ANALYZING STANDARDIZED WORKS OF NONCYCLICAL PROCESS WORKERS THROUGH *KAIZEN* IMPLEMENTATION

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THESIS ADVISOR
RECOMMENDATION LETTER

This thesis entitled "**Analyzing Standardized Works of Noncyclical Process Workers through *Kaizen* Implementation**" prepared and submitted by Irfan Zidni 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 Verbal Defense.

Cikarang, Indonesia, May 10th 2017

<u>**Johan K. Runtuk, S.T., M.T**</u>

DECLARATION OF ORIGINALITY

I declare that this thesis, entitled "**Analyzing Standardized Works of Noncyclical Process Workers through *Kaizen* Implementation**" 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, May 10th 2017

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ABSTRACT

Every year worker's salaries is increasing in every region in Indonesia. The increasing on Indonesia inflation rate causing the worker to demand salaries increase. In the other hands, the company must maintaining their manufacturing cost to minimum in order to attain profit. Companies need to find solution to maintaining their economic equity without ignoring the workers happiness. One of the problem, IJK Company currently facing is manpower efficiency in one of their warehouse. Warehouse is included in type III standardized works which is noncyclical process. The research is using standardized works for noncyclical process to collecting data of current process. The data is collected in form of yamazumi chart and noncyclic work summary sheet. The current average manpower efficiency of the warehouse is 71,43%. The data had been gathered will be used as decision making for kaizen. Kaizen will reduce non-value added activities in the warehouse process. Therefore, after kaizen manpower efficiency become 64,63%. Then, the processes will go through process balancing to equalize their working time. After process balancing one process is merged with other processes. Therefore, increasing average manpower efficiency again to 71,21% and reduce number of work force needed to run the entire warehouse processes.

Keyword: *manpower efficiency, standardize works, noncyclical process, yamazumi chart, kaizen, process balancing*.

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Manpower Efficiency:	the ability of the worker to do something without waste.
Standardized Work:	work which the sequence of job elements has been efficiently organized, and is repeatedly followed by the worker.
Yamazumi Chart:	stacked bar chart that shows the source of the cycle time in a given process.
Kaizen:	continuous improvement
Process Balancing:	procedure whereby a set of process steps are equalized in terms of time required to accomplish them.
Type III Works:	noncyclical process that have long cycle time, consist a lot non-value added activities, work sequence is not repetitive, and takt time is cannot be defined.

CHAPTER I
INTRODUCTION

1.1 Problem Background

Every year worker’s salaries is increasing in every region in Indonesia. The increasing on Indonesia inflation rate causing the worker to demand salaries increase. In the other hands, the company must maintaining their manufacturing cost to minimum in order to attain profit. Companies need to find solution to maintaining their economic equity without ignoring the workers happiness.

According to Beach (1975), manpower management is a process for determining and assuring that the organization will have an adequate number of qualified persons, available at the proper times, performing jobs which meet the needs of the enterprises and which provide satisfaction for the individuals involved. According to Yoshiki, Aura, and Lorelie (2015), effective utilization of manpower comes with a lot of advantage such as cost reduction, clarity in performing tasks, saves money as well as time, less wastage, and organizational goals can be achieved faster.

The company have to consider total amount of human resources needed to run their production line. In other words, the company need to manage their manpower to increase their efficiency. The amount of manpower needed to run the system need to be considered carefully. If the number of manpower inside the facility is exceeding the amount needed to run the system properly, it will result in high idle time and low manpower efficiency. Otherwise, if the number of manpower is less than amount needed, it will reduce the overall productivity of the company and could risk the health and safety of manpower.

Manpower efficiency greatly affect the total cost to produce the product. Wages is calculated from hours of working. The company assume workers to be working all the time with some allowance, but in reality the workers must have idle time. There is limited amount of idle time allowed in one shift of works. But, in some cases the idle time exceeding the allowed limit. Consequently, the money that used to pay the worker is not used optimally because of high number of idle time.

Toyota Production System (also called Lean Manufacturing) is a concept whereby all production employees work together to eliminate waste (Meyers and Stewart, 2002). According to Jon Miller (2010), type I, II, and III classification is a new term used to specifically explain the variants of standardized works to overseas Toyota plans.

IJK Company is one of manufacturing company that followed Toyota Production System. IJK Company produce automotive parts for light and medium duty trucks. There are three different type of standardized works which are type I, type II, and Type III. Type I standardized works for works with repetitive cycle. Type II standardized works for works with variable cycle. Lastly, type III standardized works for noncyclical works.

According to Niederstadt (2010), noncyclical work is work where the key elements are repeatable, but the sequence in which they occur is not repeatable. Also, it is important to define non-value added but necessary (NVA Necessary) and non-value added (NVA) work categories in noncyclical process.

IJK Company currently facing problem of manpower efficiency in one of their warehouse. Workers inside the warehouse are categorized as *type III* standardized works. This type is include all types of process that takt time cannot be calculated. There are nine processes of works inside the warehouse. Defining necessary and unnecessary works of the processes is important to find solution for increasing manpower efficiency and utilization.

According to Niederstadt (2010), noncyclic work summary sheet is a great tools used to define the work categories into NVA Necessary and NVA. Joseph Niederstadt (2010) also mentioned *yamazumi* chart is informative decision making tools that provide great visual display that drives the impact of the data to those viewing it. *Yamazumi* chart is mainly used in standardized work for noncyclical process to see current state and after improvement condition of the work processes. According to Imai (1986), *kaizen* is continuous improvement that involves everyone in the process and give huge impact although the improvement is small and incremental.

The warehouse for production plant 2 and plant 3 (also called warehouse 2,5) as one of the largest warehouse in IJK company need to improve their manpower efficiency and utilization. Warehouse which have noncyclical works need different standardized works unlike regular works in assembling line or machining line. Collecting information for decision making and improvement strategies act ivies is totally different from cyclical works. Because of that, type III standardized works using noncyclic work summary chart and *yamazumi* chart for decision making data. In the other hand, *kaizen* is good for creating improvement in the process that consist a lot of small tasks. Implementing *kaizen* idea will reduce waste in the process. Finally, by balancing the process it will increase the average manpower efficiency and utilization of the warehouse process.

1.2 Problem Statement

Based on the problem occurs on IJK Company, this research is conducted to answer these following questions:

- How does the company knows the current manpower efficiency and utilization of warehouse 2,5 using noncyclic work summary sheet and *yamazumi* chart?
- What is the difference between manpower efficiency and utilization inside warehouse 2,5 before and after *kaizen* idea implementation?
- How does the company reduce number of workforce needed using process balancing procedure in the warehouse?

1.3 Research Objectives

The main objectives of this research are as follows:

- To determine current manpower efficiency and utilization inside warehouse 2,5 using noncyclic work summary sheet and *yamazumi* chart.
- To determine the difference between manpower efficiency and utilization before and after *kaizen* idea had been implemented inside warehouse 2,5.
- To determine the effect of process balancing in reducing number of workforce needed to run the warehouse process.

1.4 Scope and Limitation

Due to limited time and resources in doing this research, there will be some scopes in the observation:

- The research data analysis is based on estimation of how the improvement effect manpower efficiency and utilization.
- The data were taken from July until September 2016
- The data were taken only from warehouse 2,5 and only first shift workers, with total 9 workers.

1.5. Assumption

There are several assumptions in order to support this research:

- Every shift have the same total available time.
- The data of the research is accurate.

1.5 Research Outline

Chapter I Introduction

This chapter consists of problem background, problem statements as the things to be solved, objectives to be achieved in this research, scope as the limitation, assumption, and research outline of the study.

Chapter II Literature Study

This chapter provides literature review of previous studies on the same areas of this projects. This chapter will strengthen the foundation of the project and support the calculation and analysis of the data.

Chapter III Research Methodology

This chapter describes the flow of this research and explanation of each step to conduct this research.

Chapter IV Data Collection and Analysis

This chapter explains about data collecting activities including output of data processing. Then, analyze the data that have been collected to achieve the goals.

Chapter V Conclusion and Recommendation

This chapter give a final result of the research and closing statement regarding future research and recommendation.

CHAPTER II
LITERATURE STUDY

2.1 Toyota Production System

The concept of lean manufacturing was developed by Taiichi Ohno at Toyota Motor Company in the 1950's. Toyota Production System (TPS) is an assembly-line manufacturing methodology developed originally for Toyota and for the manufacturing of the automobiles. Toyota Production System focuses on abolishing or reducing waste and on maximizing or fully utilizing the activities that add the value from the customer's perspective.

Toyota Production System (TPS) aims at half the human effort in the factory, half the manufacturing space, and half the engineering hours to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site, resulting in many fewer defects, and producing a greater and ever growing variety of products (Womack et al., 1990).

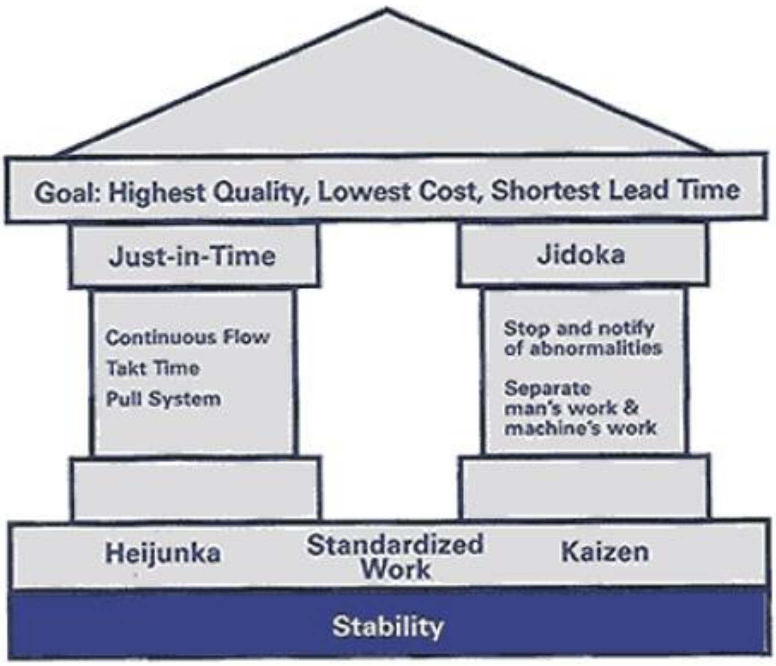


Figure 2.1 Toyota Production System "House"

Toyota Production System (TPS) is visualized as a house where each element plays an important role to the entire structure. The strong foundation of the house is the constitution of four elements – philosophy, visual management, stability and standardization, implying its importance or presence before any other part of the structure could be made. The house of TPS is a metaphor that was designed by Ohno to fit objectives, strategy, tactics, skills and foundational elements of TPS together (Wilson, 2010).

2.1.1 Wastes

The organizations' success is dependent on the integrated working of mean, method, material and machine at the worksite. Wastes are prevalent all over the organization, but as one lives with it or works around it, it gets hidden. TPS identifies series of wasteful activities in the processes and adds value to them by the thorough and continuous elimination of waste. Value is said to be added, when the products is physically changed towards what the customer is intending to purchase. It is added, when a service is provided for which the customer is willing to pay. There three types of activities classified in TPS, the three types as follows:

- ***Non-value adding (NVA)***

These are pure wastes and involve unnecessary actions which should be eliminated if possible. For example waiting time, double handling and so forth.

- ***Necessary but non-value adding (NNVA)***

These activities may be wasteful but are necessary under the current operating procedures, hence, are called 'incidental waste'. The company does not find value in these activities and does not want to pay for them but still these are required due to the process limitations, current technology and government regulations. For example walking long distances to pick up parts, unpacking deliveries and transferring a tool from one hand to another, quality check and so forth.

- ***Value adding (VA)***

These activities transform the nature, shape or characteristics of an information or product in line with the customer requirements. Customer values these activities, are willing to pay for it and they will know, if this activity is removed. For example joining parts of collar, embroidering garment and so forth.

There are three forms of waste at work namely *Muri*, Mura and *Muda* These words are interconnected and are often used together and referred to as the three M's in Japan. Mura means 'unevenness', and Muri means 'overburden' or 'excess' and *Muda* means 'waste'.

Source: Isao Kato & Art Smalley (2010)

Figure 2.2 Muda, Mura, & Muri

- **Muri**

The term 'Muri' in Japanese stands for excessive or overburdening of the people, facilities and equipment which has a direct impact on the employee's morale in a negative manner. It includes bad working conditions and pushing a machine or a person beyond its natural limits, leading to work stress. When the employee is forced to take too many decisions during the times of stress, it too ends up being a waste of fruitful labor such as carrying heavy weights, operating computerized knitting machine without the safety cover in order to work significantly faster than usual and so forth.

- ***Mura***

The term 'Mura' in Japanese stands for unevenness, irregularity, variation and inconsistency in terms of quality and the volume in the operation of a process in the production system. It is not caused by the end customers, but caused by up and down in the demand or irregular production schedule or fluctuating production problems. As it involves uneven production, it becomes necessary to have extra material, equipment, and operation on hand in anticipation of the highest demand, even though the average demand might be much less.

- ***Muda***

It is Japanese word meaning futility, uselessness, idleness, superfluity, wastage and so forth, it is a non-value added activity from customer's point of view. It is the most familiar 'M' which includes waste of time, consumable resource and dissatisfaction or incomplete satisfaction. Waste occurs when more resources are consumed than are necessary to produce the goods or provide a service that the customer actually wants. There are ten types of wastes, they are as follows:

i. *Overproduction*. It is referred to as the 'just in case' meaning producing more than the buyer's demand or production in anticipation, rather than the actual demand. It occurs due to the production of the product before it is actually required, of which there are no orders or when rate of production is faster than consumption at a given point of time. It is regarded as the most serious, worst and fundamental waste, as it not only leads to other wastes but also discourage a smooth flow of goods or services inhibiting quality and productivity.

ii. *Excess inventory*. It is called a mismatch between demand and supply. Waste of inventory requires extra space for storage; time and effort; capital locked in purchased materials and material used between processes; extensive rework; damaged, obsolete and unfit inventory; larger material handling system to move larger quantities of goods, and increase in lead time for delivery (Hines & Rich, 1997).

iii. *Waiting*. Queuing for anything is a waste. When the time is being used ineffectively and the goods are not mobbing or being worked on, then the waste of waiting occurs (Hines & Rich, 1997).

iv. *Waste of excess motion*. It involves the unnecessary movements in production where the operators have to stretch, bend and pick up, and extra "busy" movements while waiting when these actions could be avoided. Such waste is tiring for the employees and is likely to lead to poor productivity and, often, to quality problems (Hines & Rich, 1997). Causes for this type of waste are faulty equipment and plant layout, lack of 5 S's, lack of visual controls, inconsistent work methods, large batch sizes and so forth.

v. *Excess transportation*. This includes moving materials, parts, or finished goods between processes or into or out of storage. It leads to double handling, deterioration in quality, delay in communication between processes and poor quality feedback further delays corrective action (Hines & Rich, 1997).

vi. *Rework*. Product defects occur when the work pieces are reprocessed or repaired due to the incapable processes, excessive variation, incapable suppliers, management decisions, insufficient training, inadequate tools or equipment, poor layout, unnecessary handling and high inventory levels. In mass production defects are rarely visible as the get hidden below the inventory while in continuous flow, the defects destroys the balance resulting even in a missed shipment. Consequences of product defects are additional labor, extra floor space, tools, equipment, effort, time, material, missed shipments or deliveries, lower profits and money to disassemble and reassemble defective product It becomes serious when the defective product reaches the customer and it will cause customer dissatisfaction and may result in the loss of future business and market share.

vii. *Inappropriate processing*. It means over processing, incorrect process and inefficient processing. Causes of this type of waste are decision making at inappropriate levels, inefficient policies and procedures, lack of customer input concerning requirements and use of expensive, large, inflexible machine, high precision equipment instead of several, small, flexible simpler tools (Hines & Rich 1997).

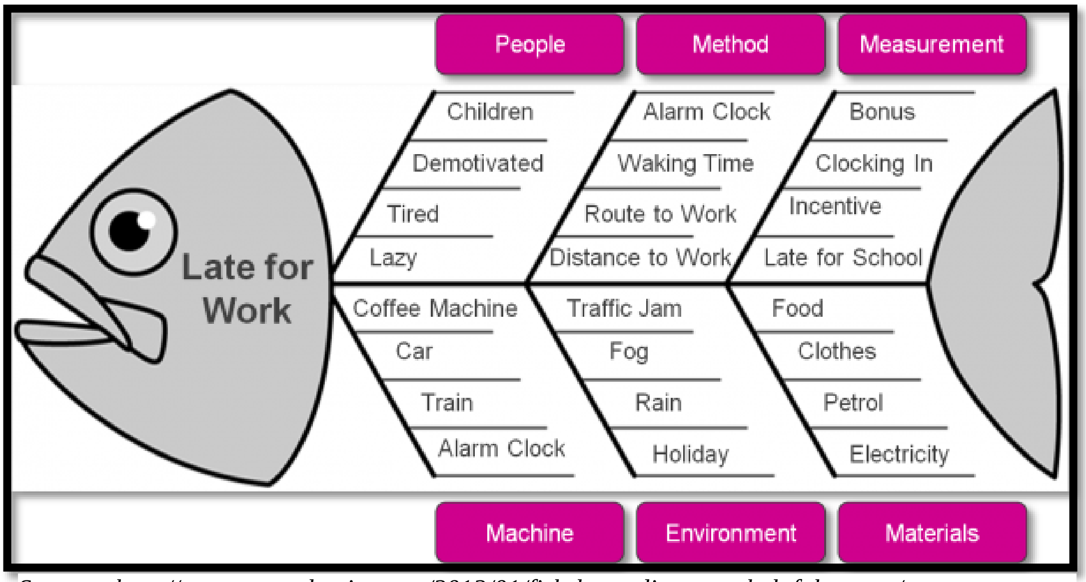
viii. *Wasting potential of people*. "Our people are our greatest asset", this proverb is true when employees developed enough understanding about value added, not – value added and then draw on their experience and creativity to find the solutions. But when people's mental, creative, and physical abilities are not used, waste of potential of people occurs.

ix. *Waste of disconnectivity*. This refers to waste stemming from administrative disconnection within the unit, and, between a unit and its suppliers creating barriers to creativity, innovation and knowledge sharing, when different departments work on their own without being connected or considering each other's demand.

x. *Waste of excessive energy consumption*. The tenth waste is the latest inclusion in the list of wastes as it has become more and more important to rationalize the consumption of energy and energy cost to give greatest advantages for the consumer and the environment. It may be due to the use of electricity when not required, release of extra steam from boiler, and use of old inefficient machines. Hence, overutilization as well as underutilization both creates wastes.

2.2 Cause and Effect Diagram

Cause and effect diagram also known as fishbone diagram is brainstorming tool used for identifying possible cause of a problem and sorting ideas into useful categories. This diagram often used in complicated problem and hard to find the root cause. This diagram offer a structured and simple way in analyzing problem. Figure 2.3 give visual display of cause and effect diagram.



Source : http://www.squawkpoint.com/2012/01/fish-bone-diagrams-helpful-or-not/

Figure 2.3 Cause and Effect Diagram

The head of the fish is representing main problem of the research. Under various categories, the bones of the fish is representing possible cause of the problem. The categories that usually used in manufacturing problem are man, method, measurement, machine/equipment, materials, and environment/ Mother Nature. These six categories usually called 6 Ms. This 6 Ms categories will be explained as below.

2.3 Standardized Works Type

In Toyota Production System (TPS) there three different type for standardized works. The works is divided by its nature of process flow. There are works with repetitive cycle, variable cycle, and long cycle. According to Miller (2010), this type 1, 2, and 3 terminology was new addition to TPS, it possibly used to explain the variants of standardized works to overseas Toyota plans. The details of every type is explained below.

2.3.1 Type I Worker

The first type is standardize works for process that have repetitive cycle. The takt time of the process can be defined. The standardized works is aim to keep the fluctuation of worker cycle time above or below takt time to a minimum. This the most common type of standardized works in Toyota Production System. It can be found assembly line or u-shaped machining cell producing well defined product family.

2.3.2 Type II Worker

The second type is standardized works for process that have short but variable cycle. This type can be found on assembly line that consist of different type of product models. The production pattern of the assembly line is not the same when the same product appeared in the patter. For example, the production line have to make models A-A-A-B-B-C. This condition may cause waiting time or prevent the operator from meeting takt time due to tools change, different material, etc.

