with loading time. The calculation for performance rate also shown in equation 2.2, which is done by dividing net operating time with operating time and the result of performance rate is 88%. Then, there are 100 defect products occur in June 2016 while the demand still the same which is 39000 products, and the result of quality rate of filling machine in June 2016 is 100% which calculated by subtracting processed amount with defect amount, and the result will be divided with processed amount and shown clearly in equation 2.3. The last calculation is OEE rate which done by multiply availability, performance, and quality, and the result is 78%. All the calculation are stated clearly in the last chapter of appendices.

4.4.2 Overall Equipment Effectiveness (OEE) from April until June 2016

As we all know, every month since April 2016 until June 2016, the number of unplanned stoppages and the planned stoppages are different. Then, the result for OEE rate for each month also must be different. All the result of Overall Equipment Effectiveness (OEE) from April until June 2016 are summarized into one Pareto Chart that shown in figure 4.12. The data is taken from the manual calculation about Overall Equipment Effectiveness (OEE) before and after SMED and 5S implementation.

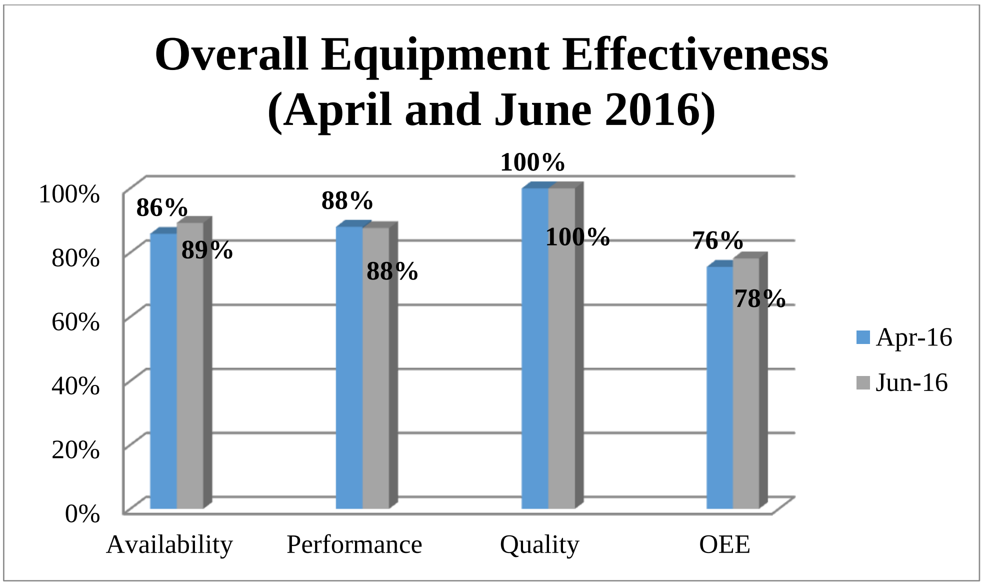


Figure 4.12 Overall Equipment Effectiveness (April and June 2016)

The first rate is availability rate which calculate the operating time divided with loading time. The calculation of availability rate is include the line preparation or set-up time. The set-up time before SMED method implementation is 34 minutes, while after SMED implementation the set-up time becomes 13 minutes. Then, after 5S implementation, the set-up time is decrease more become 10 minutes. The availability rate is calculated based on the operating time divided with loading time. The operating time is decreasing every month since April and June 2016, because the set-up time is also decreasing. The availability rates from April and June 2016 are 86% and 89%. The performance rate shows different result in filling machine. The performance rate calculations are using the minor stoppages data from in April and June 2016. The minor stoppages happen in filling machine are caused by the machine itself. When the minor stoppages are high, the performance rate will be small, because the calculation of performance rate is based on the performance loss. The performance rate from May and June 2016 are 88% and 88%. The quality rate for the entire month from May and June 2016 is 100%. Then, the OEE rate are 76% and 78% from May until June 2016.

