REDUCING COMPLETION TIME OF LOW VOLTAGE PANELS BY REDUCING BOTTLENECK THROUGH PARALLEL WORKSTATIONS IN PT SCHNEIDER ELECTRIC INDONESIA

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THESIS ADVISOR
RECOMMENDATION LETTER

This thesis is entitled "**Reducing Completion Time of Low Voltage Panels by Reducing Bottleneck Through Parallel Workstations in PT Schneider Electric Indonesia**" prepared and submitted by **Giovanni Anugraha Dharmajaya** in partial fulfillment of the requirements for the degree of Bachelor Degree in faculty of Engineering has been reviewed and found to have satisfied the requirements for a thesis fit to be examined. I therefore recommend this thesis for Oral Defense.

Cikarang, Indonesia, September 14th, 2017

Anastasia Lidya Maukar, S.T., M.Sc., M.MT.

DECLARATION OF ORIGINALITY

I declare that this thesis, entitled "**Reducing Completion Time of Low Voltage Panels by Reducing Bottleneck Through Parallel Workstations in PT Schneider Electric Indonesia**" 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, September 14th, 2017

Giovanni Anugraha Dharmajaya

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ABSTRACT

PT Schneider Electric Indonesia is a leading manufacturer of electrical panels in Indonesia that produces two line of products: Medium Voltage (MV) Panels and Low Voltage (LV) Panels with the latter claimed as their distinctive competency. Despite their success, the company regularly finds lateness in the completion time of their projects in the LV Panels product line. In the recent Project Mogas, PT Schneider Electric Indonesia's assembly line was 933.57 minutes behind the planning horizon. The lateness resulted a significant cost of IDR 289,081,374.37. The customer's order was delivered two days late and incurred unnecessary costs. Management needs to analyze the delay, and strive eliminate it. The research focuses on the LV Panels assembly line, particularly for the period of January 2017-June 2017. The research utilizes the comparison of standard and actual cycle time, with the assistance of Process Flowchart and Pareto Analysis to determine the bottleneck. The study shows process "Installing Busbar Non-Standard" paid the highest contribution to total time loss. An improvement proposal is made with "Installing Busbar Non-Standard" as the target; to run two parallel workstations under the problematic process. Predicted results of improvement suggests that PT Schneider Electric Indonesia could save 18,197.98 minutes and IDR 225,067,647.40.

Keywords: *Electrical panels, completion time, planning horizon, standard cycle time, actual cycle time, bottleneck, workstations.*

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Cycle Time	:	the period required to complete one cycle of an operation, or to complete a function, job, or task from start to finish.
Planning Horizon	:	the length of time into the future that is accounted for in a particular plan.
Electrical Panels	:	a device that functions by parting the electrical power artery into multiple “branch circuits” as well as delivering a protective function through the “circuit breaker, a protective fuse for every circuit there is in the common system. (adapted from www.schneiderelectric.com)
Bottleneck	:	an activity which delays the performance of a system and reduces overall efficiency of the process is known as bottleneck.
Workstation	:	an area where work of a particular nature is carried out, such as a specific location on an assembly line.

CHAPTER I
INTRODUCTION

1.1 Problem Background

For many years, manufacturing companies have strived to achieve high productivity to maximize profitability. Productivity improvement is one of the core strategies towards manufacturing excellence and it also is necessary to achieve good financial and operational performance (Naveen, 2015). Productivity is a term that refers to the ratio of the output produced to the input resources utilized in the production (Pandey, 2014). As told by Naveen, the term productivity can be used to examine efficiency and effectiveness of any activity conducted in an economy, business, government or by individuals.

Although related, the word productivity itself is not to be confused with effectiveness of efficiency individually. Effectiveness is the degree to which an objective is accomplished, whereas efficiency discusses how well resources are utilized in order to achieve the objective. This thesis will mainly expound the topic of efficiency in accordance to the characteristics of the case study. Time is one of the many factors to take into account in effort to maximize efficiency. Companies have taken many paths to shorten the length of time needed by a process in production – or any kind of process for that matter. Over time, the industrial/manufacturing world was introduced to various studies those reveal tools and methods to achieve the most efficient time. In the combat against inefficiency, the term "bottleneck" remains popular. It refers to the process in production which beholds the longest duration of work. This is the process that holds back the entire production, hence the term "bottleneck".

PT Schneider Electric Indonesia is a company that operates in the electricity energy industry, that produces both customized and standardized electric panels for business customers with two lines of products: the customized line (called the Low

Voltage, or LV), and the standardized line (called the Medium Voltage, or MV). The LV is dedicated to tailor products exactly to each individual customer's needs. The MV on the other hand, produces items with pre-determined specifications. To increase the significance of the study, this thesis will focus on PT Schneider Electric Indonesia's customized line: Low Voltage (LV) line of production. LV Panels is the product line that reflects the company's business focus as the world's biggest ETO (Engineering to Order).

PT Schneider Electric Indonesia has a predetermined standard cycle time for each step in their production line. This standard is used as a guidance to analyze the current efficiency of their processes. There is a substantial discrepancy found between the standard cycle time and actual cycle time of PT Schneider Electric Indonesia's LV Panel production line. In the company's most recent project: Mogas, PT Schneider Electric Indonesia committed inadvertent lateness up to 28% of the original planning horizon. The products were supposed to be finished in 47,266 minutes or 98.47 normal working days. However, PT Schneider Electric Indonesia finished the production in 60,336 minutes or 125.7 normal working days. The tardiness added up to 13,070 minutes, and resulted in significant cost increases. There are some expense accounts that jump in the presence of lateness, such as: contract fines, freight costs, and overtime salaries. The total cost of tardiness is a striking amount of IDR 289,081,374.37. Thus, management needs to identify which process causes the delay, and try to eliminate them.

1.2 Problem Statement

The problem background that has been stated leads to the statement below:

- What processes are significant to production?
- What process discloses the largest time discrepancy between actual process time and standard process time?
- How does management reduce the completion time of LV Panels?

1.3 Objectives

The objectives of this research generated from the problem statement above is to:

- Define which processes are most significant to production.
- Determine which process discloses the largest time discrepancy between actual process time and standard process time.
- Explain how management reduces the completion time of LV Panels.

1.4 Scope

The scope of doing this research is as follows:

- Due to limited time in doing this research, the observation was conducted in 1 May 2017 – 31 July 2017
- The observation was performed in production process of PT Schneider Electric Indonesia
- The production data were collected in 1 January 2017 – 31 July 2017

1.5 Assumptions

- The production floor operates 5 days per week, 1 shift per days, and 8 hours per shift
- All operator skills are good. The operators' responsibilities are not interchangeable; one person is responsible for one process only, and one process is handled by the particular operator(s) only.
- Materials for production are always available.
- The production does not involve the usage of machines. All works are done manually.

1.6 Research Outline

Chapter I	**Introduction** This chapter give the background of the problem, explain the problem statement, research objectives, assumptions, scope, and the explanation of research outline.
Chapter II	**Literature Study**

This chapter give the knowledge and the fundamentals of Process Flowchart, Bottleneck, Pareto Chart, and Gantt Chart. And then this chapter describes in more detail about how to use the tools in each theory.

Chapter III **Research Methodology**

This chapter describe the basic methodology to find the objectives of the research. This chapter explain the current method that using for the new scheduling process. In general, this chapter bring to know how the research start and finish, to make the better improvement from the current condition.

Chapter IV **Data Collection and Analysis**

This chapter explains the current condition in PT Schneider Electric Indonesia, the data needed for the research, and the standards the company applies. The problem is identified using Process Flowchart and loss time calculation, before further analyzed with Pareto Analysis to determine the largest discrepancy found. At this point, the process bottleneck is identified. An improvement is proposed as a result to increase the company's profitability, demonstrated with Gantt Chart.

Chapter V **Conclusion and Recommendation**

This chapter explains the conclusion of the research, and the result of the improvement. This chapter also explain the recommendation for future researched that will conduct new observation with same topic or method of research.

CHAPTER II
LITERATURE STUDY

2.1 Electrical Panel

Electrical Panel is commonly used by buildings to hedge electric power overloads and short circuit dangers by allocating electricity properly throughout the needing sectors of the facility. The panel functions by parting the electrical power artery into multiple “branch circuits” as well as delivering a protective function through the “circuit breaker, a protective fuse for every circuit there is in the common system.

There are two types of Electrical Panel: switchgear and switchboard. Although serve a similar purpose, switchgear and switchboard devices have innate differences that roots in the design of maximum voltage allowances. Switchgear systems are designed to cope with the higher range of voltages, the typical reaches 35,000 volts. Switchboards, on the other hand, are the commercialized version of electrical panel, suitable for managing low energy levels under 600 volts. Due to different usage functions, switchgears and switchboards use different types of breakers. To deal with medium voltages, switchgears utilize “power circuit breakers”, whilst switchboards generally apply “molded case circuit breakers” to match the low voltages characteristics. Figure 2.1 shows a prototype of a switchgear.

Source: Schneider-electric.com

Figure 2.1 Switchgear

Figure 2.2 shows a prototype of a switchboard.

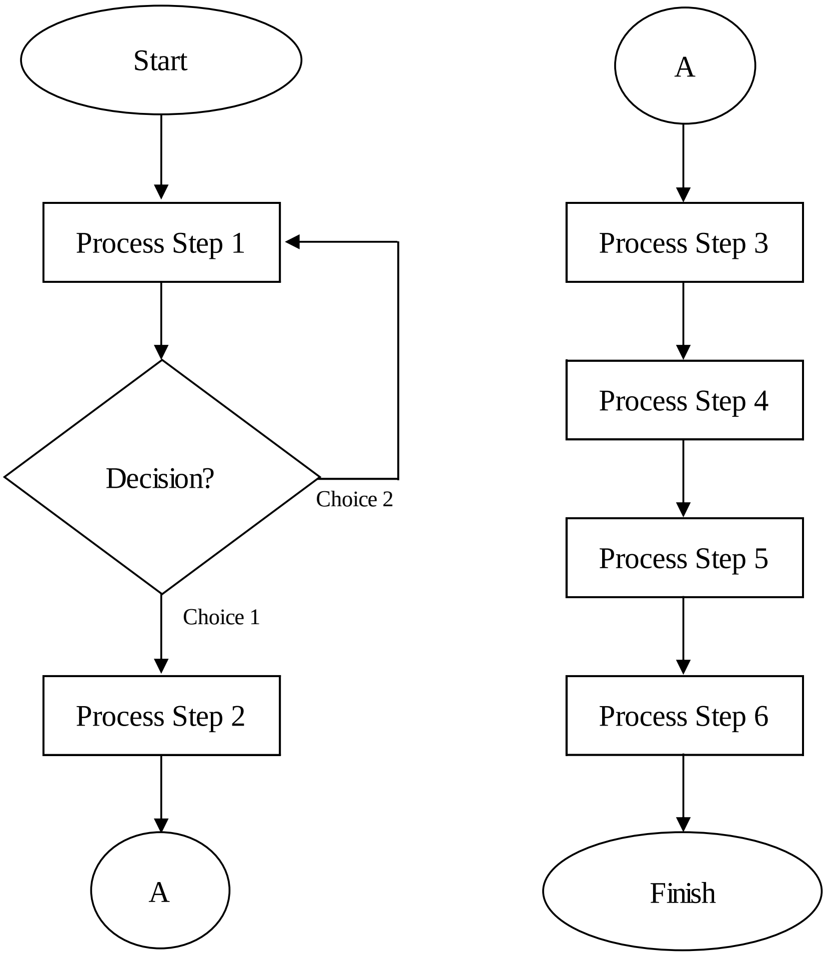
Source: Schneider-electric.com

Figure 2.2 Switchboard

2.2 Process Flowchart

A process is combination of different resources in a specific way to get the desired output through given input (Timilsina, 2012). In order to thoroughly understand the complete process of production, a process map or flowchart is useful. The flowchart will be able to tell the specific processes related to production in step-by-step order. A flowchart shows the sequence of activities as well as the flow of materials and information in a process that is drawn into a picture to map the whole system (Shankar, 2009).

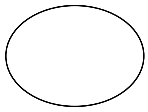
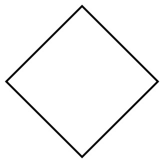
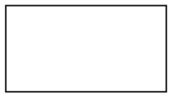
An elaborate flowchart may use up to 27 symbols. However, the commonly used format of a flowchart is as follows:



Source: Breezetree.com

Figure 2.3 Basic Flowchart

Enlisted below in Figure 2.4 is the common symbols used in a flowchart, along with the meaning of each.

Name	Symbol	Function
Event		A trigger that starts, modifies or completes a process
Gateaway		Decision point that can adjust the path based on conditions or events
Task or Activity		A particular activity performed by a person or system
Flow		The sequence, shown by lines and arrows on the map

Source: Teachengineering.org

Figure 2.4 Flowchart Symbol and Function

What needs to be done when constructing a flowchart is simply draw the relevant shape in accordance to the activity, and name each of the process. Arrange the process shape in the right order, and point out the sequences by connecting the shapes with arrows.