2.3.3 Type III Worker

The third type is standardized works for noncyclical process. Noncyclical process usually have long cycle time, consist a lot non-value added activities, work sequence is not repetitive, and takt time is cannot be defined. This type is the hardest to collect data from three type of standardized works. Every details of manpower works have to be recorded in order to get reliable data. Beside of that, the observer must have the ability to differentiate between non-value added necessary activities and non-value added activities. This type can be found on warehousing process.

2.4 Standardized Works for Noncyclical Process

Conducting type III standardized work is different from creating standardized work for other type. Type III standardized works is for noncyclical process. Noncyclical process characteristic is it have long cycle time, no repetitive works, and have a lot of non-value added activity. Therefore, collecting valuable data as foundation of the *kaizen* is not easy.

According to Niederstadt (2010), explain and show the tools that can be used to gathering valuable data that can be used for decision making in conducting *kaizen*. The tools are noncyclic work summary sheet and *yamazumi* chart. After, the data has been gathered it can be used as decision making foundation on conducting *kaizen*. Explanation will be shown below to give more details about the tools and methods.

2.4.1 Noncyclical Work Summary Sheet

This tools help listing every work elements in one shift for a noncyclical works in type III standardized works. This tools can give information about non-value added necessary and non-value added activities. Both categories can be divided to different names in order to give more explanation about the work elements. Figure 2.4 will show the display of noncyclical work summary sheet.

From example in figure 2.4, it is noncyclical work summary sheet for process *Order Picker Operator B*. This process have net available time is 433 minutes, this come from gross available time (480 minutes) minus break times (47 minutes). This 433 minutes is divided into non-value added necessary and non-value added activities. Both activates is divided again to different categories for more details. Non-value added necessary activities is divided into Work NVA Necessary. And, non-value added activities is divided into Work NVA, Wait No Choice NVA, Walk NVA, and so on. The total time of non-value added necessary and non-value added activities is equal to net available time of the process. The purpose of dividing the process into different work element ID is to help the research identify which task have potential for improvement.

Noncyclic Work Summary Sheet

Line Name/Process Name: **Order Picker Operator B**

Date: February 25, 2009

Gross Available Minutes for Shift: 480 min

Minutes at Meetings, Breaks & Meals: 47 min

Net Available Minutes for Shift: 433 min

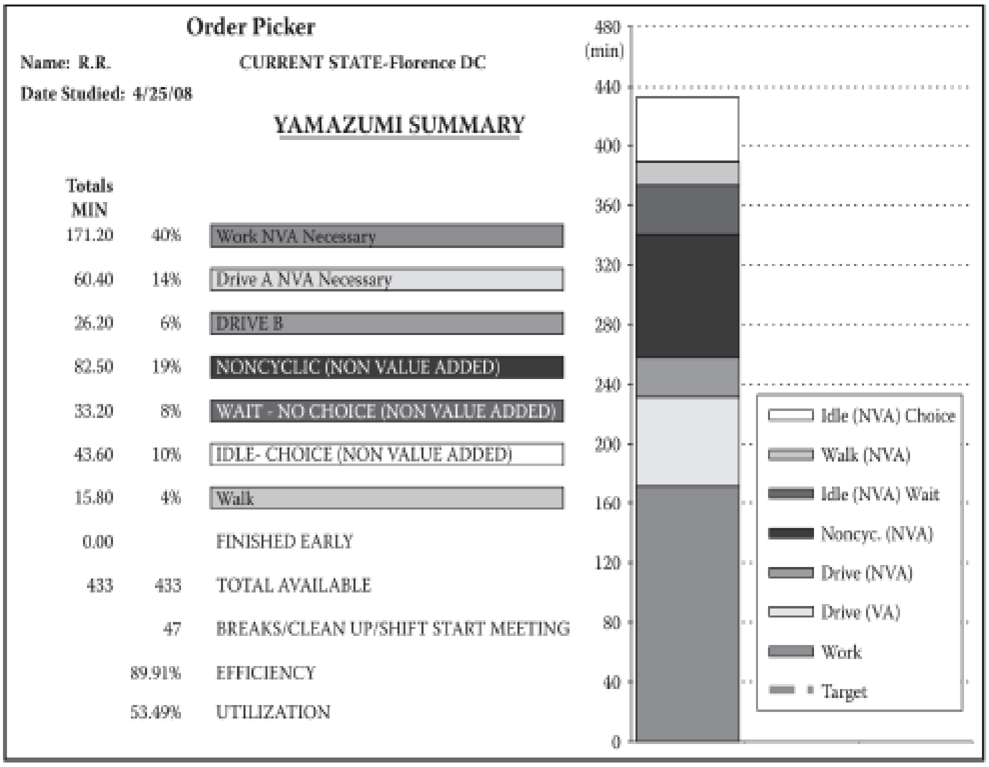
Work Element ID	Work Description	Min / Task	# Times Repeated	Cumulative Time (min)
Work NVA Necessary	Picking: Remove product from shelf & place in box on vehicle	Varies	6	28
Work NVA Necessary	Driving activity from pick location to pick location prior and delivery to pack point	Varies	4	38
Work NVA	All other driving activity. Packing	Varies	32	228
NONCYCLIC NVA	Building boxes, change battery in scanner, change truck batttery	Varies	3	94
WAIT NO CHOICE NVA	Waiting on stock in primary, out of stock, waiting on vehicles, waiting on wrapper, waiting for people, verbal instructions	Varies	1	7
WAIT CHOICE NVA	Restroom, smoke, emergency phone calls, talking, helping others, finished early	Varies	3	15
WALK NVA	Any walking	Varies	8	23
			Total	433

Source: (Joseph Niederstadt, 2010)

Figure 2.4 Noncyclic Summary Work Sheet

2.4.2 *Yamazumi* Chart

This tools is enhancing the visual display of noncyclic work summary sheet by showing stacked bar graph of the work elements. Converting the noncyclic work summary sheet into individual *yamazumi* chart of every process will give display about the current situation about the process. Grouping the individual *yamazumi* of every processes into one chart will give information about the current condition of entire process. This information give the research valuable data that can be used for generating ideas for *kaizen* activities. Figure 2.5 show the example of individual *yamazumi* chart.



Source: (Joseph Niederstadt, 2010)

Figure 2.5 Yamazumi Chart

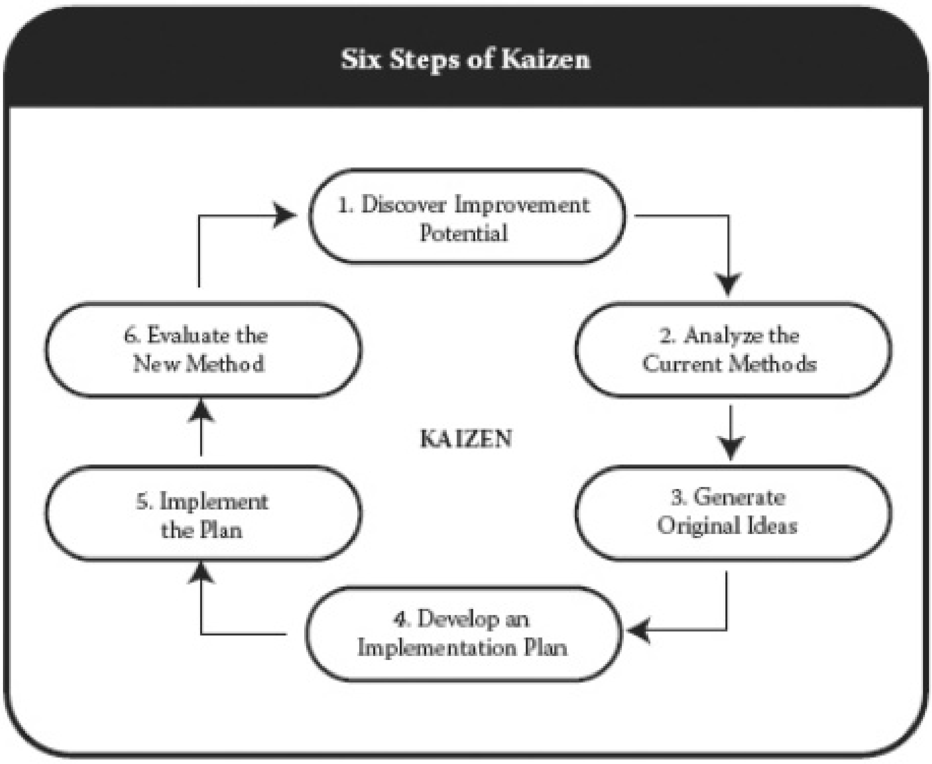
Example in figure 2.6 showing that individual *yamazumi* chart of process *Order Picker*. This chart have the same content as noncyclic work summary sheet. The chart is showing the work element and its time. But, in *yamazumi* chart it also give stacked bar chart of the work element, total efficiency and total utilization of the process. Therefore, this chart give the information about how well the process had been used by the company and giving information which task have a room for improvement.

2.5 Kaizen

Kaizen is derived from Japanese word meaning to change for better. *Kaizen* was not widely used by general Japanese population. It is only used as a technical term in text books. At early 20th century, industrial engineering movement around the world created methods-based improvement as number one priority. Later, *kaizen* is used as translation for specific word “to improve”. The term *Kaizen* started to proliferate inside Toyota in the 1950s and 1960s as an ongoing part of Toyota Production System (TPS) development (Kato & Smalley, 2010).

The advantage of conducting according to Imai (1986), worker can give ideas for *kaizen* activities therefore make the worker feel responsible and improve their involvement in the process. Brunet (2000) stated that *kaizen* is focusing in smaller, self-managing groups, consolidate team-working therefore give the worker sense of cooperation and greater understanding of change. Womack and Jones (1996) also mentioned, *kaizen* is facilitating correction for activities that absorb resources but add no value, then turning it to better process even can adding value.

Kaizen generally has six main steps. *Kaizen* is similar to other methodologies, such as scientific method and general problem solving. The big difference is that in *kaizen* there are more degrees of freedom and a greater emphasis on generating original ideas (Kato & Smalley, 2011). The six step in *kaizen* are:



Source: Isao Kato & Art Smalley (2010)

Figure 2.6 Six Steps of *Kaizen*

- **Step 1: Discover the Improvement Potential**

The first step require individual to be able to see improvement potential. This first step of *kaizen* is an exercise in helping individuals learn to see different types of waste, inefficiency, problems, and areas for improvement. The knowledge can come from experience or training.

- **Step 2: Analyze the Current Methods**

The second step is analyzing the process of current methods. This step require individual to understand the process inside the improvement area. Various technique can be used to analyze the methods. The research need to choose techniques that fit with type of works in improvement area.

- **Step 3: Generate Original Ideas**

The third step is generating ideas to solve the problems. The third step involves synthesis as much as or more than analysis. The ideas can come from analytical way, however, it also can come from creative thinking of individuals. Brainstorming the problem with *kaizen* team to have a lot of ideas to overcome the problem is important. Every individual have their unique ways in viewing and solving the problem. Therefore, resulting in ideas with low cost implementation with big impact.

- **Step 4: Develop Implementation Plan**

After analyze and generate ideas, the next step is to develop plan to implement the improvement ideas. For example when to start the implementation, who is in charge to supervise the implementation, preparing required equipment, etc.

- **Step 5: Implement the Plan**

After implementation plan had been developed, the next step is to implement the plan in improvement area. In implementing the plan the *kaizen* team must have coordination with each other in order to keep the plan on its path.

- **Step 6: Evaluate the New Method**

The last step is to review the result of *kaizen* implementation. The results is measured and compare with condition before improvement. Deciding if the *kaizen* is changing the process to be a better works or there are still room for improvement in the process.

2.6 Manpower Efficiency & Utilization

Efficiency is producing desired result with a minimum of effort, expense, or waste (Niederstadt, 2010). The formula used to calculate efficiency for type III standardized works are:

$$\text{Efficiency} = \frac{\text{Cycle Time}}{\text{Total Available time}} \times 100\% \tag{2.1}$$

The calculation is total cycle time of the process divide by total available time multiply with 100%. Cycle time is the cumulative time of non-value added necessary and non-value added activities minus idle time. Available time is total time given in one shift including break time. Efficiency showing the worker effort to finishing their works in given available time in one shift. However, it cannot show how well the resources is used.

Utilization is defined as optimizing resources that available. Utilization can show how well the resources had been used. Using the worker to as optimum as possible mean optimizing cost. The formula used to calculate based for type III standardized works are:

$$\text{Utilization} = \frac{\text{Sum of NVA Necessary}}{\text{Total Available Time}} \times 100\% \tag{2.2}$$

The calculation is sum of non-value added necessary activities of the process divided by total available time multiply by 100%. Sum of NVA Necessary is cumulative time of non-value added necessary work element. Total available time is total given time in one shift including break times. Utilization show only necessary works of the process, therefore showing how well the process had been optimized.

2.7 Flow Process Chart

Table 2.1 Flow Process Chart

Flow Process Chart (Material) for Manufacture of Perforated Cup

	Summary			
Location : Fabrication Shop	Event	Present	Proposed	Savings
Activity : Manufacture of perforated cup	Operation	9		
Date: Dec. 15, 2005	Transport	8		
Operator : HSS Analyst : SK	Delay	10		
Method and Type:	Inspection	1		
Method: *Present* *Proposed*	Storage	2		
Type: *Worker* *Material* *Machine*	Time (min)			
Remarks:	Distance (m)	43.5		
	Cost			

Event Description	Symbol	Time (in Minutes)	Distance	Method Recommendation
In store				
To press #1			10 m	
Wait		2		
Blank		0.5		
Stack		3		
Blank To Press #2			1 m	
Wait		5		
Perforate		0.5		
Stack				
Blank to press #3		5	1 m	
Wait		5		
Draw		0.5		
Stack		1		
To trim machine				
Wait		1		
Trim		0.8		
Stack		20		
To buffing machine			6 m	
Wait		2		
Buff		1		
To wash (on conveyer)			10 m	
Wash		0.9		
Dry and inspect		3		
To pack room			3 m	
Wait		30		
Place in card box		0.1		
Label		0.1		
To shelf			0.5 m	
At shelf				

Source: https://www.slideshare.net/rahulmeshram14/example-flow-process-charts

Flow process chart is used to display the mapping of certain task that happen inside a process. The task that shows in the flow process chart is consist of non-value added necessary and non-value added activities. Flow process chart for this research will be used to show which activities that can be improved to increase the manpower efficiency and utilization. Table 2.1 will show the display of general flow process chart.

Flow process chart will show every activities in the task from the start to finish. Flow process chart use symbol for certain event. The event that generally included in flow process chart are process, transport, delay, inspection, and storing as shown in table 4.2. The flow process chart showing the time needed to perform each activities in the task. Distance information can be added to give more details to the data. However, flow process chart can be modified that suitable for the research.

Table 2.2 Flow Process Chart Symbol

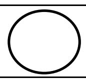
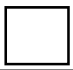
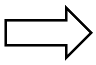
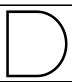
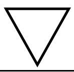
Symbol	Event	Description
	Process	Activity that happen
	Inspection	Comparing the materials with established standard
	Transport	Movement of operator, material, or equipment
	Delay	Have no other choice but waiting
	Storing	Stored the material in designated place

Table 2.6 shows five types of operation, which are process, inspection, transport, delay, and storing. Process is consist of activities which are assembly, dis-assembly, and change in shape or quality. The inspection is activity to check if the material is following the standard that had been established by the company. If the material is not satisfy the standard it become defect or rework. Transport is moving operator, tools, or equipment from initial position to other place. Delay is the process that have no other choice but waiting. Delay is occur because of interruption from other process. Storing is activities to placing material to designated place. The item might be raw material, finished products, work in process (WIP), etc.

2.8 Warehousing

Warehouse always deal with quantity-based activity. As one of the node in supply chain, warehouse has to accommodate every material required for manufacturing the products. Although warehouse mostly deal with quantity-based activity, it is important to avoid confusing quantity with quality. A highly productive warehouse operation that has high error rates, poor housekeeping, and poor service could deteriorate to a point where quantity is no longer important.

Warehousing has been argued to be time consuming activity that does not add value (Heragu, 2008). Maintaining warehouse need additional energy to store and record every materials that go into the warehouse. Because of that, Toyota Production System philosophy suggests that quantity of produced products directly correspond to the demands, therefore reducing the amount of material and decreasing works needed to maintain the warehouse. However, warehouse still have important function in connecting supplier with the company production line. The general function of warehouse will be shown in next section.

2.8.1 Warehouse Function

Every warehouse should be designed to meet specific requirements of the supply chain of which it is a part. Nevertheless, there are certain operations that are common to most warehouses. These tend to apply whether the warehouse is manual in nature with fairly basics equipment or whether it is highly automated with sophisticated storage and handling systems. These functions are as follows:

- *Receiving.*

This typically involves the physical unloading of incoming transport, checking against purchase orders and recording the incoming goods in the computer system. It can also include such activities as unpacking and repacking in a format suitable for the subsequent warehouse operations. Quality control checks may be undertakes as part of this activity. From here, the goods are then put away in the warehouse.

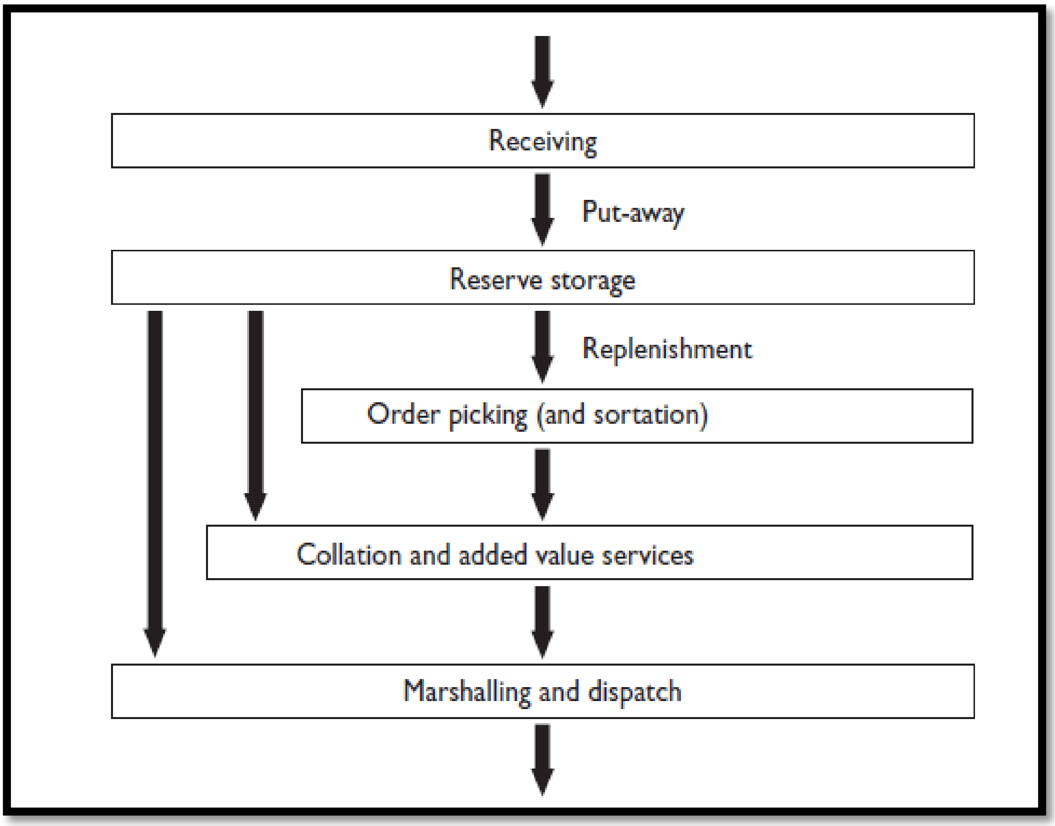


Figure 2.7 Warehouse Function

- *Reserve storage*.

Goods are normally taken to the reserve or back-up storage area, which is the largest space user in many warehouses. This area holds the bulk of warehouse inventory in identifiable locations. When required, the goods are taken from reserve storage either directly to marshalling or to replenish a picking location.

- *Order Picking*.