4.5 SEIKETSU (Standardizing)

After all the set-up activities already improve by SMED and 5S implementation. The company need to create new standards or update the old standard of set-up activities in filling machine. All the operator need to follow the standard to perform the set-up activities in filling machine. The new working instruction (WI) are shown on table 4.18 and table 4.19 below.

Table 4.18 New Working Instruction (WI)

NO	Activity	Time (minute)	
Activities done when the machine stops			
1	Checking Metal Detector		
	Record Counter Metal Detector	1	
	Verified positive sample metal detector	1	
			2
2	Cleaning Machine		
	Take Cleaning Tools	0.5	
	Cleaning Horizontal Seal Bar	1	
	Cleaning Vertical Seal Bar		
	Cleaning Colar	1	
	Cleaning Knife Jaw		
	Cleaning Cover Acrylic		
	Cleaning Conveyor Plat	1	
	Cleaning Conveyor Belt		
	Tidy Up Cleaning Tools	0.5	
			4
3	Take Sample for Bubble Test		
	Take Sample for Bubble Test	1	
	Waiting sampling result	1	
	Report sampling		
			2
4	Take Sample for Carbon Test		
	Take Sample for Carbon Test	1	
	Waiting sampling result	1	
	Report sampling		

		2
TOTAL		**10**

Table 4.19 New Working Instruction (WI) (Continued)

NO	Activity	Time (minute)	
Activities done when the machine runs			
1	Cleaning Environment		
	Take Cleaning Tools	0.5	
	Cleaning floor below the machine	3	
	Tidy Up Cleaning Tools	0.5	
			4
2	Input Data SAM		
	Pre-input data SAM	1.5	
	Collect sheet report	0.5	
	Input to computer	5	
			6
3	Cut Open Rework	3	
			3
4	SHO Update	3	
			3
TOTAL			**17**

Based on table 4.18 and 4.19, the new standard which is working instruction (WI) are different with previous standard. The activities must be done during the machine stops are the internal activities, which include the checking metal detector, cleaning machine, bubble sample test, and carbon sample test. The activities done when the machine running are the external activities, which include the cleaning environment, input data SAM/SAP, cut open rework, and fill up shift hand-over board.

There are four activities done by the operator when the machine runs. The activities would not interrupted the machine since the activities are happen in the surrounding area of the machine. The time for current set-up activities also different with previous set-up activities before SMED and 5S implementation since the 5S improvement change the location of several items in filling machine layout. The items are place near the machine to facilitate the movement of the operator in performing set-up activities of filling machine.

4.6 SHITSUKE (Sustaining)

After making the standard, the company need to make sure that all the operator still following the standard. The operator might be used to the old standard and does not used to the new standard of set-up activities. The company need to make a training of new set-up activities for the operator. Then, the operator need to try to implement the new standard during the real set-up activities. The trainer must guide the operator when performing the new set-up activities at the first time.

4.7 Summary of the Result

In this research, there are several improvement happen which are the reduction of setup activities. The actual set-up activities before the improvement of Single Minute Exchange of Dies (SMED) are eight activities in total with 34 minutes to finish the set-up activities. After Single Minute Exchange of Dies (SMED) improvement, four internal activities are converted to external activities and the rest remaining activities become the internal activities. Then, the total time needed to perform the remaining internal activities are 13 minutes.

5S implementation will help to improve the filling machine area, which means removing or replacing the unneeded items. The other improvement might be replace the location of the needed items to the appropriate location to help the operator in performing more effective movement in set-up activities. The unneeded items that are not useful for set-up activities are tip table.

The next improvement is to replace the location of SAM/SAP table to nearest place to the filling machine, and also replacing the location of cleaning tools (red and blue). The SAM/SAP table are replace from 10 meters away from the machine to only 5.6 meters, while the red and blue cleaning tools are reduce from 7 meters to 5.6 meters away from the filling machine.

The table 4.20 and 4.21 shows the result of Single Minute Exchange of Dies (SMED) and 5S implementation and will be compare with the actual set-up activities before new implementation. The table include the time for each set-up activities, and also the distance taken by the operator in performing the set-up activities. Table 4.20 shows the result for internal activities or the activities done when the machine stops.