2.3 Bottleneck

An activity which delays the performance of a system and reduces overall efficiency of the process is known as bottleneck. It is an obstacle in the process of manufacturing which restricts the production (Timilsina, 2012). The bottleneck determines the capacity of the system; the slowest resource pool refrains the whole throughput of the process (Laguna, 2005). There are many causes of bottlenecks, namely people constraints, material constraints, equipment constraints, process constraints, management constraints, policy constraints, and environmental constraints.

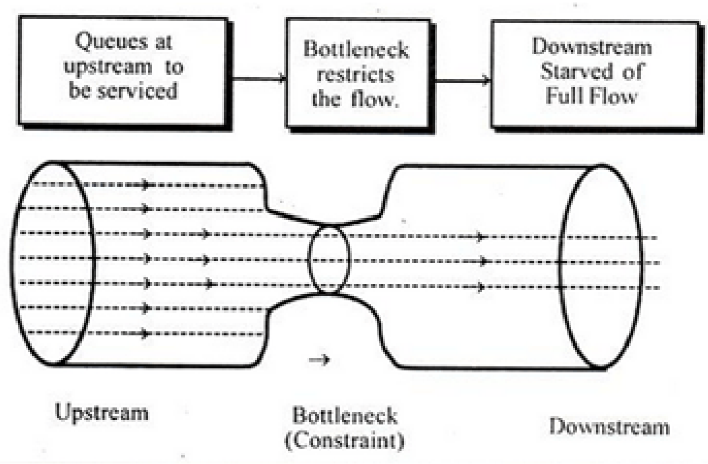
The efforts of eliminating a bottleneck reflects that the business is not only trying to remove the congestion in the process but also striving to lift up the system thoroughly ("Theory of Constraints-- Eliminate Bottlenecks-- Focus, Leverage, Manage: Structure Organization Around It..," 2014).

According to Timilsina, the manufacturing studies know several approaches in identifying bottlenecks, namely: Fishbone Diagram, Failure mode and effect analysis (FMEA), Theory of Constraints (TOC), The Five-Why Principle, and Benchmarking. In the analysis of this case study, Theory of Constraints was the method of choice, due to its simplicity. This method is rendered sufficient for analysis; therefore, no further involvement of other theories is needed.

Theory of constraints provides the guideline for regular improvements within the system. A system consists of a series of independent sub systems working together in a pre-determined method in order to fulfil a fixed target. The system has its weak points that needs to be brought to attention, because these weaknesses could lead to problems. TOC focuses on those weaknesses where improvement is deemed necessary. Theory of constraints follows following five steps:

1. Identify the constraints
2. Exploit the constraints
3. Elevate the constraints and
4. Repeat the cycle

Thus the TOC works on speed and volume of production with time and can be an effective method to find the bottleneck in the system (Eliyahu M. Goldratt& Jeff Cox, 2004).
The concept of bottleneck can be drawn in to figure 2.5 below.



Source: E-qms.co.uk

Figure 2.5 Bottleneck Concept

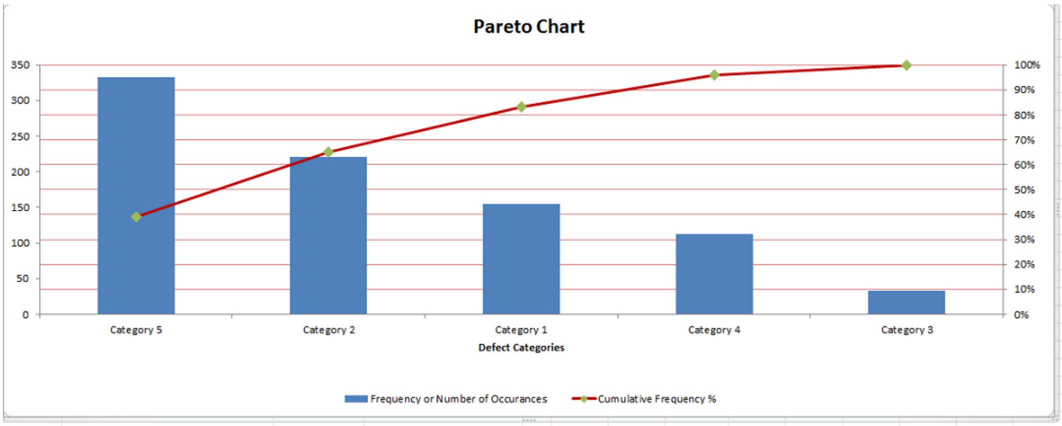
2.4 Pareto Analysis

Pareto Analysis is a tool of analysis that involves statistical approach to decision-making, based on the principle that a minority of tasks produce significant results overall. The famous 80/20 rule is the basis of Pareto Analysis, where the larger percentage (80%) problems are caused by only a few causes (20%) (Shankar, 2009).

To use a Pareto Analysis, one must construct the Pareto Chart. Doing so involves a series of steps:

1. Construct a vertical bar chart with the following labels: causes on the x-axis and count (number of occurrences) on the y-axis.
2. Arrange the variables in the bar chart in descending order of cause importance. The chart should display the cause with the highest count first.
3. Calculate the cumulative count for each cause, arrangement follows the previous point (point no. 2)
4. Convert the results of point 3 into percentage numbers, following the previous arrangement.
5. Add a second y-axis to the chart with percentages descending in increments of 10 from 100% to 0%.
6. Plot the cumulative count percentage of each cause on the x-axis.
7. Join the points to form a curve.

Below in figure 2.6 is disclosed an example of a Pareto diagram.



Source: Knowledgehills.com

Figure 2.6 Example of Pareto Diagram

2.5 Managing Cycle Time and Capacity

Professor Rob Leachman of UC Berkeley explains that total manufacturing cycle time is the elapsed time from lot creation to lot completion, which includes process time, transport time, queue time, hold time across all steps of the process flow. Standard cycle time is time to process one lot without interference (includes process time and move time but excludes queue time and hold time) – standard cycle time for each process step – standard cycle time for whole process flow.

Process capacity, as explained by Timilsina, is the maximum capacity output rate measured in units produced per unit of time. Laguna and Marklund argues that capacity is directly related with bottleneck. This argument will be elaborated further in the coming paragraphs.

The two terms expounded above are related, for both of them discusses how many outputs are possible per unit of time. A reduction of time cycle means an increase in the production capacity.

To reduce the overall cycle time, there are 5 fundamental ways to pursue:

1. Eliminate activities
2. Reduce waiting time

3. Eliminate rework
4. Perform activities in parallel
5. Move processing time to noncritical activity

There is a direct, negative relationship between the process capacity and bottleneck resource. When bottleneck resource is dealt with and the time required on the bottleneck process is decreased, process capacity is increased (Laguna, 2005). There are two options to consider in achieving higher process capacity:

1. Add resource availability on the bottleneck.
2. Reduce workload at the bottleneck.

Adding resource availability on the bottleneck may require more investment in purchasing new equipment or hiring extra labors, whereas reducing workload at the bottleneck requires process redesign. The latter includes shifting work to another resource pool or reducing the number of time/activities assign to the bottleneck resource.

2.6 Gantt Chart

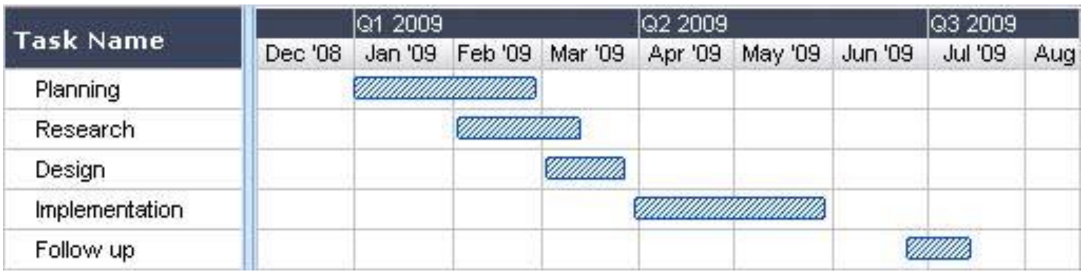
The story of Gantt charts is commonly discussed in textbooks on scheduling, for Gantt charts remain an important type of diagram for representing schedules (Herrmann, 2010). A Gantt chart is a commonly used tool in project management, it is one of the most popular and useful ways of showing activities (tasks or events) displayed against time (Shankar, 2009).

Gantt Charts follow the following format. On the left of the chart is a listed all the activities involved in the project, and along the top of the chart is displayed a suitable time scale. The time can be displayed in days, months, or weeks – all in accordance to the specific needs of the project. Each duration of activity is represented by a horizontal bar; the bar starts where the activity started in time, and ends when the activity stopped – all measured according to the calendar at the top.

This chart enables the users to fathom the following points:

- What activities are involved in the project
- When each activity begins and ends
- How long each activity is scheduled to last
- Where activities overlap with other activities, and by how much
- The start and end date of the whole project

Gantt charts weigh the actual working duration with the original plan, thus explaining in details which activity holds the most problem (the longest delay), and hence suggesting a starting point for the target of improvement. Figure 2.7 below displays an example of a Gantt Chart.



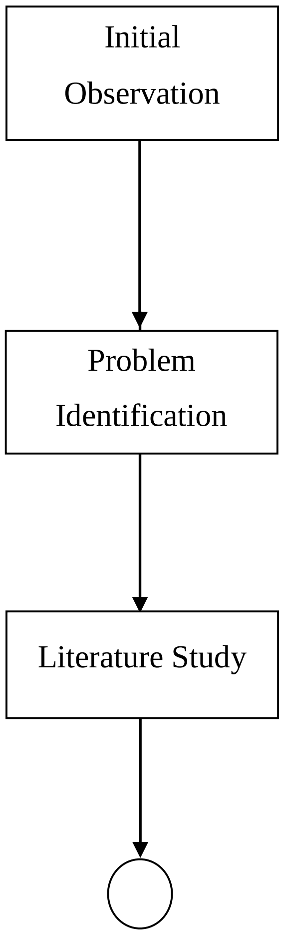
Source: www.Gantt.com

Figure 2.7 Gantt Chart

CHAPTER III

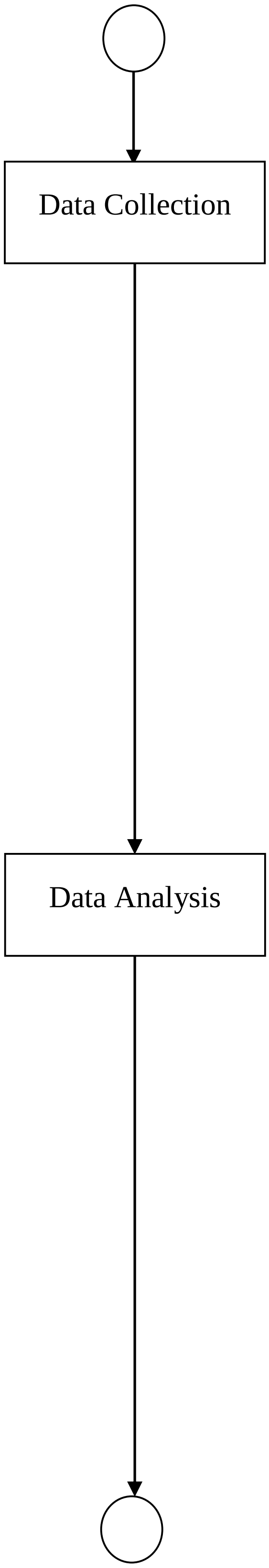
RESEARCH METHODOLOGY

In this part, the phase of the entire process in completing research is explained. The steps were planned before the research is completed so that they can be a guide for the researcher to start and do the research effectively until the goals of the research are accomplished. Below, figure 3.1 will show the theoretical framework of the research.



1. Initial Observation
   - Going to PT Schneider Electric Indonesia to observe the working process in the area and try to look for any kind of problems that occur in the production assembly area.
2. Problem Identification
   - Identify the background and problem mapping. The problem in assembly area is related with untimely process time.
   - Determine the objectives of research, scope, limitations and assumptions.
3. Literature Study
   - Searching for literature references such as books, journals, websites, and also blogs that is related to Bottlenecks and how to overcome them. Other relevant theories are included as well.

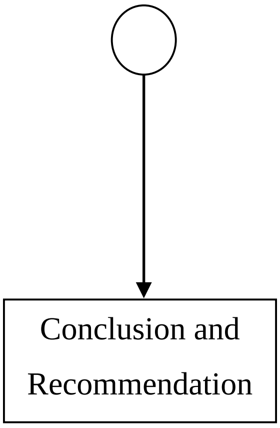
Figure 3.1 Theoretical Framework of the Research



4. Data collection
   - Collect the required data from method department. The collected data is the actual time calculations for all process works in the assembly line.
   - Perform observation and interview in method department.
   - Perform knowledge sharing with person in charge in department area.
   - Examining and reviewing the data available regarding the particular problem addressed in the point above. When the data is relevant and complete, the next step is taken.