When an order is received from a customer, goods need to be retrieved from the warehouse in the correct quantity and in time to meet the required service level. An order will frequently contain a number of order lines, each requesting a specific quantity of an individual product line. If the order line is for a full unit load (e.g. pallet) then this can be retrieved directly from the reserve storage area. However, if the order line is for less than a unit load (e.g. a number of cases or items) then the good will normally be retrieved from the picking location. If only small quantities of a product are stored in a warehouse, then the reserve and picking stock may be combined, and goods picked from this consolidated area. Order picking is a key warehouse operation, both in terms of cost and service, as a significant proportion of the warehouse staff is normally required for this function and it is critical to achieving high levels of order accuracy.

- *Sortation*.

For small sizes of order, it is sometimes appropriate to batch a number of order together and treat them as ‘one’ order for picking purpose. In this case, the picked batch will have to be sorted down to individual orders before dispatch.

- *Collation and added value services*.

Goods need to be collated into complete customer orders ready for dispatch. Unless the goods are picked directly into the dispatch containers (e.g. directly into roll cages or into cartons), they will be assembled or packed together after picking. For example, the goods may be passed to a packing station where they are packed into a carton. These may in turn be stretch-or shrink-wrapped onto a wooden pallet ready for transit. This process may also involve final production postponement activities and value added services, such as kitting and labelling.

- *Marshalling and dispatch*.

Goods are marshalled together to form vehicle loads in the dispatch area and are the loaded on to outbound vehicles for onward dispatch to the next ‘node’ in the supply chain.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Framework

Research framework is summary of all activities that need to be performed to achieve the objectives of this research. The major activities are initial observation, problem identification, literature study, data collection, data analysis, and conclusion and recommendation, as shown in figure 3.1.

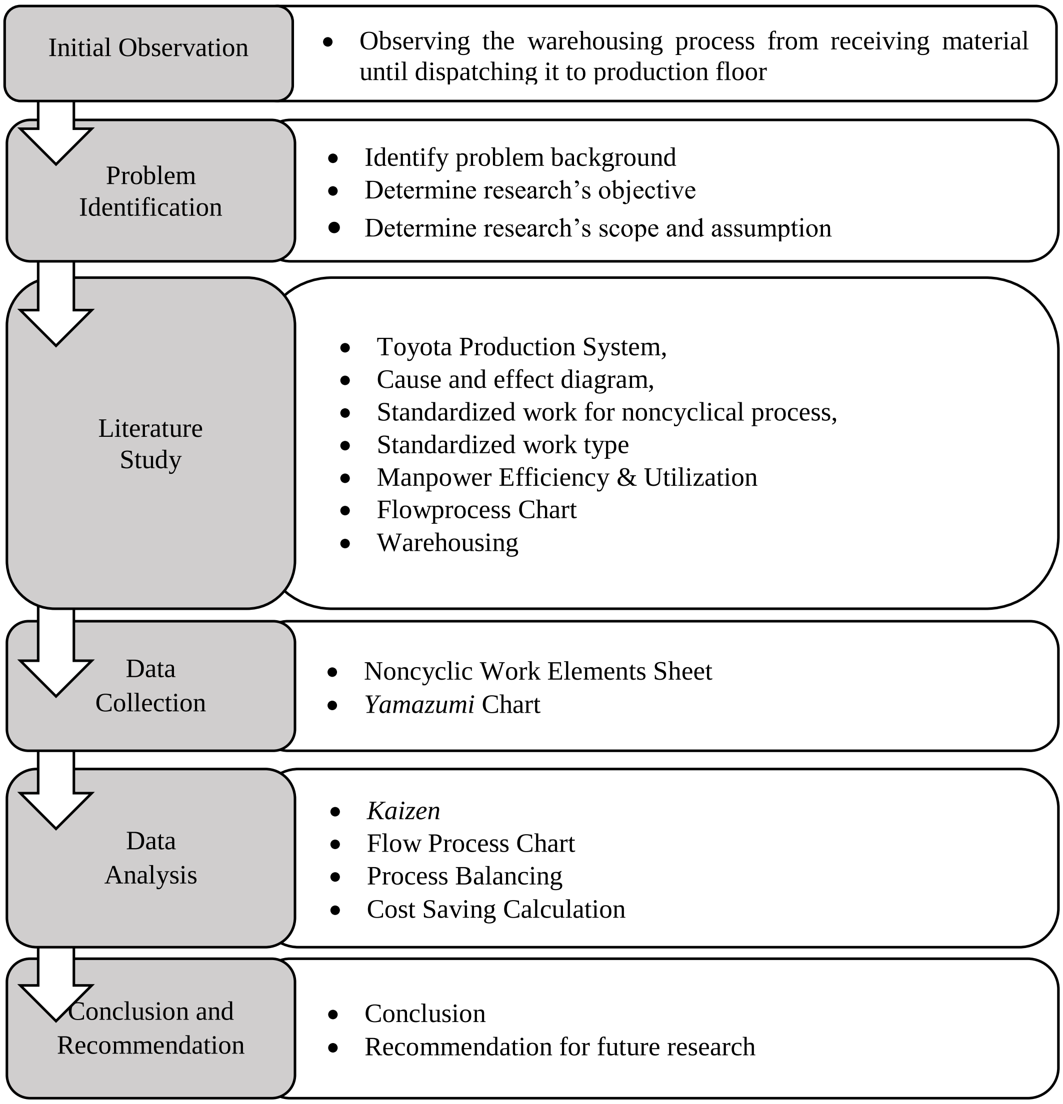


Figure 3.1 Research Methodology

3.1.1 Initial Observation

The initial observation is analyzing the current process condition and situation inside warehouse 2,5. It observes total number of worker and the details of their activities on warehouse. Beside of that, it observe the warehouse layout to understand the flow of process and location of the workers. From the initial observation the research has initial view on warehouse condition and some important information that can be used to identify the problem of the warehouse.

3.1.2 Problem Identification

Observing the current process of warehousing lead the research to problems. There is a problem regarding to manpower efficiency. The problem background will give further explanation about manpower efficiency problem in warehouse 2,5. The problem statement is a set of questions used for generating the objectives of the research which is increasing manpower efficiency. The research objectives is a set of goals used for guidance to conducting the research. The objective of the research is to answering the problem statement that already stated which are the defining current manpower efficiency and utilization of the process by using noncyclic work summary sheet and *yamazumi* chart, difference of manpower efficiency and utilization before and after *kaizen* implementation, and the economic benefits of increasing manpower efficiency for IJK Company. Identifying problem is important for deciding what tools and methods that will be used in conducting the research

3.1.3 Literature Study

Literature study give further explanation about method, tools, and knowledge related to the research. This studies based on books, journals, and past research related to objective of this research. There will be theoretical review about Toyota Production System. Since, IJK company system is based on Toyota Production System. There are will be explanation about cause and effect diagram that used for finding root causes for increasing manpower efficiency. There will be theoretical knowledge about conducting standardized works for noncyclical process. Warehouse 2,5 is included on type III standardized works. Because of that, to give more details there will theoretical knowledge about three type of standardized works. There are will theoretical explanation about process balancing. There are will be explanation about manpower efficiency and utilization, also the formula to calculate efficiency and utilization. Flow process chart is used to give detailed display of certain task, therefore there will be theoretical knowledge about flow process chat to give cleat explanation. Besides of that, there will be theoretical knowledge about warehouse, to give explanation about the duties of warehouse in manufacturing process. Lastly, literature study give theoretical explanation about tools and methods, so the research can collected and analyzed data correctly.

3.1.4 Data Collection

All the data are taken directly from IJK Company warehouse 2,5. The research is gathering data by individual observation and historical data recorded by the company. The data is collected using various tools and method mentioned in literature study. Cause and effect diagram will show possible root causes for improving manpower efficiency. Working area layout show the location of the worker for each process inside the warehouse. Noncyclical work element sheet show all working elements of the worker divided to non-value added necessary and non-value added activities, give information about duration of each work element in the process. *Yamazumi* chart is used to visualize the data and help the research for decision making and strategy to find solution. The data that had been collected will be used as foundation for analyzing the current condition of the warehouse and finding *kaizen* idea for improving the manpower efficiency.

3.1.5 Data Analysis

After the data has been collected, the next step is to analyze the problem. The collected data will be analyzed using *kaizen* method. Flow process chart also will be used to help for showing the details of the task that will be improved by the *kaizen* idea. Then, *kaizen* ideas based on information that had been gathered in data collecting activities. Generally *kaizen* has six step. The first step is to discover the potential improvement in the area. The first steps is had been done in data collection activities. The next five steps is include in data analyzing process. The other five steps are analyze the current methods, generate original ideas, develop implementation plan, implement the plan, and evaluate the plan. Next step, after process non-value added activities had been reduce by *kaizen* the process need to be balanced. Process balancing is used to equalize amount of cycle time or efficiency for each process. After, process balancing the research calculate cost that had been saved by this improvement.

3.1.6 Conclusion and Recommendation

Conclusion is the summary of the research. The result is show how the research achieving the research using tools and method which are available. Showing before and after condition of manpower efficiency on warehouse 2,5. And recommendation is giving a suggestion for future research.

CHAPTER IV
DATA COLLECTION AND ANALYSIS

IJK Company was founded in 1982. IJK Company is one of the biggest automotive manufacturer in Indonesia. The main products of IJK Company is rear axle and propeller shaft for medium and light duty vehicle. The customer of IJK Company consist of car manufacturing company from domestic international company. IJK Company can produce hundreds of products in one day. IJK Company currently employees 671 work force. Therefore, IJK Company always tries to develop their competencies, to compete with other companies in South-East Asia (SEA) region.

In order to increase their competencies IJK company is conducting improvement activities in all of their department. One of the problem IJK Company currently facing is low manpower efficiency in their warehouse department. IJK Company has several warehouse, each warehouse served different roles and accommodate material for different production plants. This research is taken place in warehouse designated to serve production plants 2 and 3. This warehouse also called warehouse 2,5, because it is located between production plants 2 and 3. Because, warehouse 2,5 served two production plan at once the warehousing process efficiency need to improve to create standardized works and optimizing the resources. Since, the salaries of the worker have likelihood to increase every year it is important to keep the efficiency and utilization of the manpower in good shape.

IJK Company motivation to increase their manpower efficiency is originated from rapid increase on sectorial minimum wages (*upah minimum sektoral*). The increasing salaries from year 2006 – 2015 is shown by figure 4.1. It is shown in figure 4.1 that less than ten years labor salaries is increasing around 290%, from Rp876.500 in 2006 to Rp3.415.000 in 2015. This situation occurs because there is a shifting in Indonesian economic growth. IJK Company need to find solution in order to satisfy their worker salaries. Because of that, IJK Company conducting improvement in every department, including increasing manpower efficiency on warehouse department.

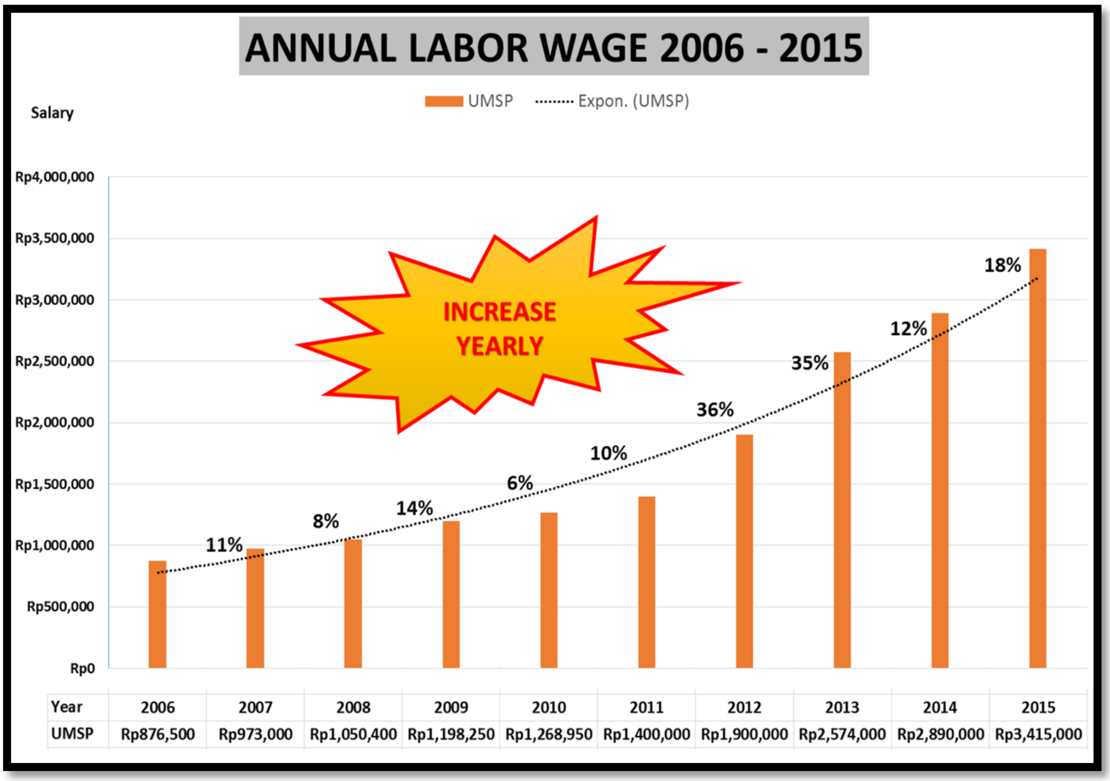


Figure 4.1 Labor Salaries 2006 - 2015

The research team was created in order to find solution and idea for improving manpower efficiency of the warehouse. Cause and effect diagram is used for brainstorming tools to find solution for increasing manpower efficiency of warehouse 2,5. The explanation of the cause and effect diagram details will be showed in next sub-chapter 4.1.

4.1 Cause and Effect Diagram

The company have one year policy for every department to improve their process. The policy is used as key performance indicator (KPI) for every head of department. The policy stated that to increase profitability every department should manage their manpower efficiency. Warehouse as one of the department in IJK Company need to create improvement to fulfill the company policy. Because of that, cause and effect diagram is created to find the problems that might causing low manpower efficiency inside the warehouse. This diagram will help the research in choosing tools and methods, creating improvement ideas, or creating new equipment that help the worker job. Therefore, the research team can have the same idea and can take correct action to improve the manpower efficiency.

Cause and effect diagram can be divided into categories. Manufacturing area usually divide cause and effect diagram into six different categories. There are materials, man, environment, machine, measurement and methods. But, this research only use four out of six categories that normally used in creating cause and effect diagram for manufacturing process. The categories are man, materials, methods, and equipment the possible cause in each categories will be explained further below.

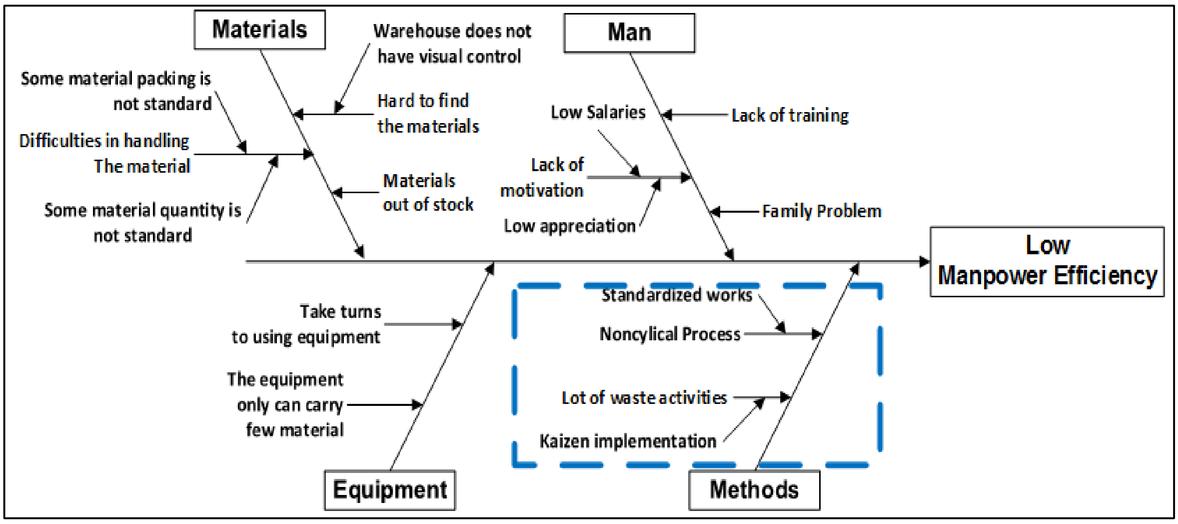


Figure 4.2 Cause & Effect Diagram

- **Methods**

The warehouse process that can be categorized as noncyclical process have a lot of non-value added activities. The warehouse need to re-standardize their works to achieve process with better average efficiency. The standardized work for noncyclical process (*type III*) is different for other work type. It has long cycle time, most of activities is non-value added, and have no repetitive sequence. Because of that, standardized work for noncyclical process is great tools to collecting data about work element and activities that occurred in the warehouse. Also because of noncyclical process consist of non-value added activities it is contain a lot of waste. Therefore, the warehouse need to reduce the waste activities. *Kaizen* implementation in the warehouse can generate improvement idea to solve the problem.

- **Man**

The worker as the actor in performing the process have responsibilities to performing the process in required efficiency. But, external factor can cause their performance to be declined. The cause and effect diagram stated three possible cause which are lack of training, lack of motivation and family problem. Creating good structured training curriculum that follow the standardized works of the process will help the worker to adapt faster to the process. Therefore, increasing their confidence in performing their works. Well trained worker will performed poorly if does not have motivation. Because of that, company need to increase their worker motivation. Low motivation can be caused by low salaries and low appreciation. The worker will not give their best performance if the company do not appreciate their hard works. The worker also does not have good performance if they have family problem or social life problem in their house. This condition will affect their efficiency in performing their works in the warehouse.

- **Materials**

Warehouse main duty is to accommodate materials that supplier deliver to the company. Warehouse have to deal with a lot of different materials. Because of that, the worker sometimes have difficulties in searching the material inside the warehouse. Lack of visual control inside the warehouse give difficulties for the worker in finding the location of certain material. Beside of that, the worker also have difficulties in handling material because of non-standard material packing and quantity. The result from this situation is over processing in handling the material in warehouse causing low manpower efficiency. The worst situation is when the material out of stock, forcing the worker to idling.

- **Equipment**

Warehouse is using a lot of tools and equipment to handle materials in their working area. Inadequate equipment will affect performance of the worker. The cause and effect diagram stated that are two possible causes. The possible cause are the worker need to take turns for using the equipment and the equipment only can carry few material. Therefore, the worker will have difficulties in handling the materials in order to finish certain activities. This condition will further reducing manpower efficiency in the warehouse.

The possible cause that had been given in cause and effect diagram is the reason of low manpower efficiency in the warehouse. From all of the possible cause, method offer solution that have low cost but affect the process greatly. Therefore, the research will focused in using this methods for solving the manpower efficiency problem. But, before collecting and analyzing the process in the warehouse first the research have to know layout design of the warehouse. Layout design in sub-chapter 4.2 will give information about amount of process, main location for the process, and the process description.

4.2 Layout Design

Layout design is used for mapping location of each process inside the warehouse. Information from layout design is useful when gathering data about work elements for each process. The location that displayed in layout design is the main location of the process. Therefore, the worker spend most of their time around that area. Figure 4.3 is displaying the initial layout of the warehouse.

As shown by figure 4.3 the warehouse is medium sized area with a shape of rectangle with total area around 2772 m^2. It is located between two production plants which are production plant 2 and plant 3. Production plant 2 is manufacturing *housing* and machining *axle shaft*, both item will be used as one of component for production process in plant 3. Production plant 3 have assembling line for *rear axle* and *propeller shaft* and machining line for *yoke, companion flange, pinion shaft*. Both production plant is served by warehouse 2,5 therefore there are a lot of different type of material for different type of product models. The warehousing process make sure the material that accommodated in the warehouse can be delivered to correct production line and for correct models.

There are nine process of works in the warehouse. Each process have their own identification, for example receiving is called MP1, and also MP is the abbreviation for manpower. These nine process is important works to make sure the material from supplier to be received, checked, stored, and delivered correctly. These nine process is divided into three zone which are receiving zone, material picking and sorting zone, and storing zone. In figure 4.3 each zone is represented by dashing line with different color. The purpose of dividing into three different zone is to help facilitate standardized the works. Therefore improvement can be focused into each zone separately, for example work elements of a process in receiving zone cannot be moved into one of process in material picking and sorting zone. Because, the main location of both process are far apart from each other and both served different function. Explanation about each working zone and the process inside of it will be explained below.