Table 4.20 Summary of the Result

NO	Activity	Time (minute)		Distance (meter)	
		Before	After	Before	After
Activities done when the machine stops					
1	Checking Metal Detector				
	Record Counter Metal Detector	1	1	1	1
	Verified positive sample metal detector	1	1	4	4
		2	**2**	**5**	**5**
2	Cleaning Machine				
	Take Cleaning Tools	2	0.5	0	5
	Cleaning Horizontal Seal Bar	1	1	7	2
	Cleaning Vertical Seal Bar			0	0
	Cleaning Colar	1	1	2	1
	Cleaning Knife Jaw			0	0
	Cleaning Cover Acrylic			1	2
	Cleaning Conveyor Plat	1	1	1	2
	Cleaning Conveyor Belt			0	0
	Tidy Up Cleaning Tools	2	0.5	7	3
		7	**4**	**18**	**15**
3	Take Sample for Bubble Test				
	Take Sample for Bubble Test	1	1	4	4
	Waiting sampling result	1	1	0	0
	Report sampling			4	4
		2	**2**	**8**	**8**
4	Take Sample for Carbon Test				
	Take Sample for Carbon Test	1	1	4	4
	Waiting sampling result	1	1	0	0
	Report sampling			4	4
		2	**2**	**8**	**8**
TOTAL		**13**	**10**	**39**	**36**

Based on table 4.20, it shows that the set-up activities which means the activities done when the machine stops are reduce from 13 minutes to 10 minutes. There are only four internal activities in total which is the current internal activities. The distance taken by the operator in performing the actual set-up activities is 39 meters, after the Single Minute Exchange of Dies (SMED) and 5S implementation, the total distance taken are reduced become only 36 meters. The total reduction time for the set-up activities is 3 minutes, while the total distance reduction are 3 meters in total.

The next table will explain about the external activities, or the activities done when the machine runs. There are four external activities and include several information which are the time needed to perform the external activities and the total distance taken to perform the external activities before and after Single Minute Exchange of Dies (SMED) and 5S implementation.

Table 4.21 Summary of the Result (continued)

NO	Activity	Time (minute)		Distance (meter)	
		Before	After	Before	After
Activities done when the machine runs					
1	Cleaning Environment				
	Take Cleaning Tools	2	0.5	7	5
	Cleaning floor below the machine	3	3	1	1
	Tidy Up Cleaning Tools	2	0.5	7	5
		7	**4**	**15**	**11**
2	Input Data SAM				
	Pre-input data SAM	2.5	1.5	10	5
	Collect sheet report	0.5	0.5	0	0
	Input to computer	5	5	10	5
		8	**7**	**20**	**10**
3	Cut Open Rework	3	3	10	5
		3	**3**	**10**	**5**
4	SHO Update	3	3	8	10
		3	**3**	**8**	**10**
TOTAL		**21**	**17**	**53**	**36**

Based on table 4.21 it shows that the time needed to perform external activities before new improvement are 21 minutes while after 5S improvement, the total time taken become only 17 minutes. Besides that, the operator movement in performing the external activities before new improvement is 53 meters while after implemented new improvement, the distance taken by the operator only 36 meters. The total reduction is 4 minutes for the external time, while the total reduction for the distance is 17 meters.

Figure 4.13 shows the difference between Overall Equipment Effectiveness (OEE) before and after new improvement. The calculation are shown more detail in the appendices. Based on previous discussion, the calculation of OEE rate are include the set-up time which comes from the availability rate. When the set-up time is reduce the availability rate will be increase since the time needed for the filling machine stops are reduce. Then, the reduction of set-up time will influence the OEE rate.