5. Data Analysis
   - Analyze the raw data with Flow Chart and Time Loss Calculations.
   - Define the most prominent processes of the production.
   - Calculate the time loss occurred in the prominent processes.
   - Analyze and find the most problematic process, identified with the largest amount of time loss.
   - Propose an appropriate improvement to reduce or eliminate the impact of bottleneck(s) within the system. The improvement is aimed at increasing the company's efficiency.

Figure 3.1 Theoretical Framework of the Research (Cont'd)



- Calculate the increased profitability of the company, based on the improved efficiency. Calculate the management saving.

6. Conclusion and Recommendation
   - Conclusion based on calculation and analysis for the research.
   - Give recommendation for further research.

Figure 3.1 Theoretical Framework of the Research (Cont'd)

3.1 Initial Observation

Problems are identified based on the database of PT Schneider Electric Company, a company that specializes in customized electric panels production. The company has set standard time limits for every process in their assembly line. However, the actual time records are tardy compared to the standards. An action is needed to be taken to improve the current situation.

Initial observation is the very first step that need to take while doing a research. It is the measurement that researcher take before starting any process that might cause a change. Then when it is being compared to the actual one, the changes will be seen and the researcher can be able to measure the change.

3.2 Problem Identification

The purpose of problem identification step was to determine the problem occurred in the assembly line, that cause the delay of the work processes. Based on field observation results, the actual working time is compared with the standard working time.

After doing an observation and the problem had been discovered, the research come up to its objectives, which is the main point of this research aimed to. The research objective itself have been mentioned in the first chapter of the research.

3.3 Literature Study

In this step, any sources that can be a reference in order to support the theories in this research will be inserted. These theories are used to guide the researcher to find the main objective of the research which is to determine the root cause of the problem and propose an improvement plan to increase efficiency. The main useful literature studies for the analysis is the theories of bottleneck management.

3.4 Data Collection and Analysis

In the step of data collection, the researcher gathered the data available from the company database regarding working time of all the processes in the assembly line.

After doing data collection, the next step is data analysis. With the current condition, the researcher analyzed the conditions at the assembly line using Process Flowchart and Time Loss Calculation. The results the previous analysis is processed further with Pareto Chart, to determine the bottleneck of the process. Then the analysis continued with the solution and improvement. The improvement proposal is demonstrated with Gantt Chart to prove its significance. A calculation of cost saving for management is done to show the benefits of this improvement for PT Schneider Electric Indonesia. When this stage is reached, it means that the research has reached its objectives.

3.5 Conclusion and Recommendation

The final step of the research is to give conclusion and recommendation. The conclusion includes the summary of the whole process of the research until the research objectives are accomplished. In the conclusion part the research objectives have been achieved.

After presenting the conclusion, a recommendation will be given. It is the act of recommending some tips as a suggestion about the best course of action for the readers or future researchers who would like to do some kind of research with a similar topic of study with this research.

3.6 Detailed Framework

After determining the research flowchart, the next action is to create research framework to visualize the research in clearer steps from the beginning until obtaining the result after conducting the research.

Please take note that the following framework is an elaboration for the steps “Data Collection”, “Data Analysis”, and “Conclusion and Recommendation” previously mentioned in the preceding Figure 3.1, Theoretical Framework of The Research. The research framework is as follows.

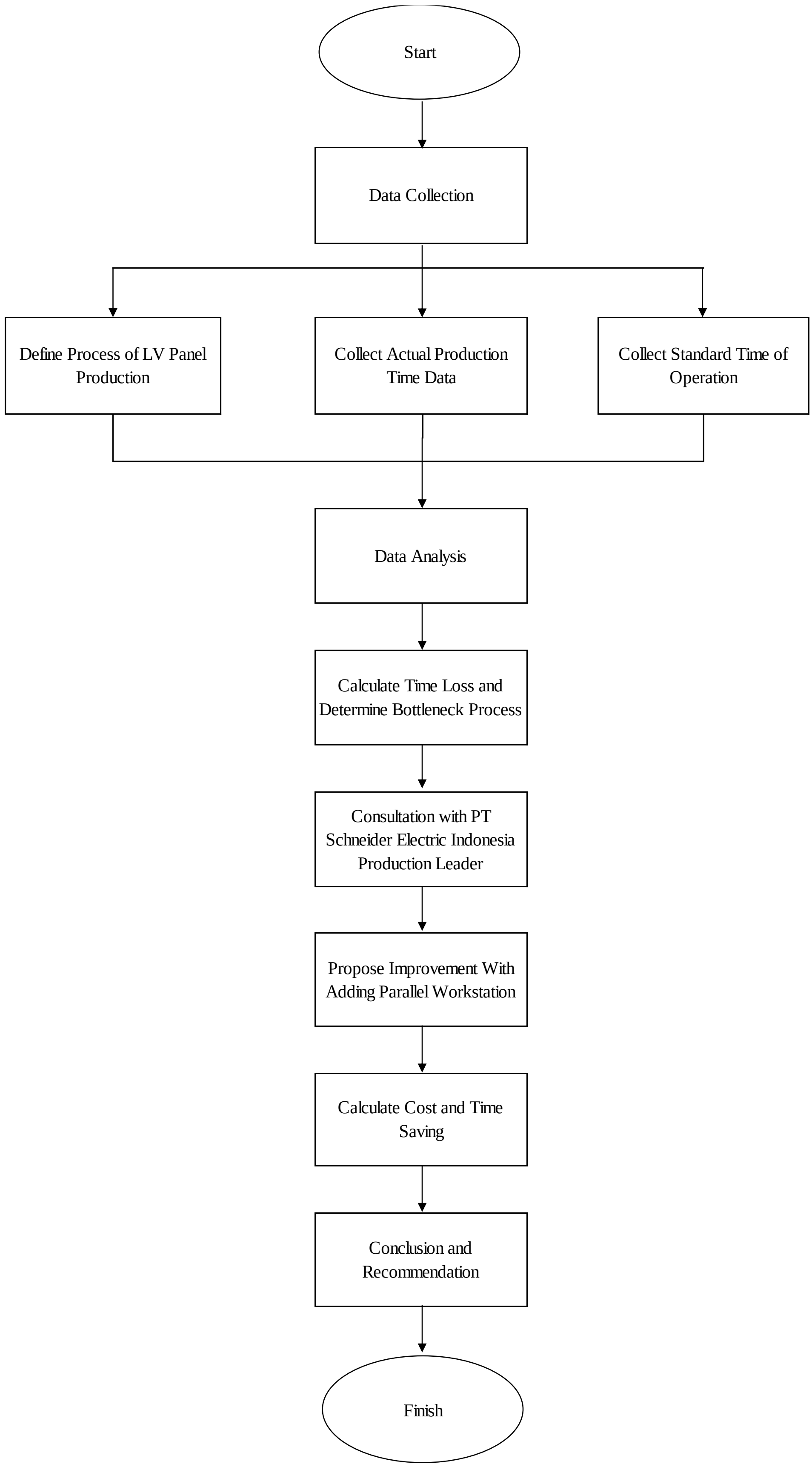


Figure 3.2 Detailed Framework of the Research

The process starts with defining the production process of LV Panels. This step is done mainly by performing a flow process analysis using the Flowchart management tool. The Flowchart gives a clear step-by-step approach to picturing the process. When the activities are identified, an analysis needs to be done in order to expound the most prominent process(es) in the whole system. Later on, the prominent/significant processes will become the main focus of analysis.

The next step is the collection of actual cycle time data on the main processes. The actual cycle time is then weighed against the design time (standard cycle time) to calculate the time losses associated with each process. The result of time loss calculation provides a strong basis to determine the bottleneck of the whole system. The bottleneck of the system is the process/activity that beholds the highest record of time loss, and must be named the target for improvement.

After the bottleneck is identified, the next step is to have a discussion with a leader in PT Schneider Electric Indonesia to consult the result of analysis so far. The high-positioned personnel should understand the production process clearly, and therefore can discuss the feasibility of improvement practices. Based on the available options, one is chosen as the best alternative of solution: adding a parallel workstation to double the capacity of the bottleneck. An improvement proposal is made based on the decision.

A cost calculation is made on the relevant expense accounts, and the possible time saving is identified. The final step of research is to conclude what had been done and what are the results of the research. A recommendation is given at the end of the research to assist future researchers and readers who find this thesis helpful.

CHAPTER IV
DATA COLLECTION AND ANALYSIS

4.1 Data Collection

In this chapter, relevant information is attached, sourced from PT Schneider Electric Indonesia's company database. The data collection method is through observation; which results are all recorded in the company's standard documents. Data collected are then assessed with several approaches, namely Process Flowchart as it was specified in Chapter III.

All the data disclosed below are free from confidentiality issues and therefore are eligible to be used as research materials. However, some calculations in the analysis may require confidential company information. To maintain the discretion of PT Schneider Electric Indonesia, this thesis will not include the accurate numbers of those confidential accounts but replace them with calculated approximation numbers. The approximated values are well consulted beforehand with some relevant personnel of the company, thus ensuring the validity of the analysis. In the construction of this chapter, such method is minimized; this thesis will always utilize the actual data unless it is specified otherwise.

4.1.1 Flow of Process

PT Schneider Electric Indonesia engages in the manufacturing of electrical panels that powers buildings. They conduct in Business to Business activities, which means their clients are other business institutions or companies. The production line in PT Schneider Electric Indonesia mainly does the assembly of parts, not the manufacturing of parts. The parts or components used in the assembly of the products are manufactured by PT Schneider Electric Indonesia's sub-contractors.

The assembly of electrical panels is divided into two main divisions: The Low Voltage Panels (LV), and the Medium Voltage Panels (MV). However, the core business value that PT Schneider Electric Indonesia claim to differ them from their competitors is within the Low Voltage Panels. The Low Voltage Panels, or the LV Panels, are customized products those are built in accordance to the client's requests (Engineer to Order Products). On the other hand, the Medium Voltage Panels are the standardized products those hold a predetermined set of specifications. The MV Panels are made in mass production.

To converge the topic of discussion, the analysis in this thesis will focus on the assembly process of LV Panels only. As expected from a company of PT Schneider Electric Indonesia's caliber, the management team already has a standard designed flow of process of each process in the assembly line.

To produce one electrical panel, a series of processes is needed. The chain includes 3 prominent processes, which are marked with the word "Workstation" next to the process box. These 3 activities are vital to the assembly process. There are several supporting activities: the receiving of the panel's cubicle, the internal check by production, final quality control, packing, and shipping.

The production of LV Panels is displayed by the following Figure 4.1, all the steps in their respective orders:

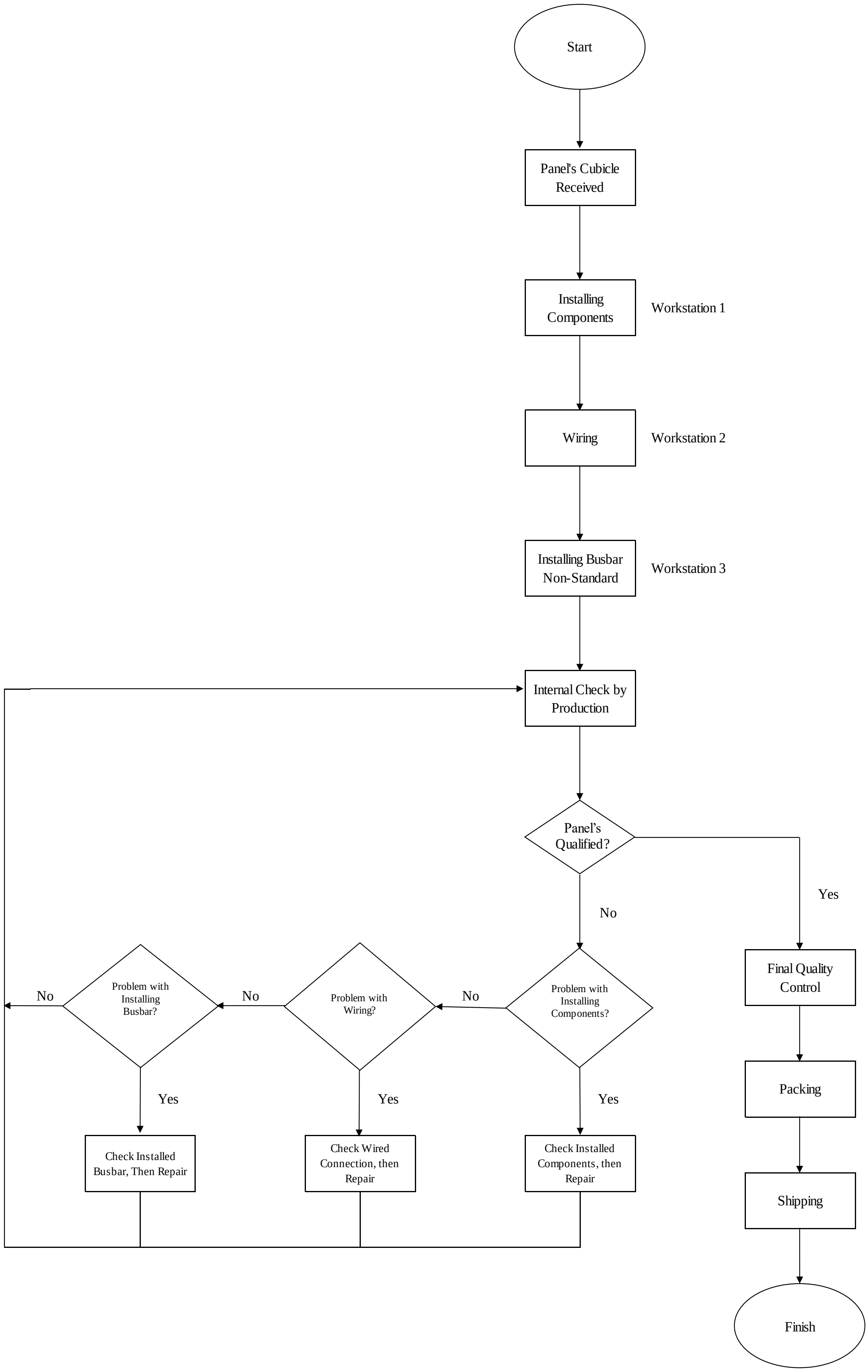


Figure 4.1 Process Flowchart

After the production starts, the first step of the assembly process is receiving the panel's cubicle, along with the collection of other components from the warehouse. As it was specified in the first paragraph of this section, PT Schneider Electric Indonesia does the assembly of the pre-manufactured components.