- **Receiving Zone**

This zone is represented by dashing line with blue colors in figure 4.3. This area main function is for serving the supplier that delivered their material to the warehouse. There are two process that included in this zone they are:

i. Receiving (Id: MP1)

This process main duties is to check quantity of material that supplier delivered to warehouse and record it to supplier arrival report book. For checking quantity the worker have to comparing actual quantity on truck with quantity written in delivery order. This activities is important to make sure the company get right amount material that they had been ordered.

ii. Forklift Receiving (Id: MP2)

The forklift driver is used for loading and unloading activities in receiving area. The main duties for this worker is to unloading material from supplier truck to receiving area. Beside of that, this process also served other purpose such as delivering material to several place, loading empty pallet to supplier truck, and dumping garbage of warehouse.

- **Material Picking and Sorting Zone**

In figure 4.3 this zone is represented by dashing line with orange colors. This zone have the most process, there are six process included in this zone. The process consist of work to picking up material according to production order, sorting up material for different product models, and replenishing shutter of material. The six process in this zone are:

i. Housing's Sub-assy Material Order Picker (Id: MP3)

This process works is picking up housing's sub assy material in shutter and put it in towing trolley. The different of sub-assy material with other material is that it need to be washed before going into the production line. . The list of material that picked by this worker is showed by table 4.1 below.

Table 4.1 Housing's Sub-assy Material

No	Material Name	Quantity / Unit
1	Upper Housing	1
2	Lower Housing	1
3	Housing Cover	1
4	Ring Plate	1
5	Inner Plate	2
6	Plate Housing	2

The worker is picking up material in accordance with the trolley that come to the warehouse. Every housing line have different color or identification for their trolley, so warehouse worker can know which material need to be put on trolley. Also, beside of picking up material to towing trolley, this process also have other activities. There are fill in material picking sheet then then inputted to computer, maintaining empty polybox from towing trolley, and replenishing shutter for housing's sub-assy material

ii. Housing's Material Order Picker (Id: MP4)

This process have the same main works as previous process, but this process picking up different material. This process must picking up more material than process MP3. The list of material picked up by this process is showed in table 4.2 below.

Table 4.2 Housing's Material

No	Material Name	Quantity / Unit
1	Bracket CJJ	2
2	Saddle Spring	2
3	Upper Arm RH	1
4	Upper Arm LH	1
5	Lower Arm RH	1
6	Lower Arm LH	1
7	Tube Clamp	2
8	Wire Clamp	2
9	Shock Absorber RH	1
10	Shock Absorber LH	1
11	Lateral Rod	2
12	Reinforcement	2
13	Flexible Hose	1
14	Clamp	1
15	Attachment Bracket 3 Way	2
16	Oil Deflector	2
17	Plate Axle Housing	2
18	Plate Buffle	2

The worker have to picking up material in accordance with from which housing production line the hand trolley come from. Every production line trolley have distinctive identification for their trolley, so warehouse worker know which production line owned the trolley. There are also other activities that performed in this process they are replenishing shutter for housing's small component, and fill in material picking sheet then inputted it to computer.

iii. Five Component's Material Order Picker (Id: MP5)

The main duties of this process is to picking up five component material and replenishing shutter for housing's material. The five component material is consist of *flange yoke, tube yoke, sleeve yoke, companion flange,* and *pinion shaft*. This five material must go through machining process then transported to propeller shaft assembly line in production plant 3. Other main works of this process is replenishing shutter of housing's material that process MP4 picked up, so the material can keep flowing. The purpose of shutter is to keep FIFO system working in the warehouse. Beside of that, this process also responsible to maintaining empty polybox in the warehouse. The worker have to stack empty polybox according to their owner. Polybox is property of supplier, so warehouse have responsibility to keep and maintain polybox in their process.

iv. Propeller Shaft’s Material Order Picker (Id: MP6)

This process is serving propeller shaft assembly line by picking up their material order. Before filling up the trolley, the worker have to take the material on the rack. There are two assembly line for propeller shaft, they are *PS 2 Joint* and *PS 3 Joint*. Both, line need different material. This process also have the same system as process MP3 and process MP4. Each line have their own distinctive trolley, so the worker know which material need to be put in the trolley and every trolley always have the same amount of materials. The list of material that this process picked up will be shown by table 4.3 below.

Table 4.3 Propeller Shaft’s Material

No	Material Name	Quantity / Unit
1	Spider	1
2	Needle Bearing	4
3	Plug	1
4	Gasket	1
5	Nut Flange	2
6	Nut Lock	2
7	Washer Plate	2

Beside of picking up order for propeller shaft assembly line this process also sorting up some material for rear axle assembly line. The worker move material from the packing into small polybox than put it on designated place on the rack. The list of material sorted up by the worker are *stud bolt*, *air breather*, *level plug*, *drain plug* and *gasket*.

v. Rear Axle’s Material Sorter (MP7)

This process main job is too sorted up rear axle’s material according to their models. This process does not involve a lot of walking, because mostly the worker spend their time sorting material. The worker only walking to get some material on the rear axle’s shutter. The material that picked from the shutter by this process are *stud bolt, air breather, level plug, drain plug gasket*, and *rotor skid control*. Other rear axle’s material is supplied by process MP8. The material that need to be sorted is shown by table 4.4 below.

Table 4.4 Rear Axle' Material

No	Material Name	Quantity / Unit	Sorted by Process
1	Stud Bolt	10	MP6
2	Air Breather	1	MP6
3	Drain Plug & Gasket	1	MP6
4	Level Plug & Gasket	1	MP6
5	Rotor Skid Control	2	MP7
6	Bearing Ball	2	MP7
7	Inner Retainer Bearing	2	MP7
8	Oil Seal	2	MP7
9	Bolt Hub	10	MP7
10	Retainer Bearing Outer	2	MP7
11	Bolt Backing Plate	8	MP7

vi. Supplying Rear Axle's Material Sorter (Id: MP8)

This process works is to supplying some material to process MP7. From table 4.4, the material that supplied by process MP8 to process MP7 are *bearing ball, inner retainer bearing, oil seal, retainer bearing outer,* and *bolt backing plate*. Material before *inner retainer bearing* need some treatment before supplied to process MP7. It is need to be washed from the oil to prevent defect when assembling.

This process also supplying some material directly to rear axle assembly line. The material that supplied directly to rear axle assembling line by MP8 worker are *shim, plug breather, oil seal holder, outer bearing L300,* and *outer bearing TBR*. The worker have to take material with hand trolley to their designated place in rear axle assembling line. Beside of that, this process also need to replenish shutter for rear axle's material.

- **Storing Zone**

In figure 4.3 this zone is represented by line with red color. The working area of this zone is the whole warehouse. Because, this zone is focused in transferring, moving, and maintaining material pallet inside the warehouse. There are only one process included in this zone which is forklift storing. The details about process forklift storing will be explained below.

i. Forklift storing (Id: MP9)

This process work is to picking up and moving up material pallet or other equipment from one place to other place. This process is important to move the material that just received on receiving area to the rack. The forklift also serving worker in picking and sorting zone to taking material on the rack when the material needed by the process.

Figure 4.3 show the flow process of warehouse itself. The first gate the material need to go through is receiving process. The material quantity is unloaded from the truck then the worker in receiving process will check the quantity of material in the packing. Then, forklift storing will handling material from receiving area into the rack, later will be picked by the warehouse worker for supplying the production line. The worker in picking and sorting zone will helping the production by giving the right material. Therefore, warehouse is essential in connecting supplier with production process in the company.

Understanding every process in the warehouse is important for increasing their manpower efficiency. Knowing what the process generally does can give overview of the process work element. The layout design already give a glance to warehouse flow process. Therefore, giving important information for conducting next step in the research. The next step is to collecting data of this nine process to help find information as foundation for decision making and strategy process in planning *kaizen*.

4.3 Standardized Works for Noncyclical Process

The data for conducting standardized works for noncyclical process is obtained through direct observation to the warehouse. The research observe the work elements of each process on the warehouse. The data is collected using noncyclic work summary sheet and *yamazumi* chart. All the data that gathered will be used for conducting *kaizen*.

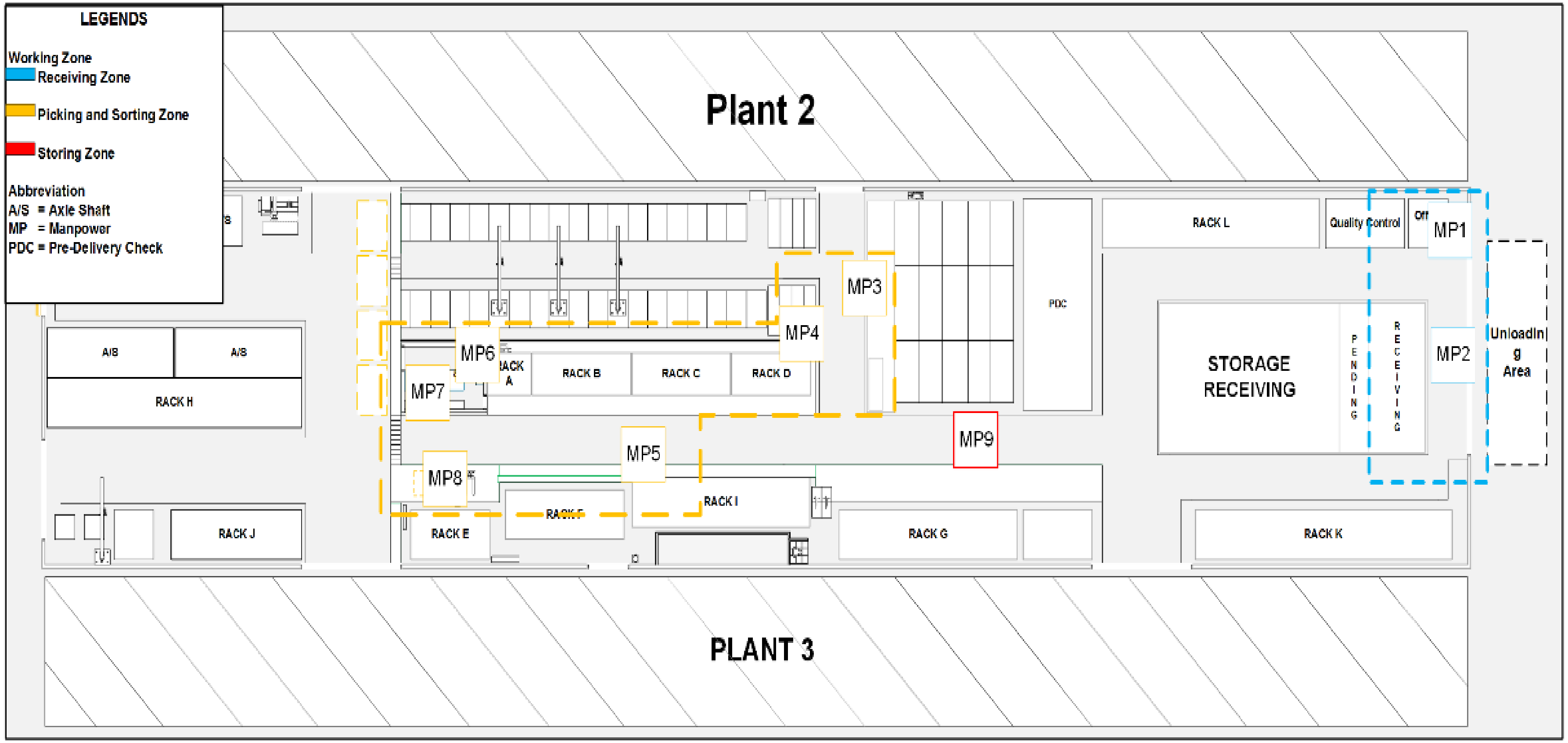


Figure 4.3 Layout Design of the Warehouse

4.3.1 Noncyclic Work Summary Sheet

The nine process that showed in figure 4.3 is observed. The result is work element that will be summarized in noncyclic work summary sheet. The duration of work element in every process is recorded using stopwatch. The research also record the occurrence frequency of the work element in one shift to calculate total time of work element. The net available time for one shift is 435 minutes, it is come from total available time minus break time. The calculation is shown below.

Net available time = Total Available Time – Break Time
= 525 minutes – 90 minutes
= 435 minutes

Then, this research divided again non-value added necessary and non-value added activities into five different work element categories. There are Work NVA Necessary, Work NVA, Waiting NVA, Walking NVA, and Idle. Work NVA Necessary is non-value added activities but have important roles in keeping the production process running. Work NVA is non-value added activities that occur because lack of resources such as technologies, method, and equipment. Walking NVA is non-value added activities that require the worker to walk to finishing a task. Waiting NVA is non-value added activities that force the worker to wait for other process to finishing their task. Idle is any activities that have no relation with production process. This five categories help the research to identify current manpower efficiency and utilization of the warehouse process from MP1 – MP9.

The data of noncyclical work summary sheet had been gathered. To see the implementation of the noncyclical work summary sheet in collecting information about every work element on each process the result will be shown below.

- **Process MP1**

Figure 4.4 show process MP1 (Manpower 1) work summary sheet. This process also called receiving. Process MP1 have 242 minutes for Work NVA Necessary. The work that included in this categories is checking material quantity from supplier and record it on supplier arrival books. Work NVA of this process have 51 minutes duration. The work that included in this categories is preparing bin card that will be used when checking material quantity and taking equipment in consumable warehouse. Process MP1 spent 58 minutes of its available time for waiting, usually the worker wait for forklift to pick up material from truck or talk to co-worker about material defect and quantity. Walking NVA take 27 minutes of total available time. The rest of duration which is 57 minutes for idling.

Noncyclic Work Summary Sheet

Line Name/Process Name: Receiving (MP1)

Gross Available Minutes for Shift:	**525 min**
Minutes at Meetings, Breaks & Meals:	**90 min**
Net Available Minutes for Shift:	**435 min**

Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Checking Material Quantity from Supplier	Varies	Varies	242
Work NVA	Preparing Bin Card, Take equipment in consumable warehouse, etc.	Varies	Varies	51
Walking NVA	Any Walking	Varies	Varies	27
Waiting NVA	Talk to co-worker, waiting for forklift to pickup the material, etc	Varies	Varies	58
IDLE		-	-	57
			Total	435

Figure 4.4 Noncyclic Work Summary Sheet of MP1

- **Process MP2**

Figure 4.5 show the work summary sheet for process MP2 (Manpower 2). This process is called forklift receiving. This process spent 240 minutes for Work NVA

Necessary. Work NVA Necessary consist of loading and unloading material from truck, material handling, moving material, and delivering material. This process spent 101 minutes of net available time for Work NVA. Work NVA consist of driving without carrying material, changing battery of forklift, and throwing's garbage. This process does not have any Walking NVA, because the worker always stay on their forklift. Process MP2 spent 47 minutes for waiting, the worker have to wait supplier truck to park in unloading area and take turns to crossing the road. This process spent 47 minutes for idling.

Noncyclic Work Summary Sheet				
Line Name/Process Name: Forklift Receiving (MP2)				
	Gross Available Minutes for Shift:	**525 min**		
	Minutes at Meetings, Breaks & Meals:	**90 min**		
	Net Available Minutes for Shift:	**435 min**		
Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Unloading Part From Supplier Truck	Varies	Varies	80
Work NVA Necessary	Loading Part & Empty Pallet To A Truck	Varies	Varies	33
Work NVA Necessary	Delivering Part And Polybox To Production Plant 1	Varies	Varies	42
Work NVA Necessary	Putting Material to Production Plant 4	Varies	Varies	50
Work NVA Necessary	Supplying Part *Brake Assy* to production plant 3	Varies	1	9
Work NVA Necessary	Material Handling	Varies	Varies	26
Work NVA	Driving Without Carrying Material, Changing Battery, Throwing Warehouse's Garbage to Garbage Truck	Varies	Varies	101
Walking NVA	Any Walking	-	-	0
Waiting NVA	Waiting for suplier truck to park, take turns crossing the roads, etc.	Varies	Varies	47
IDLE		-	-	47
			Total	435

Figure 4.5 Noncyclic Work Summary Sheet of MP2

- **Process MP3**

Noncyclic Work Summary Sheet				
Line Name/Process Name: Housing's Sub-assy Material Order Picker (MP3)				
		Gross Available Minutes for Shift:	525 min	
		Minutes at Meetings, Breaks & Meals:	90 min	
		Net Available Minutes for Shift:	435 min	
Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Pick and Put Sub Assy Material To Towing Trolly For Housing Line A	Varies	10	46
Work NVA Necessary	Pick and Put Sub Assy Material To Towing Trolly For Housing Line B	Varies	6	32
Work NVA Necessary	Pick and Put Sub Assy Material To Towing Trolly For Housing Line C	Varies	9	40
Work NVA Necessary	Pick and Put Sub Assy Material To Towing Trolly For Housing Line D & E	Varies	11	89
Work NVA Necessary	Picking Part *Inner Plate*	Varies	9	30
Work NVA Necessary	Maintaining Empty Polybox From Trolly Towing	Varies	11	16
Work NVA Necessary	Replenishing Shutter For Sub Assy Part Of Housing	Varies	Varies	31
Work NVA	Inputing Material Picking Order To Warehouse Computer, Fill in material picking report	Varies	Varies	83
Walking NVA	Any Walking	Varies	Varies	7
Waiting NVA	Waitng For Foklift To Pick Up Material On the Rack	Varies	Varies	3
IDLE		-	-	58
			Total	435

Figure 4.6 Noncyclic Work Summary Sheet of MP3

Figure 4.6 above show the work summary sheet of MP3. MP3 is process name is housing’s sub-assy material order picker. This process spend 284 minutes of total available time to do Work NVA Necessary. Work NVA Necessary in this process consist of order picking material sub-assy for line housing A, B, C, D, and E, order picking *inner plate*, replenishing sub-assy shutter and handling empty polybox. In other hand, Work NVA of this process spend 83 minutes of total available time. Work NVA for this process are fill in material order picking sheet than input it to computer system. This process does not have a lot of Walking NVA, it is only 7 minutes of total available time. Waiting NVA for this process also does not have long duration, it only covers 3 minutes of total available time. Usually this process only wait for forklift to pick up material from the rack. The rest of duration which is 58 minutes is worker idling.

- **Process MP4**

Noncyclic Work Summary Sheet

Line Name/Process Name: Housing's Material Order Picker (MP4)

Gross Available Minutes for Shift:	**525 min**
Minutes at Meetings, Breaks & Meals:	**90 min**
Net Available Minutes for Shift:	**435 min**

Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Pick And Put Material To Hand Trolly For Housing Line A	Varies	2	13
Work NVA Necessary	Pick And Put Material To Hand Trolly For Housing Line B	Varies	3	29
Work NVA Necessary	Pick And Put Material To Hand Trolly For Housing Line C	Varies	4	28
Work NVA Necessary	Pick And Put Material To Hand Trolly For Housing Line D & E	Varies	6	93
Work NVA Necessary	Replenishing Rack of Small Material For Housing	Varies	2	9
Work NVA	Inputing Material Picking Information To Computer, Fill In Material Picking Report, Checking Small Material Quantity Before Putting On The Rack, etc	Varies	Varies	120
Walking NVA	Any Walking	Varies	Varies	11
Waiting NVA	Waiting Forklift To Pick Up Material, Helping Other Worker, etc	Varies	Varies	30
IDLE		-	-	102
			Total	435

Figure 4.7 Noncyclic Work Summary Sheet of MP4

Noncyclic work summary sheet for MP4 is shown in figure 4.7. MP4 is also known as housing's material order picker. Total Work NVA Necessary for this process is 172 minutes. Work NVA Necessary in this process consist of order picking housing's material for line housing A until E, and replenishing rack for housing's small material. Work NVA in this process spend 120 minutes of total available time. Work NVA in this process consist of fill in material order picking sheet than input it to computer system, and change the quantity of housing's small material before put it into the rack. This process Walking NVA have 11 minutes from total available time. Process MP4 Waiting NVA spend 30 minutes for waiting forklift to pick material, and helping other worker. And the worker is idling for 102 minutes.