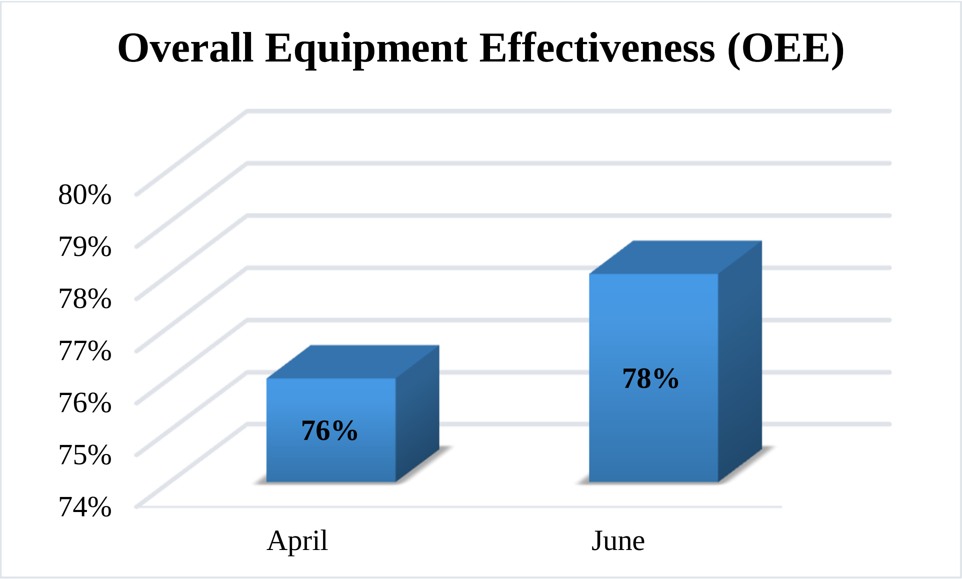


Figure 4.13 Summary of Overall Equipment Effectiveness (OEE)

Based on previous discussion and the calculation that shown in the appendices, the Overall Equipment Effectiveness (OEE) rate are increasing from 76% to 78%. The OEE rate before Single Minute Exchange of Dies (SMED) and 5S implementation are conducted in April 2016 since the SMED implementation are happen in May 2016 which result 76%. The OEE rate after SMED and 5S implementation are happen in June 2016 which result 78%. Then, the difference between the OEE before and after Single Minute Exchange of Dies (SME) and 5S implementation are 2%.

CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the result of analysis in this research, there are two conclusions that can answer the objective of this research:

- Based on Single Minute Exchange of Dies (SMED) implementation, the set-up time is reduced from 34 minutes into 13 minutes. Then, by using 5S method, the set-up time is reduced from 13 minutes into 10 minutes after implementing 5S method. The total reduction time before implementing Single Minute Exchange of Dies (SMED) and 5S implementation are 24 minutes which the reduction from 34 minutes into 10 minutes of the time of set-up activities.
- Based on the Overall Equipment Effectiveness (OEE) calculation, the difference of OEE rate is increasing from April to June 2016 76% to 78%. Since the calculation of OEE include the line preparation or set-up time, the reduction of set-up time influence the increasing of OEE rate. The OEE rate is increasing in PT. MNO, which means PT. MNO has a good productivity than before.

5.2 Recommendation

The recommendation from future research are as shown follow:

- Another recommendation might be further Single Minute Exchange of Dies (SMED) method implementation in other department such as packing, milling, and other department to reduce the set-up time.

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APPENDICES

Appendices 1 - Changeover Product April 2016

PS - Changeover Product (COP)	12	12
05. Seal Bar (H&V), T Belt & Knife Head1		**3**
4/1/2016	3	
06. Seal Bar (H&V), T Belt & Knife Head2		**3**
4/1/2016	3	
05. Seal Bar (H&V), T Belt & Knife Head3		**3**
4/1/2016	3	
06. Seal Bar (H&V), T Belt & Knife Head4		**3**
4/1/2016	3	