There are three main processes those happen in the production line: "Installing Components". "Wiring", and "Installing Busbar NSTD". Each of these processes involves one workstation, with different number of working operators. The specifications of the current workstations' conditions are as listed in Table 4.1 below:

Table 4.1 Workstations and Number of Operator

Name	Activity/Process	Number of Operator
Workstation 1	Installing Component	1
Workstation 2	Wiring	1
Workstation 3	Installing Busbar Non-Standard	2

"Installing Busbar Non-Standard" is the most complicated process, and needs two operators to handle. Below is displayed Figure 4.2 that explains the current conditions of the Workstations in the production line.

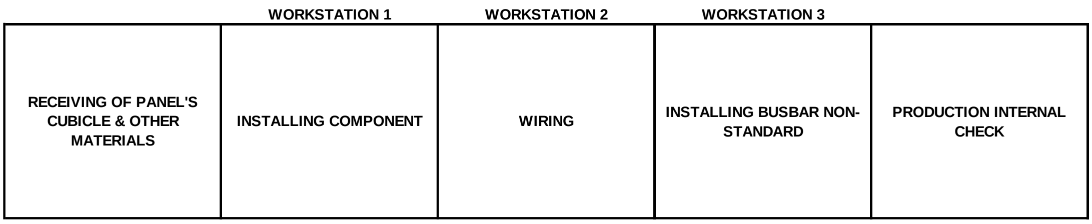


Figure 4.2 Current Workstations

Each process mentioned above involves the assembly of particular parts. To elaborate and list down the related components of every process, Table 4.2 is inserted below.

Table 4.2 Process Breakdown and Component

No	Process	Sub-process/Component
1	Installing Components	Spam
		Selector Switch
		Test block current
		Test block voltage
		Metering ampere meter
		Metering voltage meter
		Lamp Indicator
		Push Button
		Miniature circuit breaker
		Relay
		Current Test
		Timer
		Terminal
		Thermostats
		Heater
		Fuse
		Port supply
		Master pack
		Connectsium
2	Wiring	Wiring all components to selector switch according to wire list
3	Installing Busbar Non-Standard	Installing Top Fix Bracket
		Installing Middle Fix Bracket
		Installing Bottom Fix Bracket
		Installing Top Mobile Bracket
		Installing Bottom Mobile Bracket
		Setting Top Busbar
		Setting Bottom Busbar
		Setting Top Main Bar
		Setting Bottom Main Bar
		Installing Top Main Bar
		Installing Bottom Main Bar
		Installing Connection Bar

*) The term “Busbar NSTD”, “Install Busbar NSTD”, and “Install Busbar Non-Standard” are used interchangeably according to the structure of the beholding sentence throughout this entire thesis.

Please take note that the three main processes discussed in Table 4.2 are the focus of analysis that will be done here onwards, and are subject to improvement.

After the three assembly processes are done thoroughly, the next step is “Internal Check by Production”. This step involves the testing conducted by the operators in the production line to make sure that the product runs as it was designed to. If there are errors found, then the operator in checking duty should ask these questions, respectively:

1. Is the problem found in the components from “Installing Components” process? If the answer to this question is yes, then the product should be reassessed and repaired by the operator responsible for “Installing Components”, and afterwards being reviewed again for the second time by “Internal Check by Production”. If the answer is no, then the product will be assessed further with question number two;
2. Is the problem found in the components from “Wiring process? If the answer to this question is yes, then the product should be reassessed and repaired by the operator responsible for “Wiring”, and afterwards being reviewed again for the second time by “Internal Check by Production”. If the answer is no, then the product will be assessed further with question number three;
3. Is the problem found in the components from “Installing Busbar NSTD” process? If the answer to this question is yes, then the product should be reassessed and repaired by the operators responsible for “Installing Components”, and afterwards being reviewed again for the second time by “Internal Check by Production”. If the answer is no, then the product will be reassessed by “Internal Check by Production” to determine if there were any errors.

If there are no errors found in “Internal Check by Production”, the product should continue directly to the “Final Quality Control” section. The step of “Internal Check by Production” must be done as many times as it takes to deliver the product that fits the company’s standards.

After the product performs up to the standards, the next step will be “Final Quality Control”, to make sure that there are neither major nor minor defects those are unacceptable to the company’s standards. This step also involves the checking of the product’s appearance, before packing the product and shipping it to the customer’s delivery address.

4.1.2 Product Demand

An analysis will be done based on the steps of the flowchart above. A persisting problem is found in the LV Panels assembly line, where the actual time required to make the customized orders are far behind the timeline of the designed time. To analyze the problem further, data are collected from the company's records.

An analysis will be conducted upon a project which PT Schneider Electric Indonesia worked on in the period of January 2017 to June 2017. The project is called project Mogas, an order to make 14 products of LV Panels for a business client in Dubai. PT Schneider Electric Indonesia's original planning horizon on this project is 47,266 minutes, or 98.47 normal working days. According to the timeline, the project is supposed to be finished by production on 24 May 2017. The shipment will take 35 days by sea, and is supposed to be received on 27 June 2017.

However, PT Schneider Electric Indonesia's actual duration of work took 60,336 minutes or 125.7 days. The order was late for 28% of the original planning horizon. At this rate, the company is at risk of being late for 27.23 normal working days, if they continue to work at the current pace. Such lateness is intolerable for PT Schneider Electric Indonesia, because it will result in major customer dissatisfaction.

To compensate for the 28% lateness, PT Schneider Electric Indonesia pressed the 27.23 normal working days into a series of overtime shifts and switched the transportation means into airborne shipment. In reality, the products were received by its customer two days late from the original planning horizon: on 9 June 2017.

This effort has caused a lot of money for PT Schneider Electric Indonesia. The calculation of costs related to this compensation will be broken down in details in sub-chapter 4.4: Management Savings Calculations.

The Figure 4.3 below displays the disparity between the planned time and the actual production time in total:

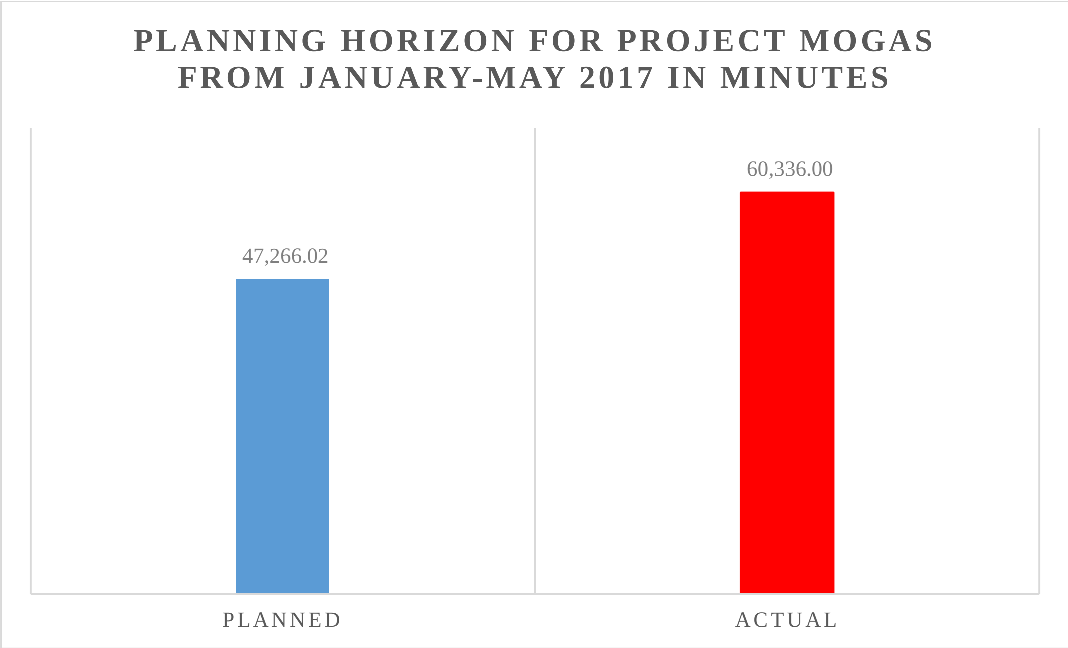


Figure 4.3 Planning Horizon for Project Mogas from January-May 2017

The following Table 4.3 shows the recorded time of LV Panels production for the project:

Table 4.3 Actual Time of Project Moga

Product No	Actual Time (Hrs)			Total (Hrs)	Actual Time (Min)			Total (Min)
	Install Component	Wire	Busbar NSTD		Install Component	Wire	Busbar NSTD	
1	12.2	21.7	38.2	72.1	732.0	1,302.0	2,292.0	4,326.0
2	9.8	14.3	40.6	64.7	588.0	858.0	2,436.0	3,882.0
3	9.0	22.1	43.8	74.9	540.0	1,326.0	2,628.0	4,494.0
4	10.5	13.9	44.5	68.9	630.0	834.0	2,670.0	4,134.0
5	12.0	17.0	41.5	70.5	720.0	1,020.0	2,490.0	4,230.0
6	8.5	21.6	46.1	76.2	510.0	1,296.0	2,766.0	4,572.0
7	11.0	18.3	45.9	75.2	660.0	1,098.0	2,754.0	4,512.0
8	7.5	21.0	48.7	77.2	450.0	1,260.0	2,922.0	4,632.0
9	11.0	17.8	44.3	73.1	660.0	1,068.0	2,658.0	4,386.0
10	9.4	19.2	48.0	76.6	564.0	1,152.0	2,880.0	4,596.0
11	12.5	17.3	43.2	73.0	750.0	1,038.0	2,592.0	4,380.0
12	8.7	18.0	40.0	66.7	522.0	1,080.0	2,400.0	4,002.0
13	10.6	16.1	39.3	66.0	636.0	966.0	2,358.0	3,960.0
14	8.3	19.7	42.5	70.5	498.0	1,182.0	2,550.0	4230.0
Total	**141.00**	**258.00**	**606.60**	**1005.60**	**8,460.00**	**15,480.00**	**36,396.00**	**60,336.00**

4.2 Data Analysis

In this section, it will be determined which process beholds the most problem out of the three processes (Install Component, Wire, and Busbar NSTD), in order to propose an improvement to the management. The main objective of the improvement is to reduce the amount of lost time due to inefficiency.

The first step of analysis to be taken is to compare the actual time of production with the designed time. When the total loss of time for every process is determined, the researcher will conduct a Pareto Analysis to figure which process is the most problematic. The process that accounts for 80% of the total problem or more (Pareto 80/20 rule), will be the target of improvement. Afterwards, the problematic process is then broken down into smaller details, with each sub-process with its own specified duration.

4.2.1 Calculation on Completion Time per Product

To calculate the completion time per product, the "variables total production time available" and "demand" are needed. The numbers originated from the contract agreement between PT Schneider Electric Indonesia and its client, Mogas.

$$Completion\ Time/Unit\ Product = \frac{Total\ Production\ Time\ Available}{Demand}$$

$$Completion\ Time/Unit\ Product = \frac{47{,}266\ Minutes}{14\ Products}$$

$$Completion\ Time/Unit\ Product = 3{,}376.14\ {}^{Minutes}/_{Product}$$

Project Mogas was promised to be completed in 47,266 minutes, and 14 products were expected to be delivered. From the numbers specified above, the completion time per unit product rate is derived, which is 3,376.14 minutes/product. Of the 3,376.14 minutes' total completion time per product, three activities/processes submit their share.