- **Process MP5**

Process MP5 which is shown in figure 4.8 also called five component's material order picker. Work NVA Necessary spend 218 minutes of total available time. Work NVA Necessary on this process consist of order picking five component's material, replenishing housing's material shutter, also handling and maintaining empty polybox for entire warehouse. Work NVA in this process spend 109 minutes of total available time. Process MP5 Work NVA consist of fill in material order picking sheet than input it to computer system, move material to standard polybox, and operating cutting machine. This process spend 31 minutes of total available time for Walking NVA. Waiting NVA in this process is 30 minutes, usually the worker waiting material to be picked or searching for material. The rest of duration is idling with 47 minutes.

Noncyclic Work Summary Sheet

Line Name/Process Name: Five Component's Material Order Picker (MP5)

Gross Available Minutes for Shift:	**525 min**
Minutes at Meetings, Breaks & Meals:	**90 min**
Net Available Minutes for Shift:	**435 min**

Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Replenishing Shutter For Material Line Housing D & E	Varies	Varies	82
Work NVA Necessary	Replenishing Shutter For Material Line Housing C	Varies	Varies	23
Work NVA Necessary	Replenishing Shutter For Material Line Housing A	Varies	Varies	2
Work NVA Necessary	Replenishing Shutter For Material Line Housing B	Varies	Varies	41
Work NVA Necessary	Stacking And Maintain Emptry Polybox On Designated Place	Varies	3	12
Work NVA Necessary	Picking Material 5 Component For Line Machining	Varies	2	58
Work NVA	Inputing Material Picking Information To Computer, Move Material to Standard Polybox, Operating Cutting Machine, etc	Varies	Varies	109
Walking NVA	Any Walking	Varies	Varies	31
Waiting NVA	Waiting Forklift To Pick Up Material On The Rack and Searching for Material	Varies	Varies	30
IDLE		-	-	47
			Total	435

Figure 4.8 Noncyclic Work Summary Sheet of MP5

- **Process MP6**

Noncyclic Work Summary Sheet

Line Name/Process Name: Propeller Shaft's Material Order Picker (MP6)

Gross Available Minutes for Shift:	**525 min**
Minutes at Meetings, Breaks & Meals:	**90 min**
Net Available Minutes for Shift:	**435 min**

Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Picking And Putting Material For Propeller Shaft 2 Joint To Hand Trolly	Varies	4	106
Work NVA Necessary	Picking And Putting Material For Propeller Shaft 3 Joint To Hand Trolly	Varies	8	200
Work NVA Necessary	Sorting Material For Line Rear Axle	Varies	9	46
Work NVA	Throwing Garbage	Varies	Varies	16
Walking NVA	Any Walking	Varies	Varies	8
Waiting NVA	Waiting For Hand Trolly, Item Out Of Stock, etc	-	-	0
IDLE		-	-	59
			Total	435

Figure 4.9 Noncyclic Work Summary Sheet of MP6

Figure 4.9 will show the work summary sheet of process MP6. MP6 also called propeller shaft's material order picker. This process spend 352 minutes of total available time for Work NVA Necessary. Work NVA Necessary for this process consist of order picking for PS 2 joint and PS 3 joint and sorting some material for line rear axle. Work NVA is only 16 minutes of total available time and only consist of throwing garbage. This process does not have a lot of Walking NVA, it only spend 16 minutes of total available time. MP6 does not have any Waiting NVA on their process. The last is the worker idling for 59 minutes of total available time.

- **Process MP7**

Noncyclic Work Summary Sheet

Line Name/Process Name: Rear Axle's Material Sorter (MP7)

Gross Available Minutes for Shift:	**525 min**
Minutes at Meetings, Breaks & Meals:	**90 min**
Net Available Minutes for Shift:	**435 min**

Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Picking Up Rear Axle Small Material On The Shutter	Varies	Varies	14
Work NVA Necessary	Sorting Material For Line Rear Axle	Varies	Varies	359
Work NVA	Dumping Trash And Garbage	6	6	10
Walking NVA	Any Walking	Varies	Varies	3
Waiting NVA	Waiting For Material, Working Error, Out Of Stock, etc.	Varies	Varies	0
IDLE		-		49
			Total	435

Figure 4.10 Noncyclic Work Summary Sheet of MP7

This process work summary sheet is shown by figure 4.10. MP7 process also called rear axle's material sorter. Total time of Work NVA Necessary of this process is 373 minutes. Work NVA Necessary included in this process is picking up some rear axle's material from the shutter, and sorting rear axle's material. Work NVA for this process is only 10 minutes of total available time. This process also does not spend much of its time for Walking NVA, because it only spend 3 minutes of total available time to walking. There is no Waiting NVA on this process and the idling time is 49 minutes.

- **MP8**

MP8 is also called as process supplying rear axle material. The work summary sheet of this process is shown in figure 4.11. The Work NVA Necessary for this process is spend 213 minutes of total available time. Work NVA Necessary in this process consist of supplying process MP7, washing *inner retainer bearing*, sorting *bearing ball* L300 and TBR, supplying line rear axle, replenishing shutter for rear axle's material, and order picking *snap ring*. Work NVA for this process spend 27 minutes of total available time. Work NVA in this process consist only for inputting data of material delivered to line rear axle to computer system. Walking NVA for this process spend 90 minutes of total available time. This process have to walk a lot in performing their work elements. Waiting NVA for this process is 51 minutes, usually the worker have to wait forklift to pick material on the rack. And idling time is 54 minutes of total available time.

Noncyclic Work Summary Sheet				
Line Name/Process Name: Supplying Rear Axle Material (MP8)				
	Gross Available Minutes for Shift:		525 min	
	Minutes at Meetings, Breaks & Meals:		90 min	
	Net Available Minutes for Shift:		435 min	
Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Supplying: delivering required parts from rack to preparation area (process 7)	Varies	Varies	41
Work NVA Necessary	Washing part *Inner Ret. Bearing* before delivered to preparation area (process 7)	Varies	2	69
Work NVA Necessary	Separating *bearing ball* from its *outer bearing* (for type L300 & TBR)	Varies	2	28
Work NVA Necessary	Direct supply to rear axle production line	Varies	2	30
Work NVA Necessary	Replenishing shutter for rear axle parts	Varies	Varies	38
Work NVA Necessary	Preparing part *snap ring* into polybox	Varies	2	7
Work NVA	Inputing data of outgoing parts to warehouse computer	Varies	1	27
Walking NVA	Any Walking	Varies	Varies	90
Waiting NVA	Waiting for material to be picked by forklift, out of stock, etc.	Varies	Varies	51
IDLE	Worker idling	-	-	54
			Total	435

Figure 4.11 Noncyclic Work Summary Sheet of MP8

- **MP9**

This process is shown by figure 4.12, it is also known as process forklift storing. The Work NVA Necessary for this process spend 284 minutes of total available time. Work NVA Necessary for this process consist of material handling, and delivering material to other production plant. Total Work NVA for this process is 40 minutes. Work NVA in this process consist of changing battery of forklift, and driving without carrying material. This process does not have any Walking NVA, because this process stay on forklift all the time. Waiting NVA for this process is

15 minutes, it is spend for updating visual control board for the rack and crossing the roads. The last is idling time, this process spend 96 minutes for idling.

Noncyclic Work Summary Sheet

Line Name/Process Name: Forklift Storing (MP9)

Gross Available Minutes for Shift:	525 min
Minutes at Meetings, Breaks & Meals:	90 min
Net Available Minutes for Shift:	435 min

Work Element ID	Work Description	Min/Task	# Times Repeated	Cumulative Time
Work NVA Necessary	Maintaining Empty Pallet	Varies	Varies	56
Work NVA Necessary	Transfering Part *Drum Brake* From Receiving Area To It's Rack	Varies	Varies	103
Work NVA Necessary	Picking Up And Putting Material On The Rack	Varies	Varies	106
Work NVA Necessary	Delivering Material 5 Component To Line Machining In Plant 3	Varies	2	5
Work NVA Necessary	Picking Up Material From Production Plant 4	Varies	1	14
Work NVA	Driving Without Material, Changing Battery, etc.			40
Walking NVA	Any Walking			0
Waiting NVA	Updating Visual Control Board, take turns crossing the roads, etc.			15
IDLE				96
			Total	435

Figure 4.12 Noncyclic Work Summary Sheet of MP9

All the data of the processes that had been gathered into noncyclic work summary sheet from MP1 until MP9 is summarized by table 4.5 below.

Table 4.5 Noncyclic Work Summary Sheet

Process	Work Element ID (in minutes)					
	Work NVA Necessary	Work NVA	Walking NVA	Waiting NVA	Idle	Total
MP1	242	51	27	58	57	**435**
MP2	240	101	0	47	47	**435**
MP3	284	83	7	3	58	**435**
MP4	172	120	11	30	102	**435**
MP5	218	109	31	30	47	**435**
MP6	352	16	8	0	59	**435**
MP7	373	10	3	0	49	**435**
MP8	213	27	90	51	54	**435**
MP9	284	40	0	15	96	**435**
Average	264	62	20	26	63	435

Table 4.5 show the summary of all of the process noncyclic work summary sheet the data come from noncyclic work summary sheet of each process. For example, process MP6 noncyclic work summary sheet data that was shown in figure 4.9 have total Work NVA Necessary 352 minutes, Work NVA 16 minutes, Walking NVA 8 minutes, Waiting NVA 0 minutes, and Idle 59 minutes. And, the total which is 435 minutes come from adding Work NVA Necessary, Work NVA, Walking NVA, Waiting NVA and Idle time together. So, there are five different type of work element which are Work NVA Necessary. Work NVA, Walking NVA, Waiting NVA, and Idle. Basically, the process consist of non-value added necessary activities and non-value added activities.

The process with highest Work NVA Necessary is process MP7 with 373 minutes. This mean process MP7 does not have a lot of room for improvement. In the other hand, process MP4 have lowest Work NVA Necessary with 172 minutes have large gap for improvement. The process with highest work NVA is process MP4. This mean process MP4 need improvement idea to reduce their non-value added activities. The process with lowest Work NVA is process MP7. This condition indicate MP7 is does not need a lot of improvement in their process. Next, process with highest Walking NVA is process MP8 with 90 minutes. This condition indicate process MP8 need to be standardized to reduce their walking activities. The process with lowest Walking NVA is MP2 and MP9, because these worker is forklift operator. Next, process with highest Waiting NVA is MP1 with 58 minutes. Lastly, process with idling time is process MP4 with 102 minutes.

The next process is to transform noncyclic work summary sheet into *yamazumi* chart. *Yamazumi* chart will give informative display and add more information for helping decision making process in *kaizen*.

4.3.2 *Yamazumi* Chart

After creating noncyclic work summary sheet, next step is to transform it to *yamazumi* chart. *Yamazumi* chart is used to show the work summary of each process in informative display. There are two kind of *yamazumi* which are individual *yamazumi* and grouped *yamazumi*. Individual *yamazumi* is used to see work element details of each process. In the other hand, grouped *yamazumi* is used to see the condition of all process. The individual *yamazumi* and grouped *yamazumi* details of each process will be explained further in this section.

- **Process MP1**

Figure 4.13 is show the individual *yamazumi* of process MP1. This process Work NVA Necessary take 46,1% of total available time. Then, Work NVA take 9,7% of total available time. Next, Walking NVA take 5,1% of total available time. Waiting NVA take 11,0% of total available time. Lastly, Idle take 10,9% of total available time. Beside of that, 17% of total available time is used as break time. Furthermore, process MP1 manpower have 72% of efficiency and 46,10% of utilization. The efficiency and utilization percentage calculation for process MP1 is shown below.

$$\text{Efficiency} = \frac{\text{Net Available Time} - \text{Idle}}{\text{Total Available Time}} = \frac{435\ \text{minutes} - 47\ \text{minutes}}{525\ \text{minutes}}\ \text{x}\ 100\% = \mathbf{73,90}\%$$

$$\text{Utilization} = \frac{\text{Work NVA Necessary}}{\text{Total Available Time}} = \frac{80+33+42+50+9+26}{525\ \text{min}}\ \text{x}\ 100\% = \mathbf{45,71}\%$$

YAMAZUMI SUMMARY SHEET

Process ID: MP1 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Checking Material Quantity from Supplier	242	46,1%	Work NVA Necessary
Preparing Bin Card, Take equipment in consumable warehouse, etc.	51	9,7%	Work NVA
Any Walking	27	5,1%	Walking NVA
Talk to co-worker, waiting for forklift to pickup the material, etc	58	11,0%	Waiting NVA
Worker Idling	57	10,9%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		72,00%	EFFICIENCY
		46,10%	UTILIZATION

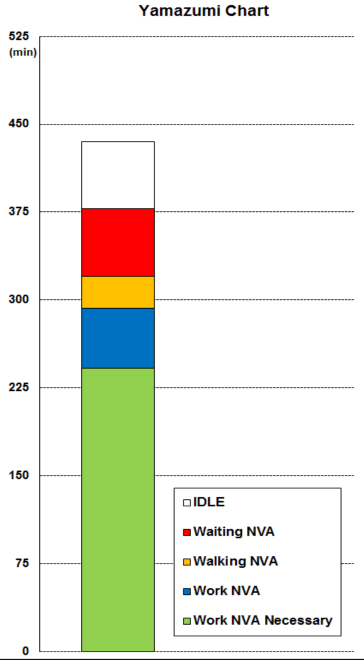


Figure 4.13 Individual *Yamazumi* Sheet of MP1

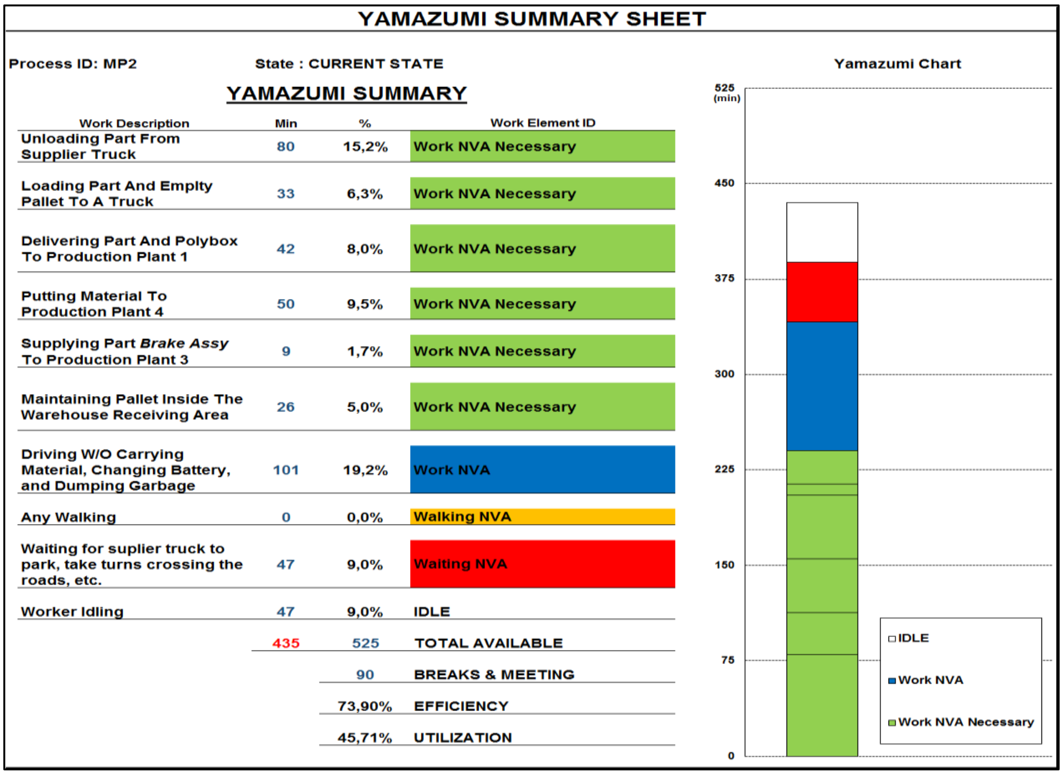
- **Process MP2**

Figure 4.14 is show the individual *yamazumi* of process MP2. The Work NVA Necessary of this process take 45,7% of total available time. The Work NVA of this process take 19,2% of total available time. Then, Waiting NVA take 9,0% of total available time. Last, Idle time take 9,0% of total available time. Furthermore, this process have 73,90% efficiency and 45,71% utilization.

- **Process MP3**

Figure 4.15 is show the individual *yamazumi* of process MP3. This process spend 54,1% of total available time for Work NVA Necessary. The Work NVA take 15,8% of total available time. Then, Walking NVA take 1,3% of total available time. And, Waiting NVA take 0,6% of total available time. Last, Idle time take

11,0% of total available time. Furthermore, process MP3 manpower have 71,81% efficiency and 54,10% utilization.



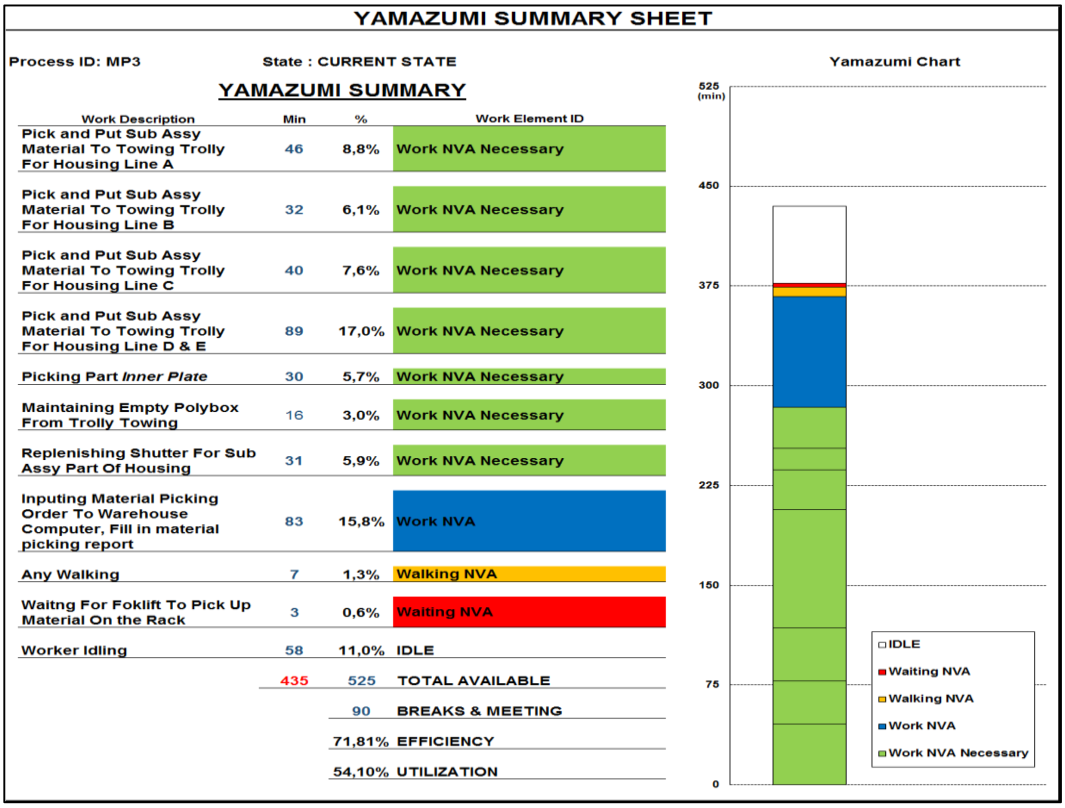
YAMAZUMI SUMMARY SHEET

Process ID: MP2 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Unloading Part From Supplier Truck	80	15,2%	Work NVA Necessary
Loading Part And Emplty Pallet To A Truck	33	6,3%	Work NVA Necessary
Delivering Part And Polybox To Production Plant 1	42	8,0%	Work NVA Necessary
Putting Material To Production Plant 4	50	9,5%	Work NVA Necessary
Supplying Part *Brake Assy* To Production Plant 3	9	1,7%	Work NVA Necessary
Maintaining Pallet Inside The Warehouse Receiving Area	26	5,0%	Work NVA Necessary
Driving W/O Carrying Material, Changing Battery, and Dumping Garbage	101	19,2%	Work NVA
Any Walking	0	0,0%	Walking NVA
Waiting for suplier truck to park, take turns crossing the roads, etc.	47	9,0%	Waiting NVA
Worker Idling	47	9,0%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		73,90%	EFFICIENCY
		45,71%	UTILIZATION

Figure 4.14 Individual *Yamazumi* Sheet of MP2



YAMAZUMI SUMMARY SHEET

Process ID: MP3 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Pick and Put Sub Assy Material To Towing Trolly For Housing Line A	46	8,8%	Work NVA Necessary
Pick and Put Sub Assy Material To Towing Trolly For Housing Line B	32	6,1%	Work NVA Necessary
Pick and Put Sub Assy Material To Towing Trolly For Housing Line C	40	7,6%	Work NVA Necessary
Pick and Put Sub Assy Material To Towing Trolly For Housing Line D & E	89	17,0%	Work NVA Necessary
Picking Part *Inner Plate*	30	5,7%	Work NVA Necessary
Maintaining Empty Polybox From Trolly Towing	16	3,0%	Work NVA Necessary
Replenishing Shutter For Sub Assy Part Of Housing	31	5,9%	Work NVA Necessary
Inputing Material Picking Order To Warehouse Computer, Fill in material picking report	83	15,8%	Work NVA
Any Walking	7	1,3%	Walking NVA
Waitng For Foklift To Pick Up Material On the Rack	3	0,6%	Waiting NVA
Worker Idling	58	11,0%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		71,81%	EFFICIENCY
		54,10%	UTILIZATION

Figure 4.15 Individual *Yamazumi* Sheet of MP3

- **Process MP4**

Figure 4.16 is shown the individual *yamazumi* of process MP4. The Work NVA Necessary take 32,8% of total available time. The Work NVA take 22,9% of total available time. Next, Walking NVA take 2,1% of total available time. Then, Waiting NVA take 5,7% of total available time. Last, the worker is idling for 19,4% of total available time. Furthermore, process MP4 have 68,95% efficiency and 31,81% utilization.