Appendices 2 - Process Failure April 2016

UPS - Process Failure (PF)	53	53
05. Seal Bar (H&V), T Belt & Knife Head1		**3**
4/1/2016	1	
4/14/2016	2	
06. Seal Bar (H&V), T Belt & Knife Head2		**4**
4/14/2016	3	
4/29/2016	1	
07. Laminate Transport (dancing roll) H1		**3**
4/28/2016	3	
08. Laminate Transport (dancing roll) H2		**2**
4/28/2016	2	
05. Seal Bar (H&V), T Belt & Knife Head3		**5**
4/14/2016	2	
4/25/2016	1	
4/28/2016	2	
06. Seal Bar (H&V), T Belt & Knife Head4		**6**
4/14/2016	3	
4/29/2016	3	
07. Laminate Transport (dancing roll) H3		**6**
4/16/2016	1	
4/20/2016	3	
4/28/2016	2	
08. Laminate Transport (dancing roll) H4		**3**
4/28/2016	3	
01. Folding Unit 1 Head 1		**2**
4/29/2016	2	
03. Folding Unit 2 Head 3		**5**
4/1/2016	2	
4/20/2016	3	
07. Robot Fanuc SIC 1		**8**
4/1/2016	2	

UPS - Process Failure (PF)		
4/8/2016	2	
4/18/2016	1	
4/29/2016	3	
01. Conveyor Roller SOCO SIC 1		**2**
4/11/2016	2	
02. Vaccum Head SOCO SIC 1		**2**
4/11/2016	2	
03. Belt Putus SOCO SIC 1		**2**
4/11/2016	2	

Appendices 3 - Minor Stoppages April 2016

UPS - Minor Stop (MS)	135	135
06. Seal Bar (H&V), T Belt & Knife Head2		**6**
4/1/2016	1	
4/19/2016	1	
4/25/2016	2	
4/27/2016	2	
08. Laminate Transport (dancing roll) H2		**1**
4/25/2016	1	
04. Small Hopper (Stirer&Auger) Head 4		**1**
4/14/2016	1	
05. Seal Bar (H&V), T Belt & Knife Head3		**11**
4/1/2016	1	
4/4/2016	1	
4/11/2016	1	
4/12/2016	7	
4/29/2016	1	
06. Seal Bar (H&V), T Belt & Knife Head4		**2**
4/28/2016	1	
4/29/2016	1	
07. Laminate Transport (dancing roll) H3		**7**
4/1/2016	3	
4/11/2016	1	
4/13/2016	1	
4/16/2016	1	
4/18/2016	1	
09. Printer Laser & Barcode Head 3		**3**
4/1/2016	1	
4/4/2016	1	
4/26/2016	1	
11. Outlet Filler Head 3		**2**
4/4/2016	1	
4/6/2016	1	
02. Detector X-ray Head 1&2		**5**
4/1/2016	1	
4/4/2016	1	
4/13/2016	1	
4/27/2016	2	

UPS - Minor Stop (MS)		
03. Rejector X-ray Head 1&2		**13**
4/1/2016	3	
4/5/2016	2	
4/6/2016	1	
4/7/2016	1	
4/11/2016	1	
4/12/2016	2	
4/14/2016	1	
4/15/2016	1	
4/16/2016	1	
03. Rejector X-ray Head 3&4		**5**
4/5/2016	2	
4/6/2016	1	
4/7/2016	1	
4/21/2016	1	
03. Folding Unit 2 Head 3		**68**
4/1/2016	1	
4/4/2016	5	
4/5/2016	10	
4/6/2016	3	
4/7/2016	5	
4/8/2016	5	
4/11/2016	7	
4/12/2016	4	
4/13/2016	2	
4/14/2016	1	
4/15/2016	2	
4/18/2016	1	
4/19/2016	5	
4/20/2016	4	
4/21/2016	2	
4/25/2016	1	
4/26/2016	2	
4/27/2016	1	
4/29/2016	5	
4/30/2016	2	
07. Robot Fanuc SIC 1		**11**
4/4/2016	1	
4/6/2016	1	
4/15/2016	1	
4/16/2016	2	
4/18/2016	5	
4/28/2016	1	
Grand Total	**135**	**135**

Appendices 4 - Changeover Product June 2016

PS - Changeover Product (COP)	8	8
05. Seal Bar (H&V), T Belt & Knife Head1		**2**
6/9/2016	1	
6/22/2016	1	
06. Seal Bar (H&V), T Belt & Knife Head2		**2**
6/9/2016	1	
6/22/2016	1	
05. Seal Bar (H&V), T Belt & Knife Head3		**2**
6/9/2016	1	
6/22/2016	1	
06. Seal Bar (H&V), T Belt & Knife Head4		**2**
6/9/2016	1	
6/22/2016	1	