Table 4.4 Distribution Time Percentage for Operation

Distribution Time Percentage for Operation				
	Installing Component	Wiring	Installing Busbar NSTD	Total Completion Time / Product
%	16%	29%	55%	100%
Hrs	9.16	16.29	30.82	56.27
Min	549.43	977.48	1849.24	3376.14

"Installing component" contributes 16%, "Wiring" contributes 29%, and "Installing Busbar NSTD" contributes the highest proportion of 55%. Based on the data collected in Table 4.4, a calculation of average actual time of production is done. Table 4.5 below depicts the results of the aforementioned calculation:

Table 4.5 Average Actual Time for Each Process in Minutes

Process	Average Actual Time in Minutes
Installing Components	604.29
Wiring	1,105.71
Installing Busbar NSTD	2,599.71

The duration of work in the process "Installing Busbar NSTD" is significantly higher than the other two. The disparity between the three process is graphed in figure 4.4 below.

Figure 4.4 is graphed based on the information in Table 4.5:

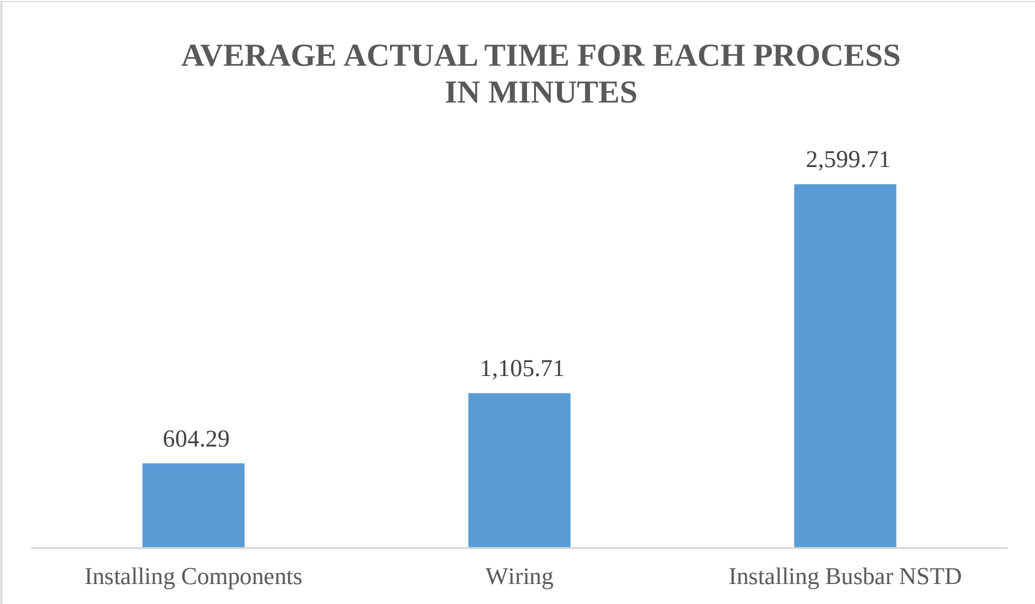


Figure 4.4 Average Actual Time for Each Process in Minutes

It is graphed in Figure 4.4 above that the process "Installing Busbar NSTD" beholds the highest number in the average actual working time. Section 4.1.1 has briefed about the complexity of this particular process. However, to determine which process is the most problematic, the numbers must be compared to the planned time; the acknowledged standard production time in the company.

Table 4.6 below enlists and compares the numbers of "Average Planned Time" and "Average Actual Time" following the three main processes in the assembly line.

Table 4.6 Comparison between Average Planned Time and Average Actual Time

Process	Average Planned Time	Average Actual Time
Installing Component	549.43	604.29
Wiring	977.48	1,105.71
Installing Busbar	1849.24	2,599.71
Total	**3376.14**	**4,309.71**

From Table 4.6, a bar chart is constructed to highlight the discrepancy between the total "Average Planned Time" and total "Average Actual Time". The difference between the two accounts is graphed in "Time Lost" (the red bar), which amounts to 933.57 minutes (approximately 27.65% of the original design time) per product made.

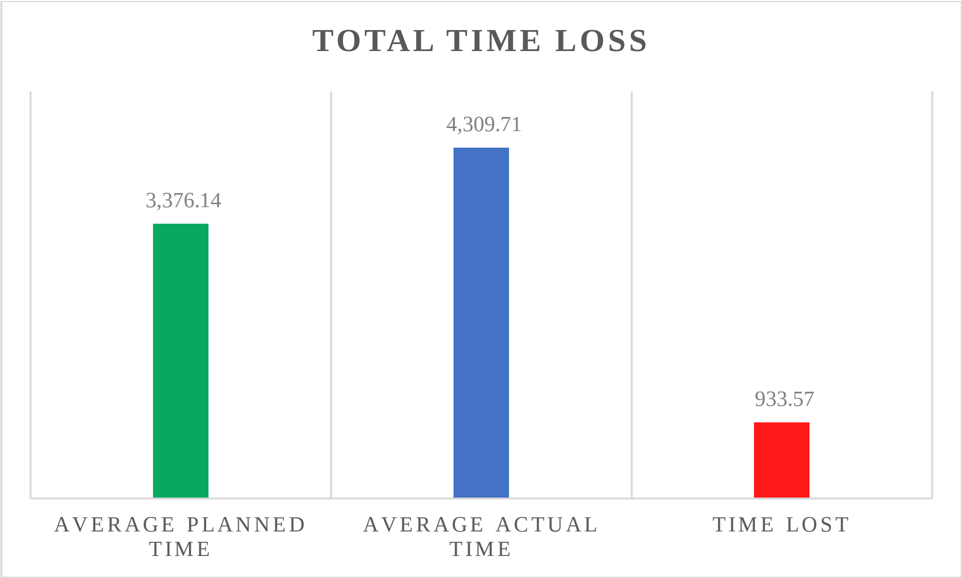


Figure 4.5 Total Time Loss

The total amount time loss is calculated based on individual time records per product made. In table 4.7 below, a detailed breakdown of time losses is specified. The largest proportion of time loss can be attributed to the process "Installing Busbar NSTD".

The following Table 4.7 shows the calculations done to determine the time loss:

Table 4.7 Time Loss Calculations

Product No	Install Component (min)			Wire (min)			Busbar NSTD (min)			Total (min)		
	Planned Time	**Actual Time**	**Time Loss**	**Planned Time**	**Actual Time**	**Time Loss**	**Planned Time**	**Actual Time**	**Time Loss**	**Planned Time**	**Actual Time**	**Time Loss**
1	549.43	732.0	182.6	977.48	1302.0	324.5	1849.24	2292.0	442.76	3376.1	4326.0	949.9
2	549.43	588.0	38.6	977.48	858.0	-119.5	1849.24	2436.0	586.76	3376.1	3882.0	505.9
3	549.43	540.0	-9.4	977.48	1326.0	348.5	1849.24	2628.0	778.76	3376.1	4494.0	1117.9
4	549.43	630.0	80.6	977.48	834.0	-143.5	1849.24	2670.0	820.76	3376.1	4134.0	757.9
5	549.43	720.0	170.6	977.48	1020.0	42.5	1849.24	2490.0	640.76	3376.1	4230.0	853.9
6	549.43	510.0	-39.4	977.48	1296.0	318.5	1849.24	2766.0	916.76	3376.1	4572.0	1195.9
7	549.43	660.0	110.6	977.48	1098.0	120.5	1849.24	2754.0	904.76	3376.1	4512.0	1135.9
8	549.43	450.0	-99.4	977.48	1260.0	282.5	1849.24	2922.0	1072.76	3376.1	4632.0	1255.9
9	549.43	660.0	110.6	977.48	1068.0	90.5	1849.24	2658.0	808.76	3376.1	4386.0	1009.9
10	549.43	564.0	14.6	977.48	1152.0	174.5	1849.24	2880.0	1030.76	3376.1	4596.0	1219.9
11	549.43	750.0	200.6	977.48	1038.0	60.5	1849.24	2592.0	742.76	3376.1	4380.0	1003.9
12	549.43	522.0	-27.4	977.48	1080.0	102.5	1849.24	2400.0	550.76	3376.1	4002.0	625.9
13	549.43	636.0	86.6	977.48	966.0	-11.5	1849.24	2358.0	508.76	3376.1	3960.0	583.9
14	549.43	498.0	-51.4	977.48	1182.0	204.5	1849.24	2550.0	700.76	3376.1	4230.0	853.9
Total	7691.98	8460.00	768.02	13684.73	15480.00	1795.27	25889.31	36396.00	10506.69	47266	60336.00	13069.98

Based on the calculations above, the process "Install Component" has a total time loss of 768.02 minutes, whereas the process "Wire" has a total time loss of 1795.27 minutes, and the process "Install Busbar NSTD" has a total time loss of 10,506.69 minutes. The total time loss of all three processes is 13,069.98 minutes, or 27.23 days. Figure 4.6 pictures the time loss calculations.

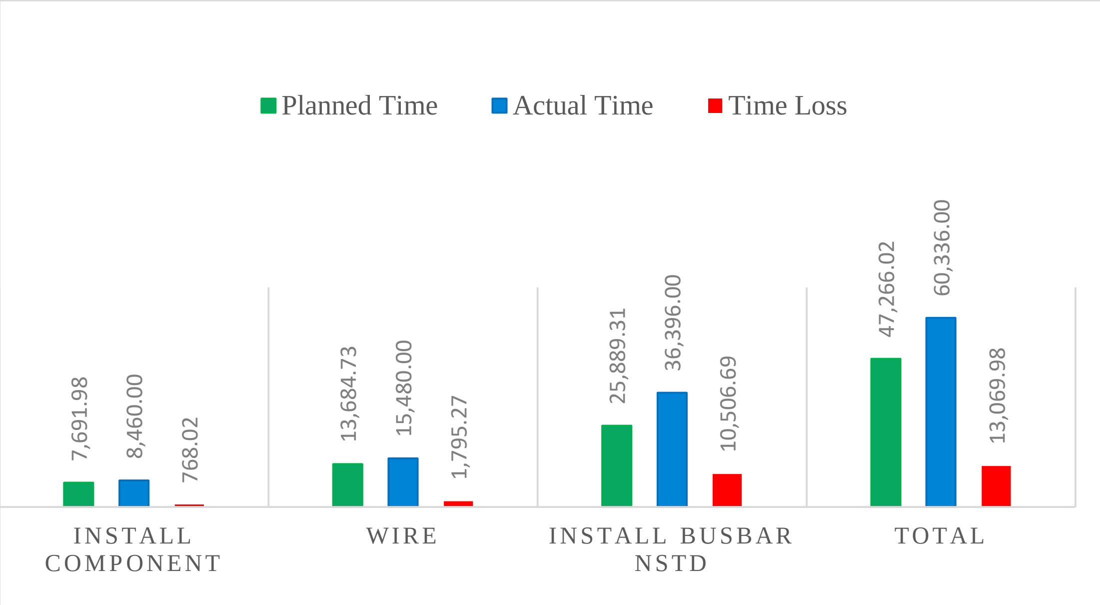


Figure 4.6 Mogas Project Time Difference Analysis in Minutes

As seen in the red colored bars, Install Busbar NSTD contributed the highest proportion to the total Time Loss. Wire is in second place with a far discrepancy, and Install Component has the least amount of Time Loss.

4.2.2 Pareto Analysis

The next step of analysis involves the Pareto Analysis. The numbers derived from the table above are sorted from the largest to the smallest, to form the Pareto Table as disclosed in Table 4.8 below:

Table 4.8 Pareto Table

Process	Time Loss (min)	Cumulative (min)	Cumulative % (min)
Install Busbar NSTD	10,506.69	10,506.69	80%
Wire	1,795.27	12,301.96	94%
Install Component	768.02	13,069.98	100%

The numbers from the columns “Time Lost” and “Cumulative %” are the basis of the analysis in Pareto Chart. It is visible that Busbar NSTD is the most problematic area, holding 80% of the total Time Lost, all to one process. This situation is depicted in Figure 4.7 below:

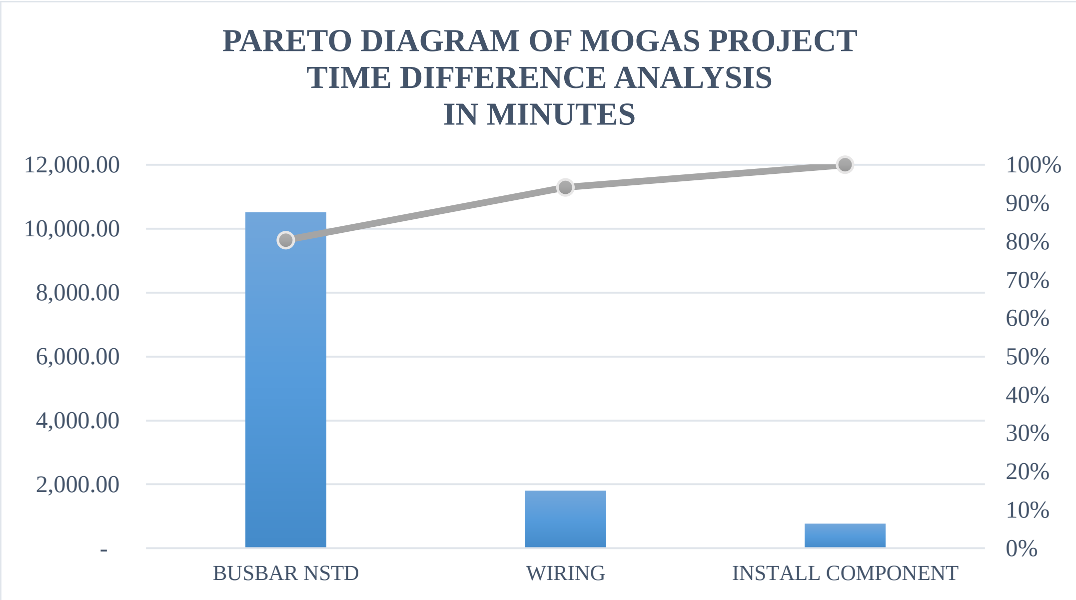


Figure 4.7 Pareto Chart

According to the Pareto 80/20 rule, 80% or more of the problem is caused by one source only. Thus, it is determined that Busbar NSTD (Installing Busbar NSTD) is the process that becomes the target of improvement.