YAMAZUMI SUMMARY SHEET

Process ID: MP4 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Pick And Put Material To Hand Trolly For Housing Line A	13	2,5%	Work NVA Necessary
Pick And Put Material To Hand Trolly For Housing Line B	29	5,5%	Work NVA Necessary
Pick And Put Material To Hand Trolly For Housing Line C	28	5,3%	Work NVA Necessary
Pick And Put Material To Hand Trolly For Housing Line D & E	93	17,7%	Work NVA Necessary
Replenishing Rack of Small Material For Housing	9	1,7%	Work NVA Necessary
Inputing Material Picking Information To Computer, Fill In Material Picking Report, Checking Small Material Quantity Before Putting On The Rack, etc	120	22,9%	Work NVA
Any Walking	11	2,1%	Walking NVA
Waiting Forklift To Pick Up Material, Helping Other Worker, etc	30	5,7%	Waiting NVA
Worker Idling	102	19,4%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		63,43%	EFFICIENCY
		32,76%	UTILIZATION

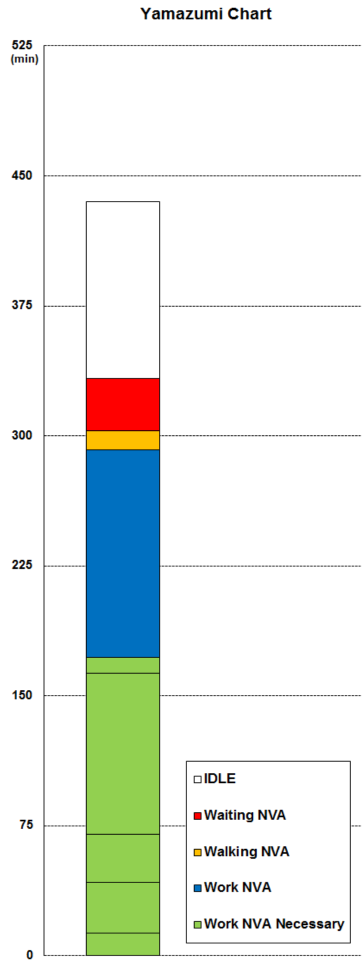


Figure 4.16 Individual *Yamazumi* Sheet of MP4

- **Process MP5**

Figure 4.17 is show the individual *yamazumi* of process MP5. The Work NVA Necessary of process MP5 take 41,52% of total available time. Work NVA take 20,76% of total available time. Next, Walking NVA take 5,00% of total available time. Then, Waiting NVA spend 5,7% of total available time. Last, Idle time take

9,0% of total available time. Furthermore, this process manpower have 73,90% efficiency and 41,52% utilization.

YAMAZUMI SUMMARY SHEET

Process ID: MP5 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Replenishing Shutter For Material Line Housing D & E	82	15,6%	Work NVA Necessary
Replenishing Shutter For Material Line Housing C	23	4,4%	Work NVA Necessary
Replenishing Shutter For Material Line Housing A	2	0,4%	Work NVA Necessary
Replenishing Shutter For Material Line Housing B	41	7,8%	Work NVA Necessary
Stacking And Maintain Emptry Polybox On Designated Place	12	2,3%	Work NVA Necessary
Picking Material 5 Component For Line Machining	58	11,0%	Work NVA Necessary
Inputing Material Picking Information To Computer, Double Handling, Operating Cutting Machine, etc	109	20,8%	Work NVA
Any Walking	31	5,9%	Walking NVA
Waiting Forklift To Pick Up Material On The Rack	30	5,7%	Waiting NVA
Worker Idling	47	9,0%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		73,90%	EFFICIENCY
		41,52%	UTILIZATION

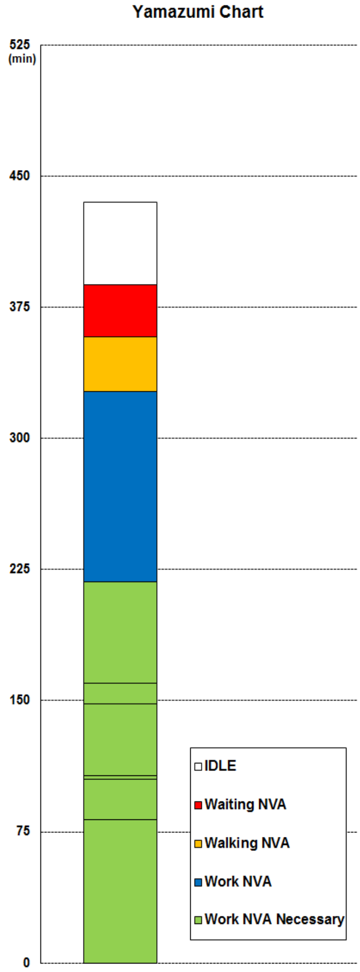


Figure 4.17 Individual *Yamazumi* Sheet of MP5

- **Process MP6**

Figure 4.18 will show the individual *yamazumi* for this process. Work NVA Necessary take 67,0% of total available time. Next, Work NVA take 3,0% of total available time. Then, Walking NVA take 1,5% of total available time. Last, Idle time take 11,2% of total available time. Furthermore, this process manpower have 71,62% efficiency and 67,05% utilization.

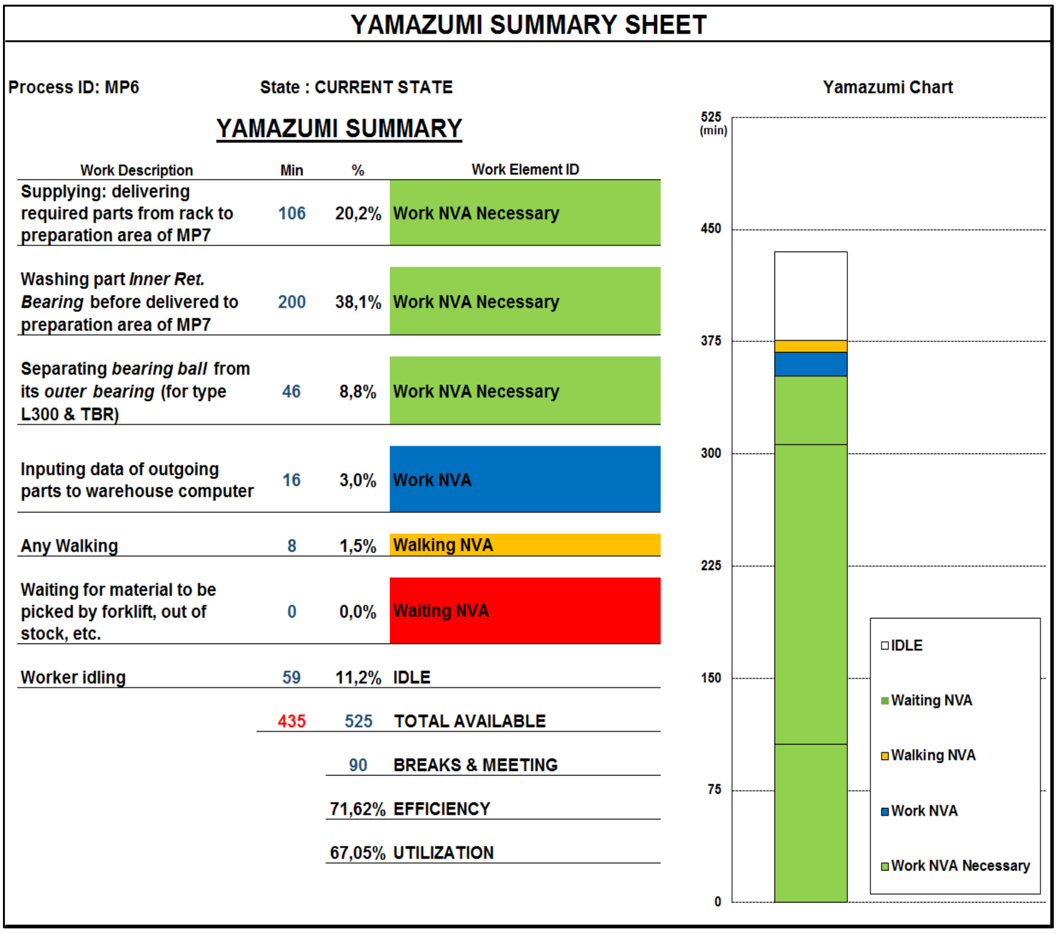


Figure 4.18 Individual *Yamazumi* Sheet of MP6

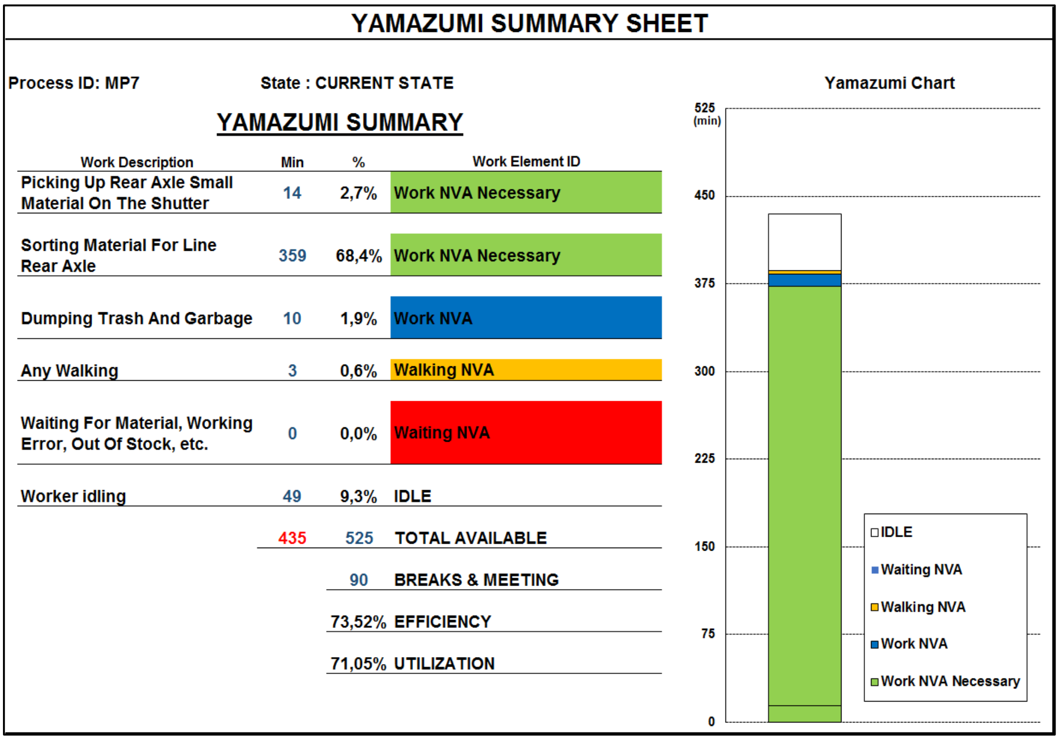
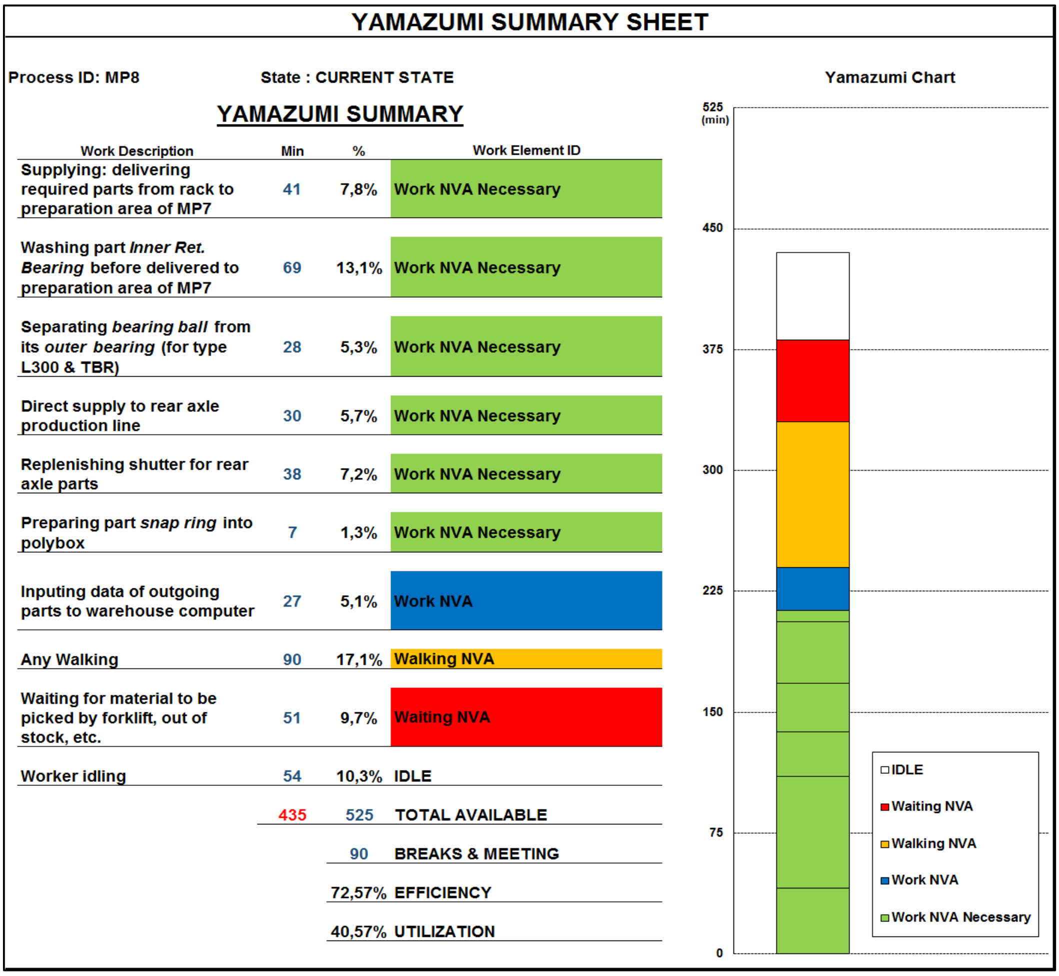


Figure 4.19 Individual *Yamazumi* Sheet of MP7

- **Process MP7**

Figure 4.19 show the individual *yamazumi* of this process. Process MP7 Work NVA Necessary take 71,05% of total available time. Work NVA of this process take 1,9% of total available time. The small percentage of total available time is used for Walking NVA which is 0,6% of total available time. Last, Idle time take 9,3% of total available time. Furthermore, process MP7 manpower have 73,52% efficiency and 71,05% utilization.


YAMAZUMI SUMMARY SHEET

Process ID: MP8 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Supplying: delivering required parts from rack to preparation area of MP7	41	7,8%	Work NVA Necessary
Washing part *Inner Ret. Bearing* before delivered to preparation area of MP7	69	13,1%	Work NVA Necessary
Separating *bearing ball* from its *outer bearing* (for type L300 & TBR)	28	5,3%	Work NVA Necessary
Direct supply to rear axle production line	30	5,7%	Work NVA Necessary
Replenishing shutter for rear axle parts	38	7,2%	Work NVA Necessary
Preparing part *snap ring* into polybox	7	1,3%	Work NVA Necessary
Inputing data of outgoing parts to warehouse computer	27	5,1%	Work NVA
Any Walking	90	17,1%	Walking NVA
Waiting for material to be picked by forklift, out of stock, etc.	51	9,7%	Waiting NVA
Worker idling	54	10,3%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		72,57%	EFFICIENCY
		40,57%	UTILIZATION

Figure 4.20 Individual *Yamazumi* Sheet of MP8

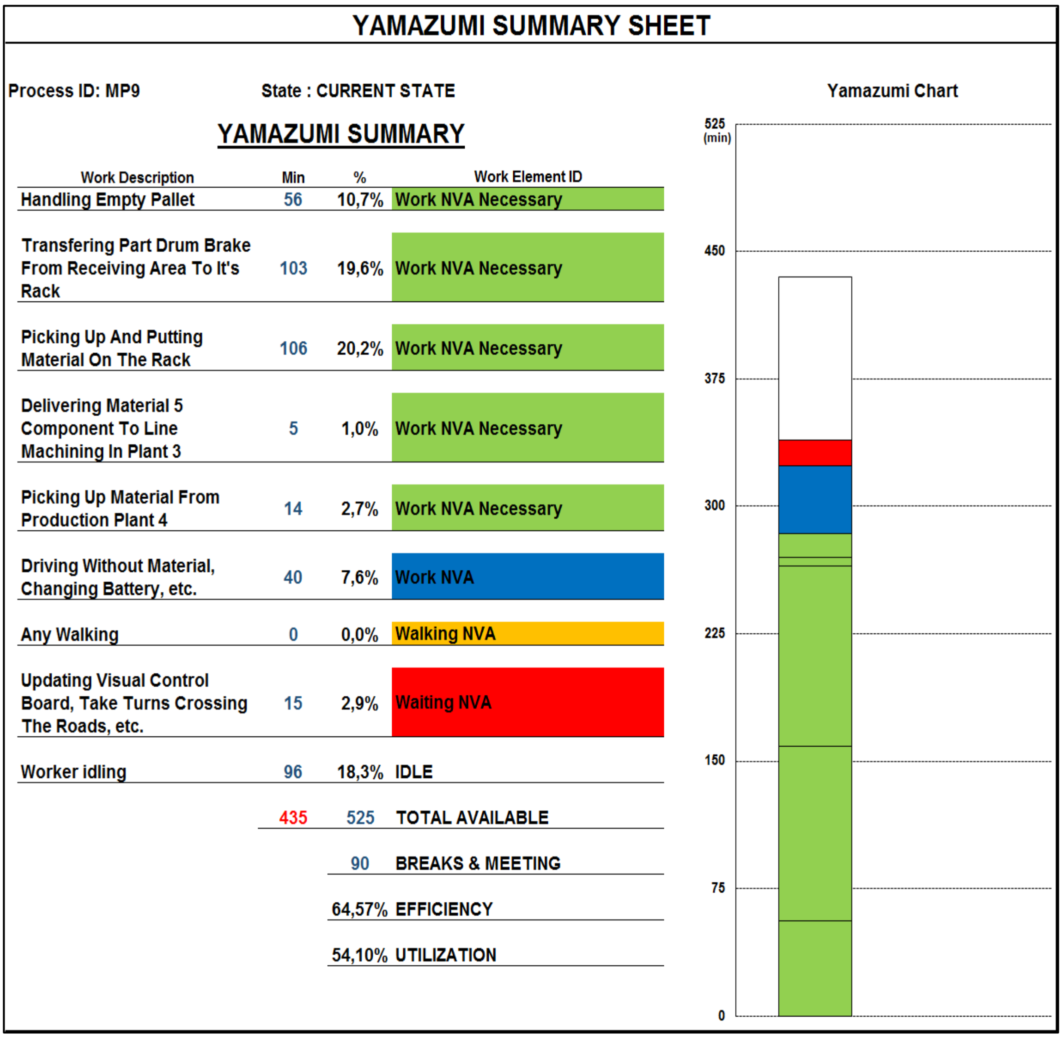
- **Process MP8**

Figure 4.20 show the individual *yamazumi* of process MP8. The Work NVA Necessary of this process take 40,57% of total available time. Then, Work NVA take 5,1% of total available time. Then, Walking NVA take 17,1% of total available time. Next, Waiting NVA take 9,7% of total available time. Last, Idle time take

10,3% of total available time. Furthermore, process MP8 manpower have 72,57% efficiency and 40,57% utilization.