Appendices 5 - Process Failure June 2016

UPS - Process Failure (PF)	33	33
05. Seal Bar (H&V), T Belt & Knife Head1		**1**
6/7/2016	1	
06. Seal Bar (H&V), T Belt & Knife Head2		**4**
6/13/2016	2	
6/15/2016	1	
6/20/2016	1	
07. Laminate Transport (dancing roll) H1		**4**
6/1/2016	1	
6/10/2016	2	
6/13/2016	1	
08. Laminate Transport (dancing roll) H2		**5**
6/7/2016	1	
6/16/2016	2	
6/17/2016	1	
6/22/2016	1	
11. Outlet Filler Head 1		**1**
6/16/2016	1	
03. Small Hopper (Stirer&Auger) Head 3		**2**
6/22/2016	2	
05. Seal Bar (H&V), T Belt & Knife Head3		**3**
6/15/2016	2	
6/20/2016	1	
06. Seal Bar (H&V), T Belt & Knife Head4		**2**
6/3/2016	1	
6/15/2016	1	

UPS - Process Failure (PF)		
07. Laminate Transport (dancing roll) H3		**4**
6/9/2016	2	
6/21/2016	1	
6/23/2016	1	
08. Laminate Transport (dancing roll) H4		**2**
6/9/2016	1	
6/23/2016	1	
01. Folding Unit 1 Head 1		**2**
6/2/2016	1	
6/8/2016	1	
08. Case Erector SIC 1		**1**
6/16/2016	1	
04. Folding Unit 2 Head 4		**1**
6/20/2016	1	
13. WITT Oxygen Analyzer Head 3		**1**
6/15/2016	1	

Appendices 6 - Minor Stoppages June 2016

UPS - Minor Stop (MS)	89	89
06. Seal Bar (H&V), T Belt & Knife Head2		**5**
6/1/2016	1	
6/9/2016	1	
6/10/2016	1	
6/20/2016	2	
08. Laminate Transport (dancing roll) H2		**3**
6/13/2016	1	
6/14/2016	1	
6/16/2016	1	
04. Small Hopper (Stirer&Auger) Head 4		**1**
6/9/2016	1	
05. Seal Bar (H&V), T Belt & Knife Head3		**8**
6/1/2016	1	
6/7/2016	2	
6/15/2016	1	
6/20/2016	1	
6/21/2016	2	
6/22/2016	1	
06. Seal Bar (H&V), T Belt & Knife Head4		**3**
6/7/2016	1	
6/14/2016	1	
6/21/2016	1	

UPS - Minor Stop (MS)		
07. Laminate Transport (dancing roll) H3		**9**
6/2/2016	3	
6/16/2016	1	
6/17/2016	1	
6/20/2016	2	
6/21/2016	1	
6/22/2016	1	
09. Printer Laser & Barcode Head 3		**3**
6/7/2016	1	
6/10/2016	1	
6/20/2016	1	
11. Outlet Filler Head 3		**1**
6/23/2016	1	
02. Detector X-ray Head 1&2		**1**
6/10/2016	1	
03. Rejector X-ray Head 1&2		**8**
6/1/2016	2	
6/2/2016	1	
6/8/2016	1	
6/13/2016	1	
6/16/2016	1	
6/17/2016	1	
6/22/2016	1	
03. Rejector X-ray Head 3&4		**1**
6/16/2016	1	
03. Folding Unit 2 Head 3		**44**
6/1/2016	2	
6/2/2016	3	
6/7/2016	6	
6/8/2016	3	
6/9/2016	8	
6/10/2016	3	
6/13/2016	1	
6/14/2016	4	
6/15/2016	1	
6/16/2016	4	
6/17/2016	2	
6/20/2016	1	
6/21/2016	5	
6/22/2016	1	
07. Robot Fanuc SIC 1		**2**
6/7/2016	1	