4.3 Improved Method

4.3.1 Possible Improvement Methods

There are 2 possible methods that can be used to reduce the bottleneck process in LV Panel production based on consultation with the production leader of PT Schneider Electric Indonesia. Those methods are; adding parallel workstations and upgrading tools to pneumatic types. The two options are going to be elaborated in the points below:

1. Adding Parallel Workstations

   This option was assessed as the most feasible option in the short run. According to the management, there is almost no initial investment required to install the parallel workstation. The extra workstation is located next to the production line, marked by an additional table and two extra operators. The additional table and tools can be obtained from the company's existing inventory, because the current number of tools is adequate to cover the needs. The improvement can be done almost immediately, with minimal arrangements needed.

   The drawbacks of this improvement is that the additional workstation needs extra salaries paid to the new operators. The payment needs to be done per month, thus the cost will be stable as long as the line operates.

2. Upgrading Tools to Pneumatic Types

   PT Schneider Electric Indonesia uses manual tools to assist the operators to do the job. However, the current tools are in poor condition, resulting in difficult work for the operators. Hence, the operators needed more time to finish each product.

   This solution also comes with significant shortcomings. Firstly, the pneumatic tools are only helpful for the outer part of the panels, and not the inside. Therefore, utilizing the tools will not make too much of a difference, for a large proportion of work is related to the inside part of the product. Secondly, the pneumatic tools are very expensively priced. One tool can be purchased at the price of approximately IDR 50,000,000.00. Since there will be 2 operators manning the "Install Busbar NSTD" station, PT Schneider Electric Indonesia would need to purchase 4 tools (it takes 2 tools per person to do the job).

In order to reduce the incurred time loss in the Busbar NSTD process, the researcher proposes a solution. Based on the consulting sessions with the company's personnel and further analysis on the current workstations conditions, a suggestion is made.

Busbar NSTD's sub-processes can be divided into two types: panel related (non-detachable components from the panels), and non-panel related (detachable components from the panels). The sub-processes mentioned are in reference to Table 4.1. Amongst the 10 sub-processes, 4 sub-processes can be done outside the panel (detachable components), whereas the other 6 must be done in the panel directly (non-detachable components). Table 4.9 shows the division of the sub-processes:

Table 4.9 Division of Sub-Processes Based on Detachabilities

Process	Sub-process/Component	Detachable from Panels
Installing Busbar NSTD	Installing Top Fix Bracket	NO
	Installing Middle Fix Bracket	NO
	Installing Bottom Fix Bracket	NO
	Installing Top Mobile Bracket	NO
	Installing Bottom Mobile Bracket	NO
	Setting Top Busbar	YES
	Setting Bottom Busbar	YES
	Installing Top Main Bar	YES
	Installing Bottom Main Bar	YES
	Installing Connection Bar	NO

After categorizing the sub-processes according their detachabilities, the sub-processes are assigned to two parallel workstations to share the workload. The first new workstation under the Busbar NSTD process will be named Workstation 3A, and it is responsible for assembling the non-detachable components. The second new workstation under the Busbar NSTD process will be named Workstation B3, which is responsible for assembling the detachable components.

According to the consultation with PT Schneider Electric Indonesia, the addition of one Workstation for the process Busbar NSTD can reduce the duration of work in the Busbar NSTD process in the average of 50%.

This is possible due to the equal workload handled by the two parallel workstations. The most difficult sub-processes of Busbar NSTD are “Setting Top Busbar” and “Setting Bottom Busbar”. Furthermore, Table 4.10 below shows the time workload allocations between the Busbar NSTD sub-processes. The numbers below are stated based on an advisory consultation with PT Schneider Electric Indonesia’s personnel, calculated with approximation approach based on the average time spent on each sub-process.

Table 4.10 Time Workload Allocations for Busbar NSTD

Install Bracket and Busbar Non-Standard	**Planned Time (min)**	
	Duration (min)	**%**
Install Top Fix Bracket	166.43	0.09
Install Middle Fix Bracket	166.43	0.09
Install Bottom Fix Bracket	166.43	0.09
Install Top Mobile Bracket	129.45	0.07
Install Bottom Mobile Bracket	129.45	0.07
Setting Top Busbar	258.89	0.14
Setting Bottom Busbar	258.89	0.14
Install Top Main Bar	203.42	0.11
Install Bottom Main Bar	203.42	0.11
Install Connection Bar	166.43	0.09
TOTAL	**1,849.24**	**100%**

As listed above, the rows highlighted in blue are the sub-processes /components which fall under the “detachable” category, which will be Workstation 3B’s responsibility. The total percentage of time of these four sub-processes are 50%, which makes Workstation 3A responsible for the exact amount of workload (in time).

Figure 4.8 below depicts the new condition of the workstations after improvement:

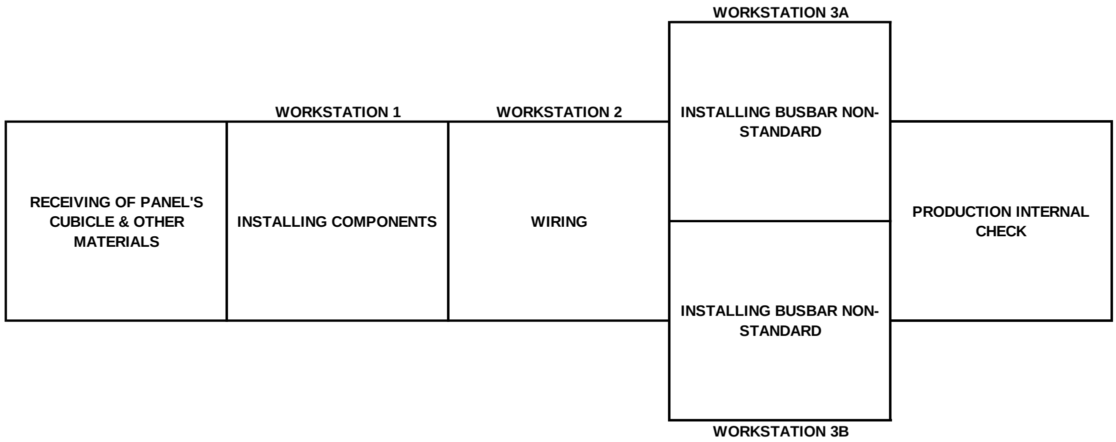


Figure 4.8 New Workstations After Improvement

As argued above, Workstation 3A is responsible for the non-detachable parts:

1. Installing Top Fix Bracket
2. Installing Middle Fix Bracket
3. Installing Bottom Fix Bracket
4. Installing Top Mobile Bracket
5. Installing Bottom Mobile Bracket
6. Installing Connection Bar

On the other hand, Workstation 3B handles the detachable parts:

1. Setting Top Busbar
2. Setting Bottom Busbar
3. Installing Top Main Bar
4. Installing Bottom Main Bar

Both Workstation 3A and Workstation 3B will handle 50% of the workload, cutting the duration of work in Busbar NSTD in half. To quantify the significance of the improvement, the researcher has done further calculations on the available data.

The following Table 4.11 shows the calculations done by the researcher to count the improvement results:

Table 4.11 Time Loss Calculation After Improvement

Pro-duct No	Install Component (min)			Wire (min)			Busbar NSTD (min)			Total (min)		
	Planned Time	Actual Time	Time Loss	Planned Time	Actual Time	Time Loss	Planned Time	Actual Time	Time Loss	Planned Time	Actual Time	Time Loss
1	549.4	732.0	182.6	977.5	1302.0	324.5	1849.2	1146.0	-703.2	3376.1	3180.0	-196.1
2	549.4	588.0	38.6	977.5	858.0	-119.5	1849.2	1218.0	-631.2	3376.1	2664.0	-712.1
3	549.4	540.0	-9.4	977.5	1326.0	348.5	1849.2	1314.0	-535.2	3376.1	3180.0	-196.1
4	549.4	630.0	80.6	977.5	834.0	-143.5	1849.2	1335.0	-514.2	3376.1	2799.0	-577.1
5	549.4	720.0	170.6	977.5	1020.0	42.5	1849.2	1245.0	-604.2	3376.1	2985.0	-391.1
6	549.4	510.0	-39.4	977.5	1296.0	318.5	1849.2	1383.0	-466.2	3376.1	3189.0	-187.1
7	549.4	660.0	110.6	977.5	1098.0	120.5	1849.2	1377.0	-472.2	3376.1	3135.0	-241.1
8	549.4	450.0	-99.4	977.5	1260.0	282.5	1849.2	1461.0	-388.2	3376.1	3171.0	-205.1
9	549.4	660.0	110.6	977.5	1068.0	90.5	1849.2	1329.0	-520.2	3376.1	3057.0	-319.1
10	549.4	564.0	14.6	977.5	1152.0	174.5	1849.2	1440.0	-409.2	3376.1	3156.0	-220.1
11	549.4	750.0	200.6	977.5	1038.0	60.5	1849.2	1296.0	-553.2	3376.1	3084.0	-292.1
12	549.4	522.0	-27.4	977.5	1080.0	102.5	1849.2	1200.0	-649.2	3376.1	2802.0	-574.1
13	549.4	636.0	86.6	977.5	966.0	-11.5	1849.2	1179.0	-670.2	3376.1	2781.0	-595.1
14	549.4	498.0	-51.4	977.5	1182.0	204.5	1849.2	1275.0	-574.2	3376.1	2955.0	-421.1
Total	**7691.98**	**8460.00**	**768.0**	**13684.7**	**15480.0**	**1795.3**	**25889.3**	**18198.0**	**-7691.3**	**47266.0**	**42138.0**	**-5128.0**

After improvement, PT Schneider Electric Indonesia is able to reduce the time loss from 13,069.98 minutes to -5,128 minutes. The negative number of time loss implies that PT Schneider Electric Indonesia could finish the project even sooner than the deadline promised in the planning horizon. The predicted reduction of time loss is 18,197.98 minutes or 37.91 days for project Mogas. PT Schneider Eletric Indonesia could cut 30.16% of the total actual production time.

4.4 Management Saving Calculations

4.4.1 Time Saving

The reduction of working time is 37.91 days, or 30.16% of the total actual production time. First, the calculation begins with the substraction of 37.91 days from the actual length of working time (125.7 days):

$$125.7\ days - 37.91\ days = 87.79\ days$$

The three numbers above are depicted in the following Figure 4.9 to be compared.

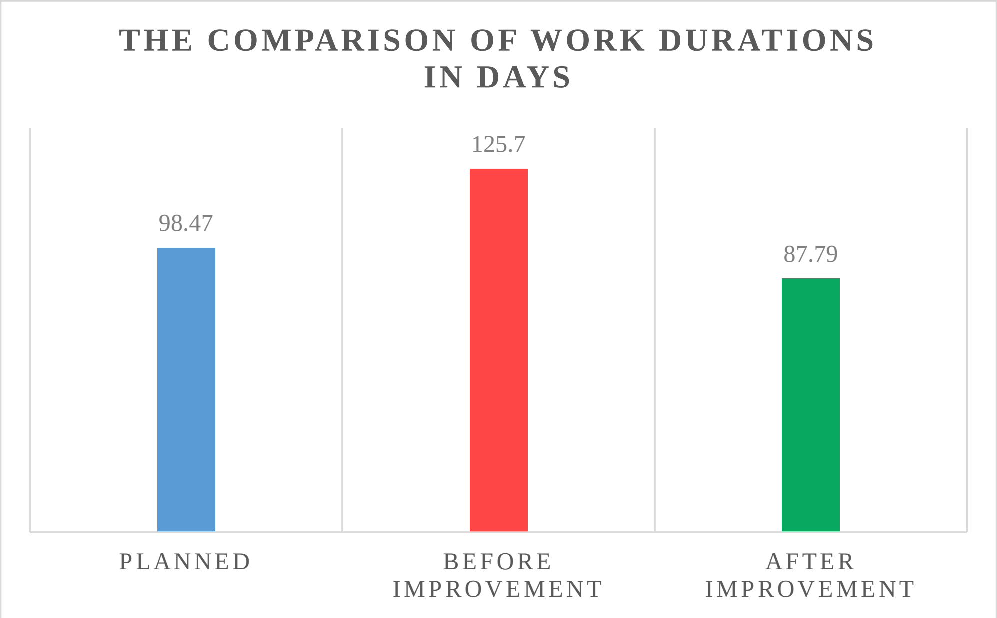


Figure 4.9 The Comparison of Work Durations in Days

The lateness of Project Mogas is pictured in Gantt Chart form in Figure 4.10, Figure 4.11, Figure 4.12, Figure 4.13, Figure 4.14, and Figure 4.15 below. The Gantt Charts attached below will only account the last three months of the project when the lateness happened in order to compare the timeline with the original planning, as well as showing where the improvement could make a difference. To focus and simplify the analysis, the Gantt Chart will only display the three key activities affected by the improvement.