- **Process MP9**

Figure 4.21 show the individual *yamazumi* of process MP9. Work NVA Necessary of this process take 54,1% of total available time. Then, Work NVA take 7,6% of total available time. Next, Waiting NVA take 2,9 of total available time. Last, Idle time take 18,3% of total available time. Furthermore, process MP9 manpower have 64,57% efficiency and 54,10% utilization.



YAMAZUMI SUMMARY SHEET

Process ID: MP9 State : CURRENT STATE

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Handling Empty Pallet	56	10,7%	Work NVA Necessary
Transfering Part Drum Brake From Receiving Area To It's Rack	103	19,6%	Work NVA Necessary
Picking Up And Putting Material On The Rack	106	20,2%	Work NVA Necessary
Delivering Material 5 Component To Line Machining In Plant 3	5	1,0%	Work NVA Necessary
Picking Up Material From Production Plant 4	14	2,7%	Work NVA Necessary
Driving Without Material, Changing Battery, etc.	40	7,6%	Work NVA
Any Walking	0	0,0%	Walking NVA
Updating Visual Control Board, Take Turns Crossing The Roads, etc.	15	2,9%	Waiting NVA
Worker idling	96	18,3%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		64,57%	EFFICIENCY
		54,10%	UTILIZATION

Figure 4.21 Individual *Yamazumi* Sheet of MP9

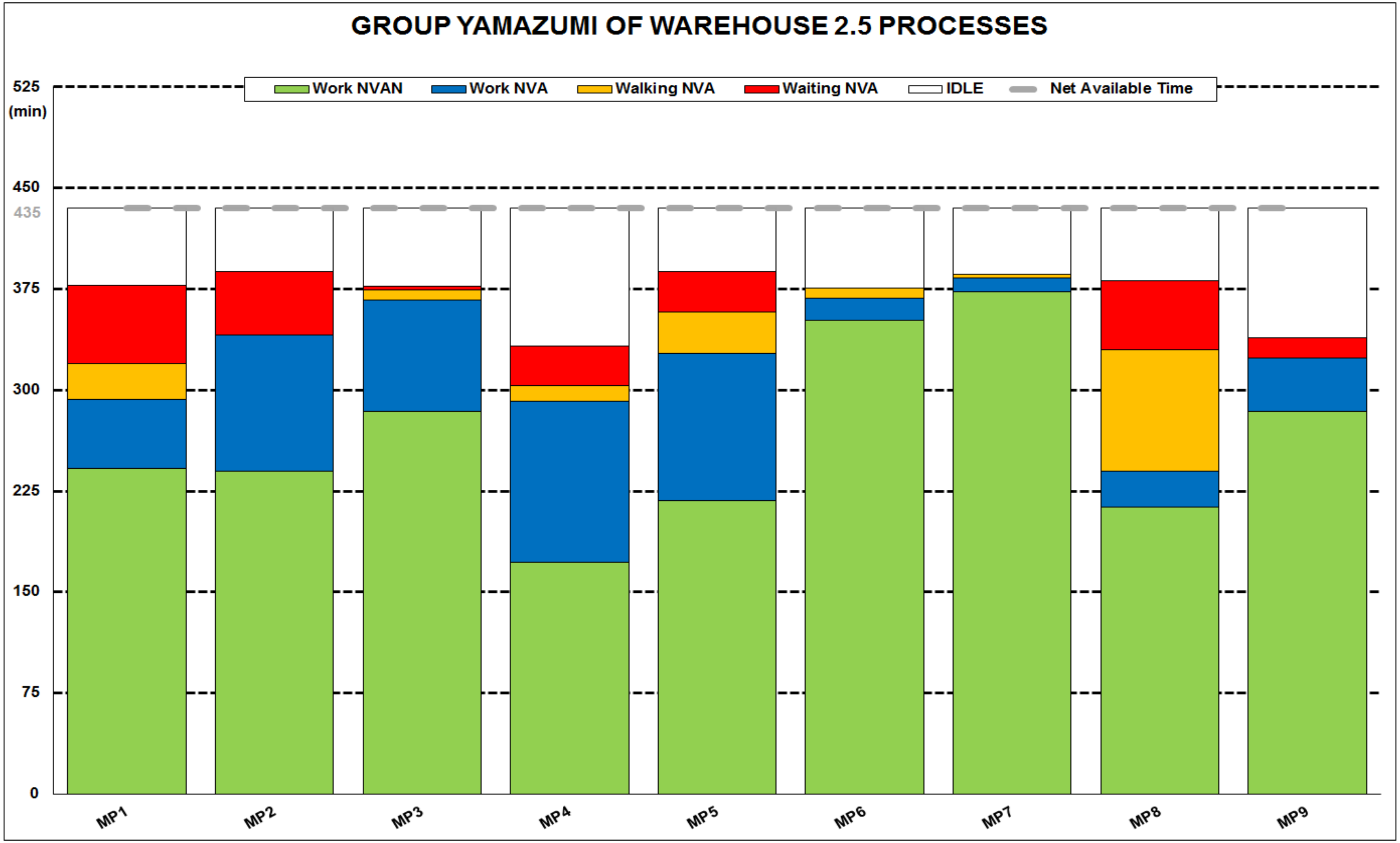


Figure 4.22 Grouped *Yamazumi*

Figure 4.22 of grouped *yamazumi* show the current condition of the warehouse process. It show clearly which process have a lot of non-value added necessary activities and which process have a lot of non-value added activities. Table 4.6 show the summary of *yamazumi* chart of each process that have been shown previously. Table 4.6 show cycle time, lowest and highest value for each element, and efficiency. The formula of calculating the efficiency is using formula 2.1 that have been given in chapter II.

Table 4.6 *Yamazumi* Chart

Process	Cycle Time (Min)	Work NVA Necessary	Work NVA	Walking NVA	Waiting NVA	Idle	Efficiency	Utilization
MP1	378	46,10%	9,71%	5,14%	**11,05%**	10,86%	72,00%	46,10%
MP2	388	45,71%	19,24%	**0%**	8,95%	**8,95%**	**73,90%**	45,71%
MP3	377	54,10%	15,81%	1,33%	0,57%	11,05%	71,81%	54,10%
MP4	362	**32,76%**	**22,86%**	2,10%	5,71%	**19,43%**	**63,43%**	**32,76%**
MP5	388	41,52%	20,76%	5,90%	5,71%	8,95%	**73,90%**	**41,52%**
MP6	376	67,05%	3,05%	1,52%	**0%**	11,24%	71,62%	67,05%
MP7	386	**71,05%**	**1,90%**	0,57%	**0%**	9,33%	73,52%	**71,05%**
MP8	381	40,57%	5,14%	**17,14%**	9,71%	10,29%	72,57%	**40,57%**
MP9	339	54,10%	7,62%	**0%**	2,86%	18,29%	64,57%	54,10%
Average	375	50,24%	12%	4%	5%	12%	71,43%	50,33%

As shown by table 4.6, the process that have the highest Work NVA Necessary are process MP6 and MP7 with 67,05% and 71,05% of total available time. This indicate this process already have a lot of non-value added necessary activities which have direct impact to production process. In the other hand, process MP4, process MP5 and process MP8 have the lowest Work NVA Necessary with 32,76%, 41,52% and 40,57%. This condition indicate process MP4, process MP8 and process MP5 have a lot of non-value added activities in their processes. Therefore, non-value added activities for process MP4 and MP5 need to be reduced. Non-value added work elements is included Work NVA, Walking NVA, and Waiting NVA.

Process with highest Work NVA is process MP4 and MP5. This process spend 22,86% and 20,76% of total available time to perform non-value added activities. Therefore, both of this process will be analyzed to see the cause behind this high amount of non-value added activities.

The next non-value added work elements is Walking NVA. The process that have highest Walking NVA percentage is process MP8. Process MP8 use 17,14% of its time for walking. Therefore, wasting valuable time to do necessary activities. Because of excessive amount of walking the research will focused on this process to see what cause this problem.

Another non-value added work elements is Waiting NVA. The process that have highest amount of waiting NVA is process MP1 and MP8 with 11,05% and 9,71% of total available time. However, the worker of process MP1 and MP8 does not have any other choice but wait. Since, the worker need to wait material to be picked by the forklift. The research did not focused on reducing Waiting NVA because with current process technology and system it is hard to reduce Waiting NVA. Example of Waiting NVA activities is waiting material to be picked by forklift, talk to co-worker, and waiting for supplier truck to be parked. There is not much the research can do to reduce this kind of non-value added activities.

Since process MP4, MP5, and MP8 have the lowest utilization, indicating three process have a lot of non-value added activities, mainly in their Work NVA and Walking NVA. The plans and ideas for reducing non-value added activities will be discussed in *kaizen* activities.

4.4 Kaizen

After collecting enough about work element in each process of the warehouse, next step is to conducting *kaizen* in the process. Generally, *kaizen* has six steps which are discover improvement potential, analyze the current methods, generate original idea, develop an implementation plan, implement the plan, evaluate the new method. Each *kaizen* steps will be explained further below.

4.4.1 Discover Improvement Potential

In this first step the research need to find improvement potential in every process. As stated in previous chapter, process that have potential improvement are process MP4, MP5, and MP8. These process have a lot of non-value added activities in their work element. Therefore, the research need to analyze the processes in order to find solution to reduce non-value added activities in that processes mainly Work NVA and Walking NVA.

4.4.2 Analyze the Current Methods

This second step purpose is to find the details of the process methods. Observing flow of the process to find which non-value added activities that can be reduced or even eliminated. The research is using flow process chart to analyze process MP4, MP5, and MP8 process activities. Further details for each process's flow process chart will explained below.

- **MP4 Flow Process Chart**

The activities that need to be reduce in this process is founded through direct observation and data collection that had been gathered in this research. The problem is over processing in replenishing rack of housing's small material. So, in this activities the worker need to change the quantity of material in the packing to match the production lot before put it to rack. This situation occur because the trolley that use to deliver material have to follow production lot, each production lot is 40 units. In the other hand, one housing's small material packing contain material that not a multiple of 40. The aims of this activities is for easy housing's material output recording.

Table 4.7 show the flow process chart for replenishing rack of housing's small material activities. The housing's small material are *bracket cjj, wire clamp, tube* *clamp, flexible hose, plate lock, cover plug, att. Brake 3 way, att. skid control*, and *att. Tube clamp*. The material is packing is using plastic. As table 4.7 shown the worker have to change the packing after weigh the materials, it is because the old plastic packing is unusable. This situation create over processing in the activities, adding more duration to non-value added activities.

Table 4.7 Replenishing Rack of Housing's Small Material

Process : MP4	Summary	
	Event	Present
Activities : Replenishing Rack of Housing's Small Material	Operation	5
	Transport	5
Time (in minutes) : 35 minutes	Delay	2
Frequency : 2	Inspection	2
Total Time : 70 minutes	Storing	1

No	Work Element ID	Task Description	Opt.	Trans	Delay	Insp.	Storing	Time (sec)	Notes
1	Waiting NVA	Asking forklift to pick up material	○	⇨	◗	□	▽	108	
2	Work NVA	Open the pallet plastic wrapping	●	⇨	D	□	▽	41	
3	Work NVA Necessary	Take the part packing	○	➡	D	□	▽	154	
4	Work NVA	Open the part packing	●	⇨	D	□	▽	88	
5	Work NVA	Take out some material (repeat until get required quantity)	○	➡	D	□	▽	220	The quantity of material does not match the production batch
6	Work NVA	Weigh the material (repeat until get required quantity)	●	⇨	D	■	▽	275	
7	Work NVA	Move material to new packing	○	➡	D	□	▽	715	Overprocessing
8	Work NVA	Binding the packaging	●	⇨	D	□	▽	198	
9	Work NVA	Write the quantity on the packaging	●	⇨	D	□	▽	154	
10	Work NVA Necessary	Put into the rack	○	➡	D	□	▼	99	
11	Waiting NVA	Asking forklift to pick up material	○	⇨	◗	□	▽	60	
12	Work NVA Necessary	Put into the rack	○	➡	D	□	▽	36	The quantity already match the production lot

- **MP5 Flow Process Chart**

The activities that need to be reduce in this process is founded through direct observation and data collection that had been gathered in this research. Process MP5 have the same problem with process MP4, which it has over processing activities. The activities is replenishing shutter of housing’s material. Table 4.8 will show the flow process chart of MP5 to show the detail of activities replenishing shutter of housing’s material.

As shown by table 4.8, the worker have to move the material to standard polybox. The example of material are *shock absorber*, *lower arm RH/ LH*, *lateral rod*, *saddle spring*, *reinforcement*, and *upper arm RH/ LH*. This situation occur because, the polybox from supplier does not fit in the shutter and some material quantity does not match with production lot. So, the worker have to change polybox and quantity of the material to fit with warehouse current condition. Therefore, adding non-value added activities to the process.

Table 4.8 Replenishing Shuter of Housing’s Material

Process : MP5							Summary		
							Event		Present
Activities : Replenishing Housing's Material Shutter							Operation		3
							Transport		3
Time (in minutes) : var.							Delay		2
Frequency : var.							Inspection		0
Total Time :							Storing		0
No	Work Element ID	Task Description	Opt.	Trans	Delay	Insp.	Storing	Time (sec)	Notes
1	Waiting NVA	Asking forklift to pick up material	○	⇨	◗	□	▽	103	
2	Work NVA Necessary	Open the pallet plastic wrapping	●	⇨	D	□	▽	46	
3	Wokr NVA Necessary/ Walking NVA	Take standard polybox	○	➡	D	□	▽	Var.	Polybox on the pallet is non-standard
4	Work NVA	Moving the material to standard polybox	●	⇨	D	□	▽	Var.	Overprocessing
5	Work NVA Necessary	Put Material to the shutter	○	➡	D	□	▼	Var.	
6	Work NVA Necessary/ Walking NVA	Put non-standard polybox to designated place	○	➡	D	□	▽	Var.	
7	Waiting NVA	Asking forklift to pick up material	○	⇨	◗	□	▽	103	
8	Work NVA Necessary	Open the pallet plastic wrapping	●	⇨	D	□	▽	46	
9	Work NVA Necessary	Put Material to the shutter	○	➡	D	□	▽	Var.	Already using standard polybox

- **MP8 Flow Process Chart**

The activities that need to be reduce in this process is founded through direct observation and data collection that had been gathered in this research. The problem in process MP8 is long walking distance, also can be called waste of motion. There are two activities that causing high Walking NVA which are washing *inner retainer bearing* and supplying slow moving material directly to rear axle's assembling line.

Table 4.9 Washing *Inner Retainer Bearing*

Process : MP8								Summary	
								Event	Present
Activiteis : Washing *Inner Retainer Bearing*								Operation	0
								Transport	10
Time (in minutes) : 66 minutes								Delay	2
Frequency : 2								Inspection	0
Total Time : 132 minutes								Storing	0
No	Work Element ID	Task Description	Opt.	Trans	Delay	Insp.	Storing	Time (sec)	Notes
1	Work NVA Necessary/ Walking NVA	Taking hand trolly	○	➡	D	□	▽	44	
2	Work NVA Necessary	Taking large polybox and put it on trolly	○	➡	D	□	▽	288	
3	Walking NVA	Walk to *inner retainer bearing* storing area	○	➡	D	□	▽	51	
4	Waiting NVA	Asking forklift to pick up *irb* on the rack	○	⇨	◗	□	▽	748	
5	Work NVA Necessary	Moving *irb* to large polybox	○	➡	D	□	▽	1295	Need to change to polyobx that have holes
6	Walking NVA	Walking to washing machine	○	➡	D	□	▽	360	
7	Work NVA Necessary	Put large polybox to washing machine	○	➡	D	□	▽	94	
8	Waiting NVA	Waitin washing process to finish	○	⇨	◗	□	▽	504	
9	Work NVA Necessary	Put large polybox to the trolly	○	➡	D	□	▽	230	
10	Walking NVA	Walk back to warehouse	○	➡	D	□	▽	182	
11	Work NVA Necessary	Supplying *irb* to process MP7	○	➡	D	□	▽	97	
12	Work NVA Necessarry	Put hand trolly to its place	○	➡	D	□	▽	46	

So the first activities, material *inner retainer bearing* need to be washed before entering production line to prevent defect. Because, *inner retainer bearing* is covered in oil to prevent rust, the oil can cause defect in production process. Table 4.9 will show the details of washing *inner retainer bearing* activities flow process chart.

This activities occur because of lack of methods to keep the material from rust. As shown by figure 4.23 below, the worker need take the material to washing machine on rear axle assembling line on production plant 3 in order to wash them. Because, current methods is using oil based stain cover to prevent rust on the material. This situation causing the material to be washed first before entering production process to prevent defect. If, there is another methods to cover the material from rust, this activities can be eliminated and *inner retainer bearing* can be directly supplied to process MP7.

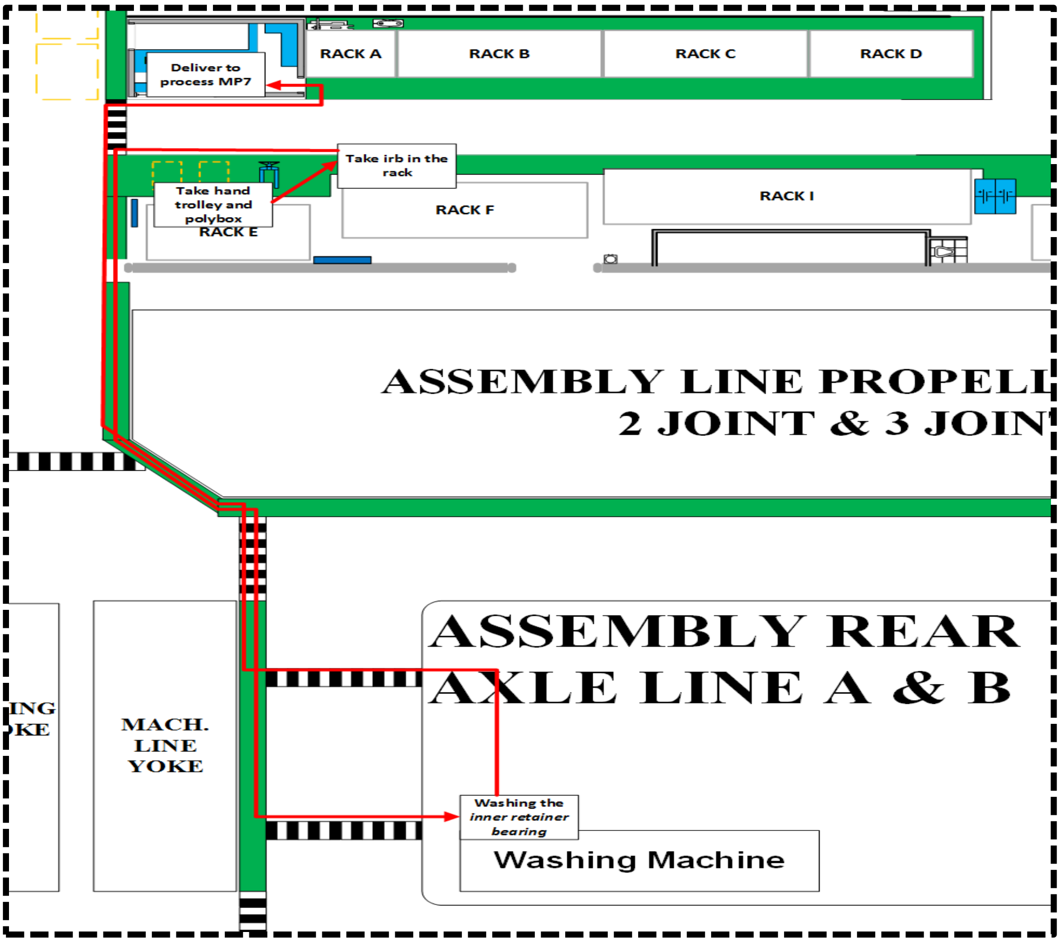


Figure 4.23 Washing *Inner Retainer Bearing* Movement

The second activities is supplying material directly to rear axle's assembling line. This activities occur because the product models that used this material is rarely produced in rear axle's assembling line. So, this material is not included in rear axle's assembling line towing system. Causing the warehouse worker to deliver it directly to the production line. Table 4.10 will show the details of the activities flow process chart.