UPS - Minor Stop (MS)		
6/22/2016	1	
Grand Total	**89**	**89**

Appendices 7 – Downtime Loss Calculation April and June 2016

April 2016

Changeover Product

= 12 x 60 minutes

= 720 minutes

Process Failure

= 53 x 60 minutes

= 3180 minutes

Line Preparation or Setup time

= 792 minutes

Downtime Loss

= 720 minutes + 3180 minutes + 792 minutes

= 4692 minutes

June 2016

Changeover Product

= 8 x 60 minutes

= 480 minutes

Process Failure

= 33 x 60 minutes

= 1980 minutes

Line Preparation or Setup time

= 175 minutes

Downtime Loss

= 480 minutes + 1980 minutes + 175 minutes

= 2635 minutes

Appendices 8 – Performance Loss Calculation April and June 2016

April 2016

Minor Stoppages

= 135 x 60 minutes

= 8100 minutes

Performance Loss

= 8100 minutes

June 2016

Minor Stoppages

= 89 x 60 minutes

= 5340 minutes

Performance Loss

= 5340 minutes

Appendices 9 – Loading Time Calculation April and June 2016

April 2016

Planned Maintenance = 7 days

Loading Time

= (30 days – 7 days) x 24 hours x 60 minutes

= 552 x 60 minutes

= 33120 minutes

June 2016

Planned Maintenance = 13 days

Loading Time

= (30 days – 13 days) x 24 hours x 60 minutes

= 480 x 60 minutes

= 24480 minutes

Appendices 10 – Operating Time Calculation April and June 2016

April 2016

Operating Time = Loading Time – Downtime Loss

= 33120 minutes – 4692 minutes

= 28428 minutes

June 2016

Operating Time = Loading Time – Downtime Loss

= 24480 minutes – 2635 minutes

= 21845 minutes

Appendices 11 – Operating Time Calculation April and June 2016

April 2016

Net Operating Time = Loading Time – Performance Loss

= 33120 minutes – 8100 minutes

= 25020 minutes

June 2016

Net Operating Time = Loading Time – Performance Loss

= 24480 minutes – 5340 minutes

= 19140 minutes

Appendices 12 – Availability Rate Calculation April and June 2016

April 2016

$$Availability\ Rate = \frac{Operating\ Time}{Loading\ Time}$$

$$= \frac{28428}{33120} x\ 100\%$$

= 86%

June 2016

$$Availability\ Rate = \frac{Operating\ Time}{Loading\ Time}$$

$$= \frac{21845}{24480} x\ 100\%$$

= 89%

Appendices 13 – Performance Rate Calculation April and June 2016

April 2016

$$Performance\ Rate = \frac{Net\ Operating\ Time}{Operating\ Time}$$

$$= \frac{25010}{28428} x\ 100\%$$

= 88%

June 2016

$$Performance\ Rate = \frac{Net\ Operating\ Time}{Operating\ Time}$$

$$= \frac{19140}{21845} x\ 100\%$$

= 88%

Appendices 14 – Quality Rate Calculation April and June 2016

April 2016

Processed Amount = 39000

Defect Amount = 130

$$Quality\ Rate = \frac{(Processed\ Amount - Defect\ Amount)}{Processed\ Amount}$$

$$= \frac{(39000 - 130)}{39000} x\ 100\%$$

$$= \frac{38870}{39000} x\ 100\%$$

= 99.66% = 100%

June 2016

Processed Amount = 39000

Defect Amount = 100

$$Quality\ Rate = \frac{(Processed\ Amount - Defect\ Amount)}{Processed\ Amount}$$

$$= \frac{(39000 - 100)}{39000} x\ 100\%$$

$$= \frac{38900}{39000} x\ 100\%$$

= 99.74% = 100%

Appendices 15 – Overall Equipment Effectiveness (OEE) Rate Calculation April and June 2016

April 2016

OEE Rate = Availability Rate x Performance Rate x Quality Rate

= 86% x 88% x 100%

= 75.5435% = 76%

June 2016

OEE Rate = Availability Rate x Performance Rate x Quality Rate

= 89% x 88% x 100%

= 78.1863% = 78%