The columns which heads highlighted in purple are weekends (PT Schneider Electric Indonesia operates 5 days a week), and those highlighted in orange are public holidays. Each activity is recorded within 3 timelines respectively from top to bottom: the planned timeline is highlighted in blue, the actual timeline is highlighted in red, and the improved timeline is highlighted in green. Red cells with numbers in them indicate that overtime was done on the day. Overtime shifts may happen both on working days and public holidays or weekends.

Figure 4.10 Simplified Gantt Chart for The Month January 2017

PT Schneider Electric Indonesia started working on Project Mogas on 2 January 2017. The pace of work follows the original planning horizon, resulting in a total of 22 working days. No overtime shift was imposed during this month.

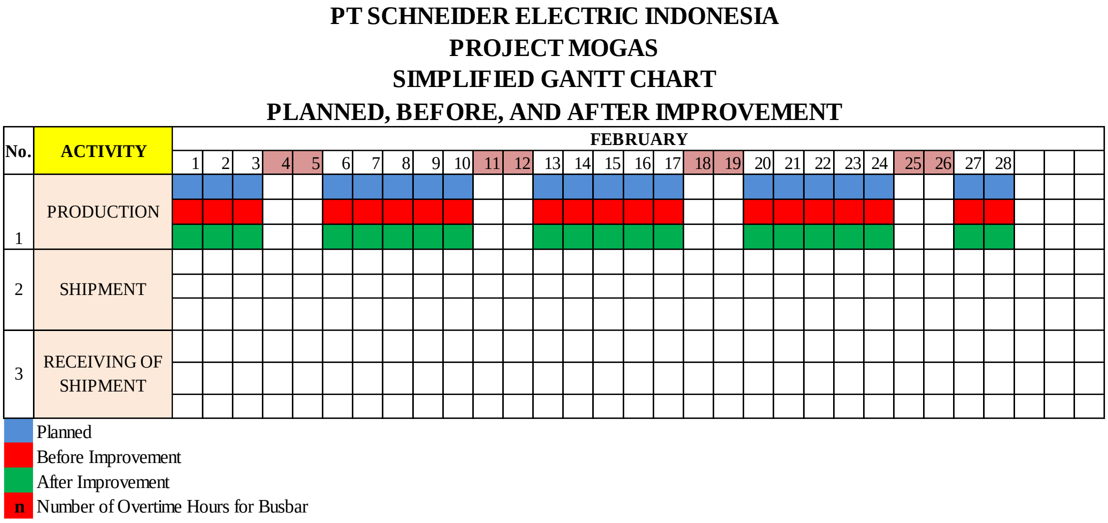


Figure 4.11 Simplified Gantt Chart for The Month February 2017

The month of February went according to plan as well, resulting in a total of 20 working days. No overtime shift was imposed during this month.

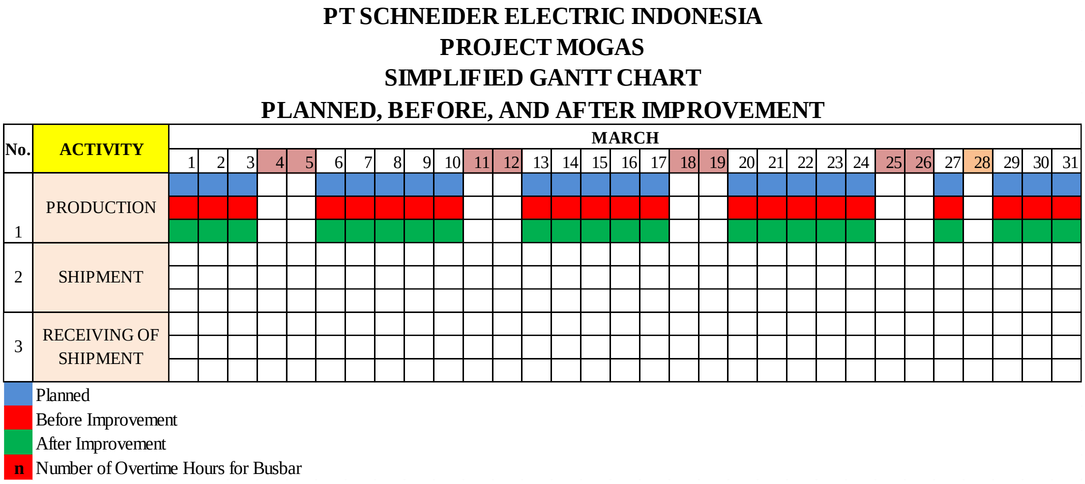


Figure 4.12 Simplified Gantt Chart for The Month March 2017

The month of March went according to plan as well, resulting in a total of 22 working days. There was 1 public holiday, and no overtime shift was imposed during this month.

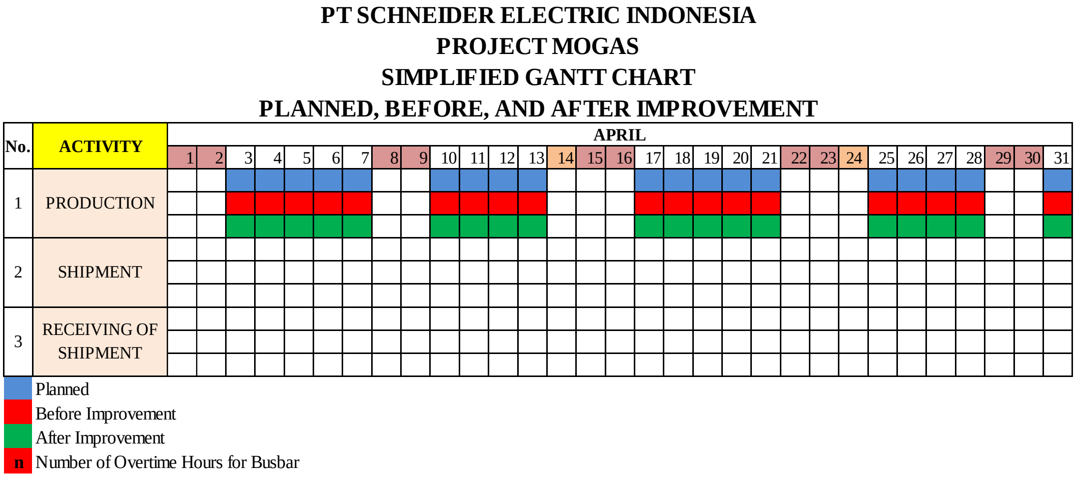


Figure 4.13 Simplified Gantt Chart for The Month April 2017

The month of April went according to plan as well, resulting in a total of 19 working days. There was 2 public holidays, and no overtime shift was imposed during this month.

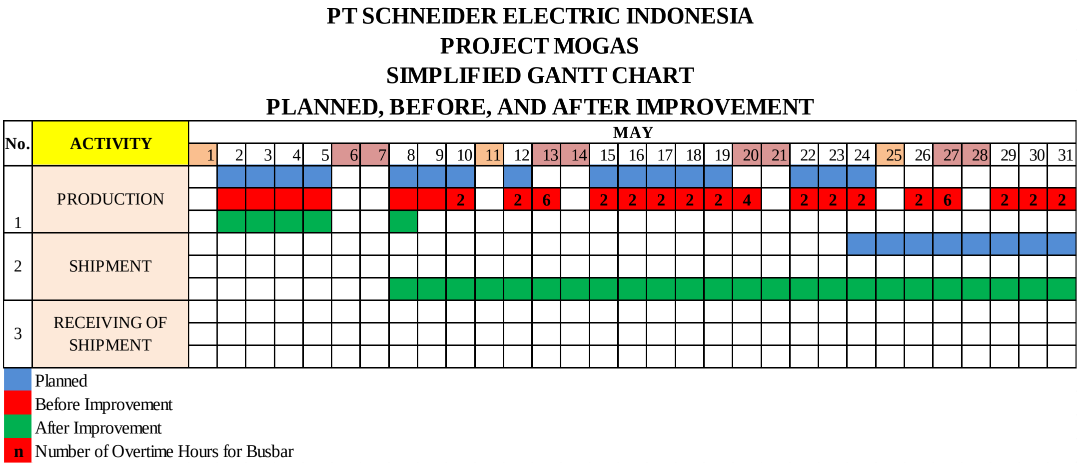


Figure 4.14 Simplified Gantt Chart for The Month May 2017

In May, the lateness becomes evident. The production of panels was suppposed to be finished on 24 May 2017. However, the actual production was not finished until the following month. This happened despite PT Schneider Electric Indonesia's effort to speed up the production with additional overtime shifts. 48 hours of overtime shifts were imposed on normal working days, and 16 hours of overtime shifts were imposed on weekends. Under the improvement, the production could speed up and finish even before the planning horizon. The finishing of production and the shipment could begin immediately on 8 May 2017.

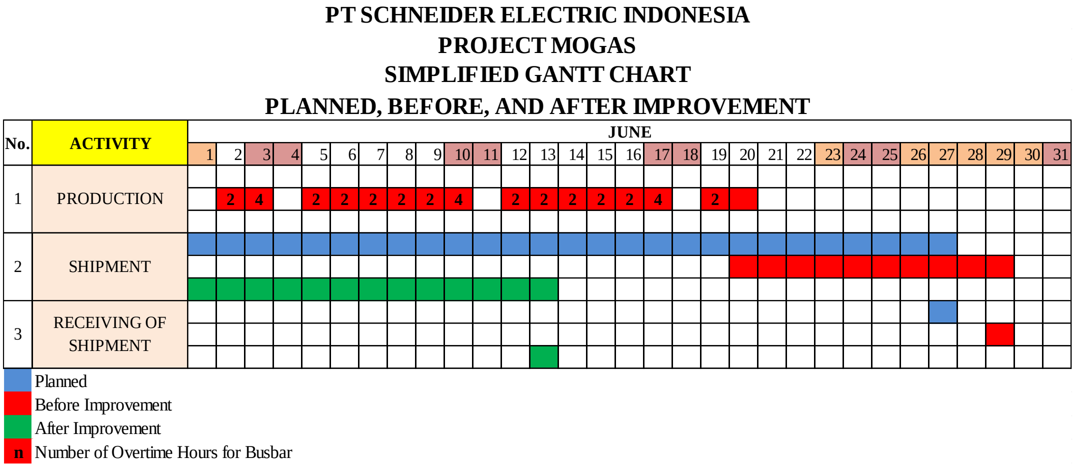


Figure 4.15 Simplified Gantt Chart for The Month June 2017

The actual production was finished on 20 June 2017. This lateness pushed the shipping timeline to 20 June 2017, just 8 days before the receiving date in sales contract agreement. Thus, PT Schneider Electric Indonesia was forced to convert the transportation means from marine shipment to airborne shipment. The air transportation managed to cut the length of delivery time from 35 days to just 10 days, but with great cost. The total lateness was 2 days, resulting in effective fine for Schneider's end. However, this situation could improve under the improvement. With a cut on the production time, the products could be delivered notably faster, hence received on 13 June 2017; way before the original timeline.

Since the project can be finished earlier than the planning horizon (98.47 days), PT Schneider Electric Indonesia's costs related to the project will change accordingly. Many factors will be affected when the improvement comes into effect. The changes between the before and after improvement situations will be elaborated in details below.

4.4.2 Cost Saving

In order to complete the proposal, a thorough financial analysis had been conducted to calculate the savings PT Schneider Electric Indonesia could gain from the improvement.

The expense accounts related to the improved method are only the following: basic salary, overtime working hours, delivery/freight costs, and lateness fines. There is no difference in the amount of energy utilized under the new condition, because the extra work station will be located in the same production room (no extra electricity or energy budget required). The extra workstation will be using available tool stock at their disposal, since the company already has an adequate number of tools to operate an extra workstation. There is also no tax difference under the improved method. The only tax accounts affected will be those of the employees's. However, PT Schneider Eletcric Indonesia's tax system for employee deducts the tax payable from the basic salary pay. Therefore the final amount of budget remains the same. PT Schneider Electric Indonesia does not pay extra for the employees's taxes; the employee tax payable is included in the salary.

In the current situations (before improvement), PT Schneider Electric Indonesia is at risk of being late 27.23 normal working days. Such tardiness is intolerable, and the company needs to compensate with extra efforts. Below is listed several expense accounts those are relevant to the conditions before improvement:

1. Basic salary paid. The calculation of salary will follow a standard salary rate for operators in PT Schneider Electric Indonesia, which is IDR 4,200,000 per month. According to the national standard, in order to find the rate per hour, the formula will divide the monthly salary rate by 173 hours.

$$Normal\ Salary\ Rate = \frac{1}{173\ hr} \times Basic\ Pay$$

$$Normal\ Salary\ Rate = \frac{1}{173\ hr} \times IDR\ 4{,}200{,}000$$

$$Normal\ Salary\ Rate = {}^{IDR\ 24{,}277.46}/_{hr}$$

This analysis will only account for the change in ”Installing Busbar NSTD” operators’s salary. This is due to the effect of the improvement that will only be impactful toward the operators responsible for ”Installing Busbar NSTD”. The remaining operators’s salary will not be affected by the improvement.

As explained in Table 4.3, Project Mogas was finished in 1,005.60 hours. Since the calculation will only focus on the ”Installing Busbar NSTD” process, the number of hours should follow that of Busbar NSTD’s, which took 606.60 hours to finish. Amongst the 606.60 hours, 526.6 hours were categorized as normal working hours (the remaining 80 hours are overtime shifts, the breakdown is visible in the Gannt Chart for the months May and June).

Based on the calculations above, PT Schneider Electric Indonesia paid the following amount per worker for ”Installing Busbar NSTD” Operator in Mogas Project, excluding overtime pay:

$$Salary\ per\ Worker = IDR\frac{24{,}277.46}{hr} \times\ 526.6\ hr$$
$$= \ IDR\ 12{,}784{,}510.44$$

Under the current situations, PT Schneider Electric Indonesia hires 2 operators for ”Installing Busbar NSTD” process in the production line. The total salary paid for the 2 operators is:

$$Total\ Salary\ Paid = IDR\ 12{,}784{,}510.44\ \times\ 2$$
$$= \ \ IDR\ 25{,}569{,}020.87$$

2. Overtime working hours for the operators. To speed up the production process, PT Schneider Electric Indonesia needs to schedule the operators for long working hours. A shift is categorized as overtime when it exceeds 8 hours per day and 40 hour per week for 5 working days. The overtime

pay rate calculation will follow the local regulation of the Indonesian Government.

a. On working days:

i. 150% of the normal salary rate on the first hour,

ii. 200% of the normal salary rate on the following hours,

iii. Maximum of 3 hours per day per worker, and 14 hours per week per worker,

b. On weekends or public holidays:

i. 200% of the normal salary rate on the first 8 hours,

ii. 300% of the normal salary rate on the 9th hour.

iii. 400% of the normal salary rate on the 10th hour and the 11th.

iv. Maximum of 11 hours per day per worker on public holidays or 2 resting days of the week.

Refering to the Gannt Chart for the months May and June, PT Schneider Eletric Indonesia imposed the following overtime shifts in Project Mogas: The first, Table 4.12 discloses the detailed of the overtime hours that was done on normal working days.

Table 4.12 Overtime Shifts on Normal Working Days

Date	No. of Hours	Date	No. of Hours
10/5	2	31/5	2
12/5	2	2/6	2
15/5	2	5/6	2
16/5	2	6/6	2
17/5	2	7/6	2
18/5	2	8/6	2
19/5	2	9/6	2
22/5	2	12/6	2
23/5	2	13/6	2
24/5	2	14/6	2
26/5	2	15/6	2
29/5	2	16/6	2
30/5	2	19/6	2
TOTAL		**52 hours**	

On the other hand, Table 4.13 will show the overtime hours that was done on weekends or public holidays.

Table 4.13 Overtime Shifts on Weekends/Public Holidays

Date	No. of Hours	Date	No. of Hours
13/5	6	3/6	4
20/5	4	10/6	4
27/5	4	17/6	4
Total		**28 hours**	

Based on the data displayed above, the overtime pay calculation is as follows:

Table 4.14 Overtime Calculation for Working Day

Hour Number	Number of Operator	Number of Days	Salary Rate	Overtime rate	Overtime Cost
1	2	26	IDR 24,277.46	150%	IDR 1,893,641.62
2	2	26	IDR 24,277.46	200%	IDR 2,524,855.49
Total					IDR 4,418,497.11

Table 4.15 Overtime Calculation for Public Holidays and Weekends

Hour Number	Number of Operator	Number of Days	Salary Rate	Overtime rate	Overtime Cost
1	2	6	IDR 24,277.46	200%	IDR 582,658.96
2	2	6	IDR 24,277.46	200%	IDR 582,658.96
3	2	6	IDR 24,277.46	200%	IDR 582,658.96
4	2	6	IDR 24,277.46	200%	IDR 582,658.96
5	2	2	IDR 24,277.46	200%	IDR 194,219.65
6	2	2	IDR 24,277.46	200%	IDR 194,219.65
Total					IDR 2,719,075.14

$$Total\ Overtime\ Cost = IDR\ 4{,}418{,}497.11 + IDR\ 2{,}719{,}075.14$$

$$Total\ Overtime\ Cost = IDR\ 7{,}137{,}572.25$$

3. The acceleration of the delivery. This is important to keep the customers satisfied with PT Schneider Electric Indonesia’s services. The standard freight costs of the company is based on marine/sea logistics prices. However, in case of lateness, PT Schneider Electric Indonesia needs to switch their delivery method from Sea freights to Air freights. This switch

also incurs a significant raise of costs on PT Schneider Electric Indonesia's end. The airborne freight estimated tarriff follows a price specified in US dollar, which is USD 11,569. For this calculation, a conversion rate of IDR 13,343.75 per USD 1 is used, resulting in an estimated price of IDR 155,574,781.25 for shipping 14 electrical panels to Dubai.

4. Lateness fines are based on contract agreements. To ensure maximum customer satisfaction, PT Schneider Electric Indonesia gives out compensation for any possible inconvenience caused by their lateness. The fine rate differs from one contract to another, but the average rate is 2% of the total price per day of lateness. Each LV Panel in Mogas project is sold at an estimated price of IDR 180,000,000.00. Hence, the total estimated price for 14 panels accummulated is IDR 2,520,000,000.00. Since the saes contract is valued at such an expensive price, one day of lateness is charged IDR 50,400,000.00. Referring to the Gantt Charts on Figure 4.10 to Figure 4.15, PT Schneider Electric Indonesia's delivery was late for 2 days. The company became subject to fine, charged at IDR 100,800,000.00.

After improvement, PT Schneider Electric Indonesia is able to make more LV Panel products per month, at the expense of additional costs for improvement. Below is broken down the expense accounts relevant to the conditions after improvement:

1. The basic salary of four operators. With efficient process, PT Schneider Electric Indonesia does not need to impose overtime shift for its employees, hence the eliminated overtime pay account. The calculation on this section resembles the one displayed in the previous condition (before improvement). After the improvement, PT Schneider Electric Indonesia would be able to cut down the length of "Installing Busbar NSTD" process from 606.6 hours to 303.3 hours. At *ceteris paribus*, the value of basic salary paid per worker for project Mogas is:

$$Salary\ per\ Worker = IDR\,\frac{24{,}277.46}{hr} \times\ 303.3\ hr$$
$$= IDR\ 7{,}363{,}353.62$$

To man the additional workstation in ”Installing Busbar Non-Standard” process, PT Schneider Electric Indonesia needs to hire two extra operators at the cost of normal salary rate at IDR 4,200,000.00/month. The total basic salary paid to 4 workers is:

$$Total\ Salary\ Paid = IDR\ 7{,}363{,}353.62\ \times\ 4 =\ IDR\ 29{,}453{,}414.47$$

Note that the calculations done in this point involve the variable salary rate, which is derived from the calculation of normal salary rate in the preceeding before improvement section.

2. Standard freight cost by sea. Without the lateness, PT Schneider Electric Indonesia does not need extra budget to switch the shipment from sea to air. Even by marine shipment, the products can be received ahead of time. The induced tarriff of sea/marine logistics is significantly lower than the condition before improvement. Marine logistics tarriff for delivering the order of project Mogas will also follow a price in US dollars, which is USD 2,590.00. Since the conversion rate to IDR is IDR 13,343.75, the total freight cost by sea for Project Mogas is IDR 34,560,312.50.

The calculations above lead to financial benefits for PT Schneider Electric Indonesia. Table 4.15 below does a summary of cost calculations under the two conditions: before improvement and after improvement. By implementing this proposed improvement, PT Schneider Electric Indonesia is able to save IDR 225,067,647.40 overall; marking a significant management saving to increase the company’s profitability.

Table 4.16 Total Cost & Management Saving Calculation

Total Cost & Management Saving Calculation		
Expense Accounts	**Before Improvement**	**After Improvement**
Salary	IDR 25,569,020.87	IDR 29,453,414.47
Overtime	IDR 7,137,572.25	-
Airborne Freight	IDR 155,574,781.25	-
Sea Freight	-	IDR 34,560,312.50
Fines	IDR 100,800,000.00	-
Total Cost	**IDR 289,081,374.37**	**IDR 64,013,726.97**
Saving	**IDR 225,067,647.40**	

Figure 4.16 below depicts the significant cost saving, feasible due to the improvement.

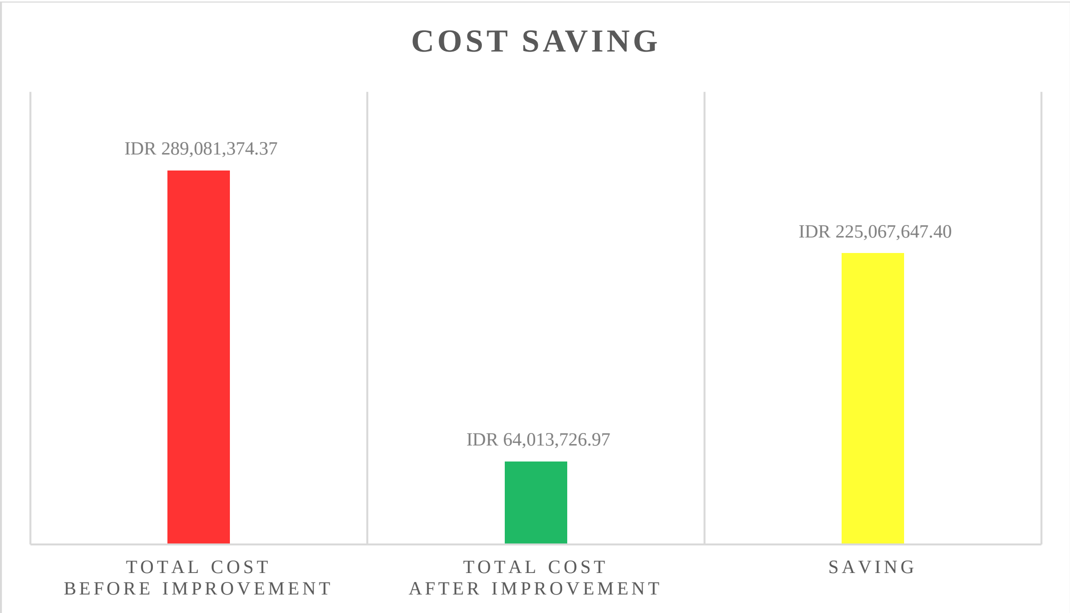


Figure 4.16 Cost Saving

The improvement results in a substantial cost saving of 77.86% of the current actual total cost. PT Schneider Electric Indonesia only needs to pay 22.14% of their current actual total cost to fund the Mogas Project operations.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

From this research, it can be concluded as follows:

1. The most prominent processes that require attention are: “Installing Components”, “Wiring”, and “Installing Busbar Non-Standard”. These are the activities that happen in the production line.

2. Amongst the three processes, “Installing Busbar Non-Standard” is the most problematic process; occupying 80% proportion of total time loss in the Pareto Chart. Therefore, it can be concluded that “Installing Busbar Non-Standard” is the bottleneck of the process, hence becoming the target for improvement.

3. Based on the options available for reducing/eliminating the impact of bottleneck, management chooses to improve capacity by adding resources. Management believes the most feasible option in the short run is to run two parallel workstations for the process “Installing Busbar Non-Standard”. The solution for reducing completion time of LV Panels is by dividing the “Installing Busbar Non-Standard” process into two categories: detachable components and non-detachable components, each deserving its own workstation carrying 50% of the workload. By imposing this improvement, PT Schneider Electric Indonesia could speed up the production process by 30.16% or 18,197.98 minutes normal working days from 125.7 normal working days to 87.79 normal working days. After improvement, management is able to save 77.86% of the actual current costs or IDR 225,067,647.40.

5.2. Recommendation

There is also another option to consider in proposing the improvement. Currently, PT Schneider Electric Indonesia does not own adequate tools to aid their operators. The tools at their disposal are in poor quality and in need of more intensive maintenance or even replacement. However, the management discarded this option when consulted, due to the high initial investment needed to purchase the new tools.

In contrast to the improvement proposed in this paper, buying new tools might incur large initial investment but require lower costs afterwards. Hiring new operators will incur a flat distribution of cost each month, which is the monthly salary payment. The purchasing of new tools does not incur as much cost in the coming period, only regular minimum maintenance fee is needed.

Therefore, even though the “buying new tools” option seems rather expensive, the price tag should not scare off if it could yield apparent rewards in the long run.

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