Table 4.10 Supplying Material Directly to Rear Axle's Assembling Line

Process : MP8	Summary	
	Event	Present
Task : Supplying Material to Rear Axle Assembling Line	Operation	0
	Transport	4
Time (in minutes) : 41 minutes	Delay	0
Frequency : 2	Inspection	0
Total Time : 82 minutes	Storing	0

No	Work Element ID	Task Description	Opt.	Trans	Delay	Insp.	Storing	Time (sec)	Notes
1	Walking NVA	Take hand trolly						44	
2	Work NVA Necessary	Taking needed material						332	
3	Work NVA Necessary/Walking NVA	Delivered it to line RA						1803	
4	Walking NVA	Back to warehouse						238	

Activities that showed in table 4.10 is caused by lack of methods in supplying rarely used material. The material that delivered are *shim*, *plug breather*, *oil seal holder*, and *outer bearing*. This situation causing the worker for process MP8 to walking long distances and adding more non-value added activities to warehouse process. To give the details of operation figure 4.26 below will show the flow diagram of this activities.

Figure 4.24 below show the movement of the worker in performing the activities. First, the worker need to take hand trolley for carrying the material. Second, the worker need to search and pick the needed material in warehouse. Next, deliver and supplying the material to rear axle assembling line in production plant 3. After all material had been delivered the worker walk back to the warehouse. Because of that, the worker need to walk long way in order to performing one activities. Therefore, Walking NVA for this process need to reduced in order to achieve better efficiency.

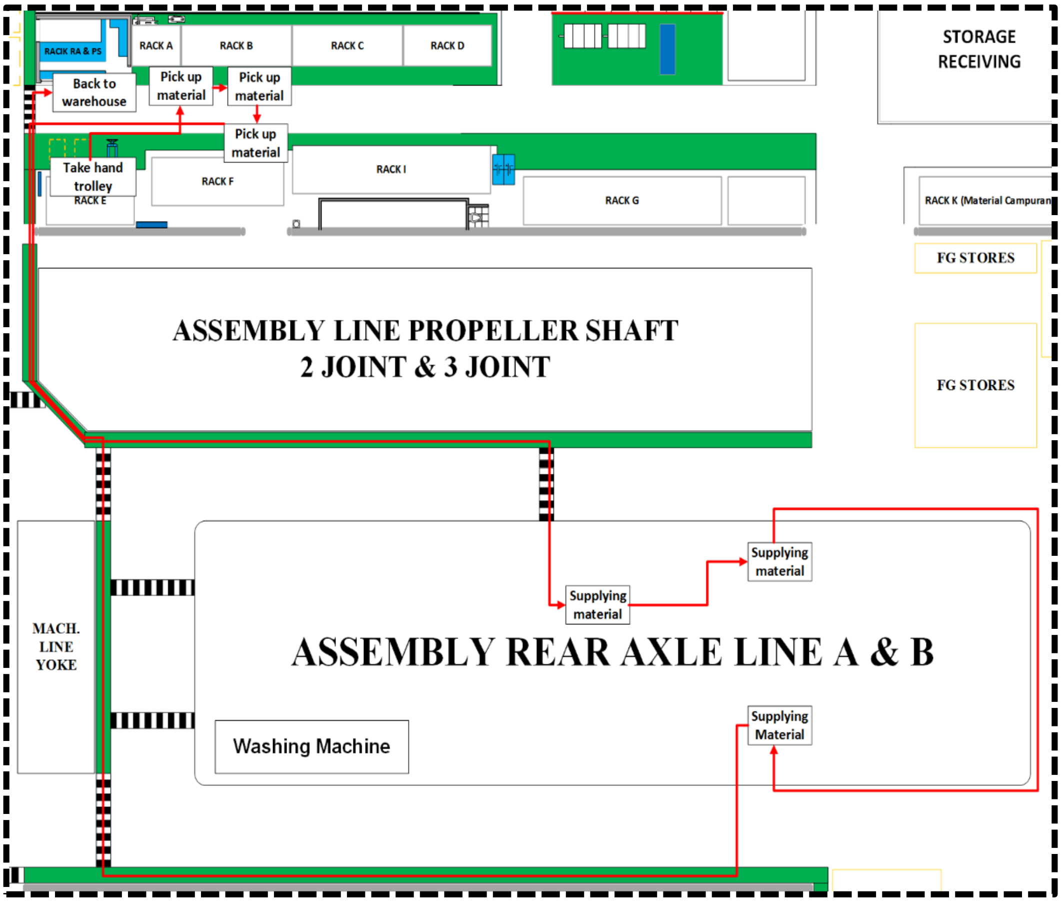


Figure 4.24 Supplying Material to Rear Axle Assembling Line Movement

The activities that causing high non-value added activities had been analyzed. The process are MP4, MP5, and MP8. The detail of the activities is already given by flow process chart. The problem mainly caused by over processing and waste of motion. Therefore, the research need to generate original ideas to find solution to this problem.

4.4.3 Generate Original Ideas

This third step in *kaizen* is to find solution through original ideas. After, analyzing non-value added activities in process MP4, MP5, and MP6 using flow process chart the research need to find solution to solve the problem mentioned in previous section. The ideas that used for solving the problem will be further explained to in this section.

- **Ideas For Process MP4**

As mentioned in previous section, the problem in process MP4 is over processing in replenishing rack of housing's small material. The root cause of this problem is different between material quantities with production lot. The research proposed ideas is to standardized material quantity from supplier. The company proposed standard quantity per packing to supplier in order to match the quantity with production lot. Therefore, the worker does not need to change the quantity before put the material into rack, so the material can directly put into the rack.

- **Ideas For Process MP5**

As mentioned in previous section, the problem in process MP5 is over processing in replenishing shutter of housing's material. This condition is caused by non-standard material packing and quantity. Causing the worker to move the material to standard polybox before put it on the shutter. The research proposed to the company to standardize their supplier material packing and quantity to match the production lot and warehouse current condition. Therefore, with standard polybox and quantity the worker only need to put the material directly to the shutter.

- **Ideas For Process MP8**

As mentioned in previous section, the problem in process MP8 is waste of motion. For the first activities which is washing *inner retainer bearing*, the research proposed to Supplier Company to change from oil-based rust preventive to water-based rust preventive. This idea will make *inner retainer bearing* does not need to be washed before entering production process. Therefore, washing *inner retainer bearing* activities can be eliminated.

For the second activities which is supplying material directly to rear axle's assembling line. The research proposed solution for this problem is to create system for material ordering using bill or note. The worker in the warehouse only need to odder picking the material and put it into special rack, then if the material needed in the production process the group leader of rear axle's assembling line will order the material into the warehouse and take the needed material then distribute it to the production line. With this system, the worker does not need to walk to production area and the warehouse can record the material output clearly.

The *kaizen* ideas for solving the problem had been proposed by the research. The key of success improvement is a good planning. The next step is to develop implementation plan for the ideas. The purpose is to keep the idea implemented correctly. Therefore, the goals of the improvement can be achieved.

4.4.4 Develop Implementation Plan

This fourth step of *kaizen* is used to planning the implementation of *kaizen* ideas that had been proposed in previous step. The research team will be divided into smaller groups. Every groups will have responsibility to handling each *kaizen* ideas. Therefore, the research team can focused their energy to each *kaizen* ideas maintaining the implementation process. After the implementation plan had been created, next step is implementing the plan.

4.4.5 Implementing the Plan

The fifth step is implementing the plan in the warehouse. However, the research is based on estimation of how the idea will affect the warehouse process. The research implementing the *kaizen* ideas by estimating the affect by using the available data and information that had been gathered. After, implementing the plan the last step is to evaluate the process.

4.4.6 Evaluate the Process

The last step of *kaizen* is to evaluate the result of *kaizen* ideas in the process MP4, MP5, and MP8. In this step the research want to see how much non-value added activities that had been reduced in each process. The information about how much the improvement reduce the non-value added activities will be explained with bar chart below.

- **Process MP4**

Through *kaizen* ideas process MP4 have reduced its Work NVA by 45%. The Work NVA before *kaizen* was 120 minutes per shift, but after *kaizen* the Work NVA become 65 minutes. This indicate, the process non-value added activities had been reduced. The percentage calculation is shown below.

$$\text{Work NVA After Kaizen} = \frac{120 \text{ minutes} - 65 \text{ minutes}}{120 \text{ minutes}} \text{x } 100\% \approx \mathbf{45}\%$$

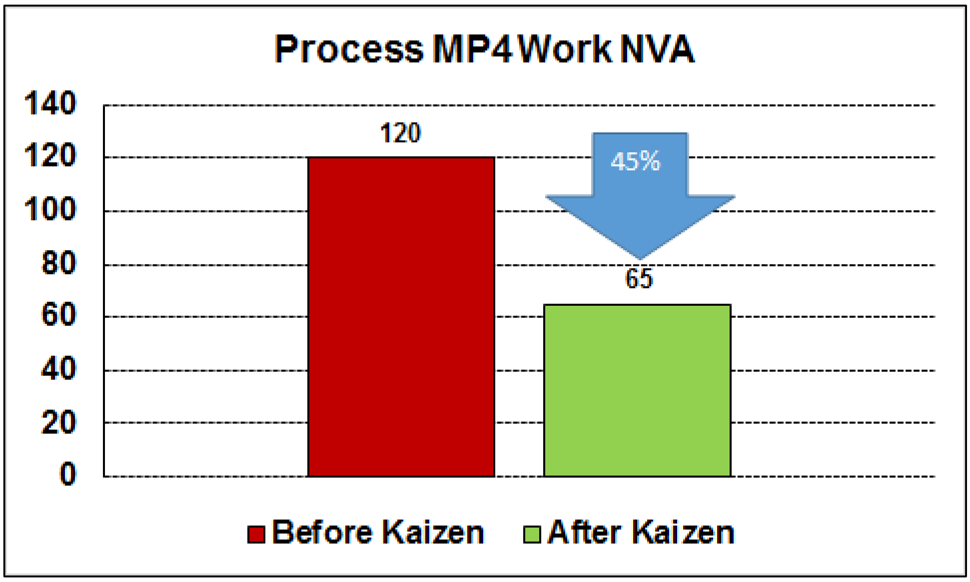


Figure 4.25 MP4 Work NVA Before and After *Kaizen*

- **Process MP5**

Over processing in replenishing shutter of housing's material in Process MP5 had been eliminated. Through, *kaizen* ideas that had been mentioned before the Work NVA is reduced by 72%. Before the *kaizen* it was 109 minutes, but after *kaizen* it become 31 minutes. The *kaizen* ideas greatly reduce the non-value added activities in process MP5.

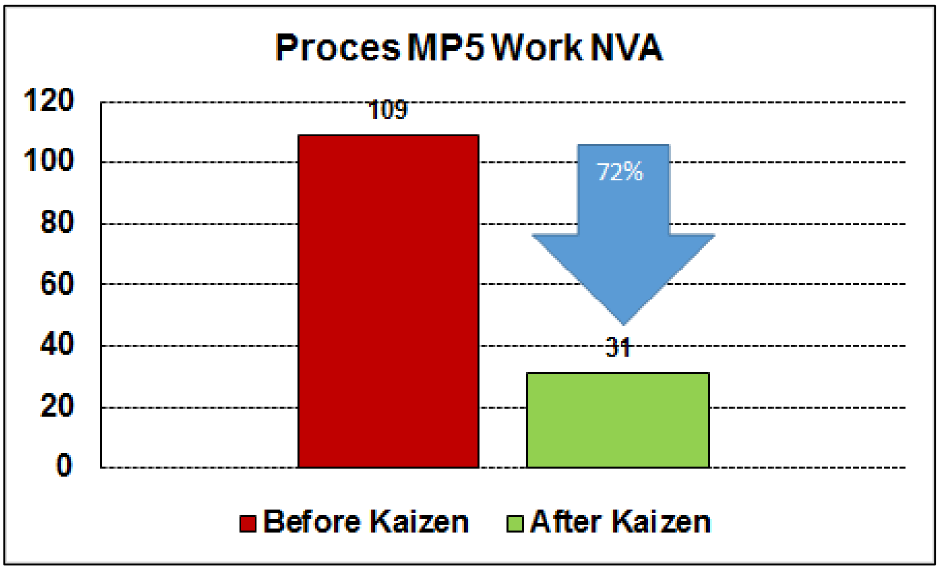


Figure 4.26 MP5 Work NVA Before and After *Kaizen*

Because of reducing Work NVA this improvement also reduce Walking NVA of process MP5 as shown by figure 4.27 below. So, in flow process chart table 4.8, the worker have to walk to take standard polybox because all material already used standard packing the worker do not need to do it anymore. This result reducing more non-value added activities of Walking NVA in this process by 52%. Before the *kaizen* it was 31 minutes, but after *kaizen* it become 15 minutes.

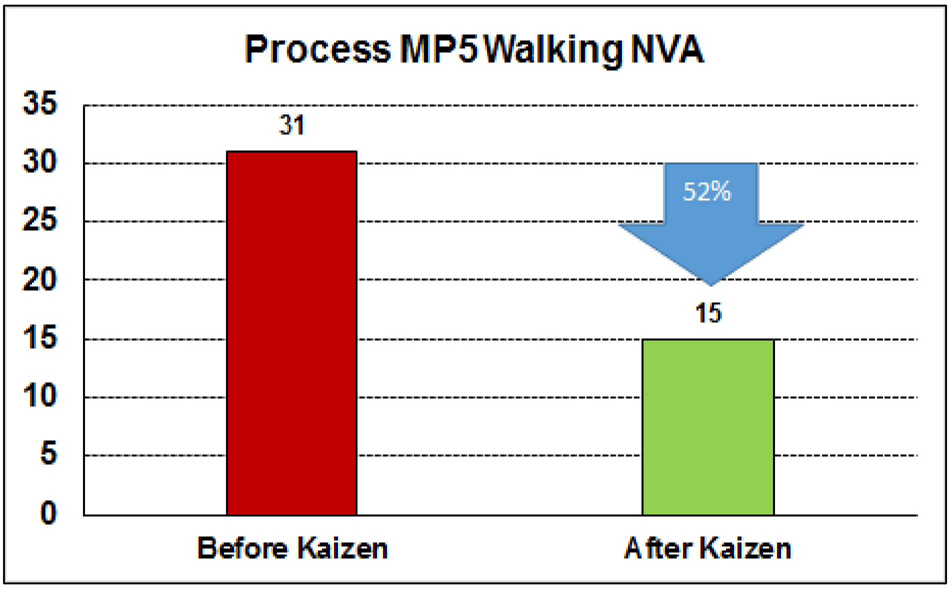


Figure 4.27 MP5 Walking NVA Before and After *Kaizen*

- **Process MP8**

After *kaizen* the Walking NVA of process MP8 have reduced greatly. The Walking NVA is reduce by 80%. Before *kaizen* it was 90 minutes, but after the washing *inner retainer bearing* activities had been eliminated and material ordering system is proposed it reduced to 18 minutes. This, indicating process MP8 non-value added activities had been decreasing.

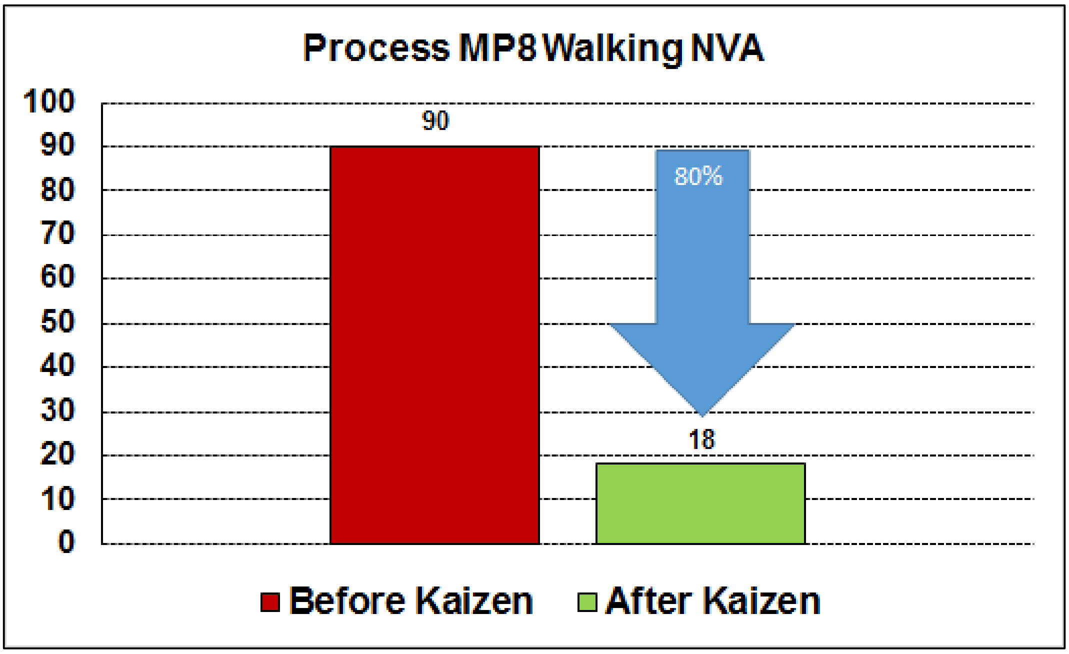


Figure 4.28 MP8 Walking NVA Before and After *Kaizen*

Beside of reducing Walking NVA the *kaizen* ideas also reduce Waiting NVA of process MP8. Because, washing *inner retainer bearing* (*irb*) is eliminated the worker does not need to wait for the material to finish washing. It is reduced by 33%. Before *kaizen* it was 51 minutes, but after *kaizen* it become 34 minutes. The result is shown by figure 4.29 above.

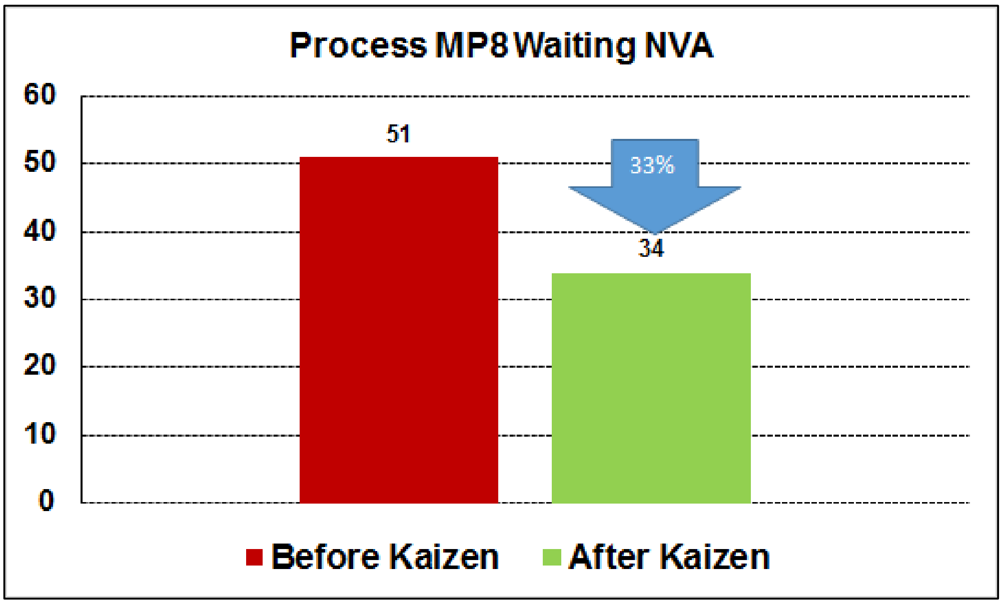


Figure 4.29 MP8 Waiting NVA Before and After *Kaizen*

Because of elimination of activities washing *inner retainer bearing* (*irb*) some Work NVA Necessary also eliminated. Work NVA Necessary exist in this previous process because of lack of methods in handling the *irb*. Therefore, after *kaizen* Work NVA Necessary for process MP8 is reduced by 25% from 213 minutes to 159 minutes. The result is shown by figure 4.30 below.

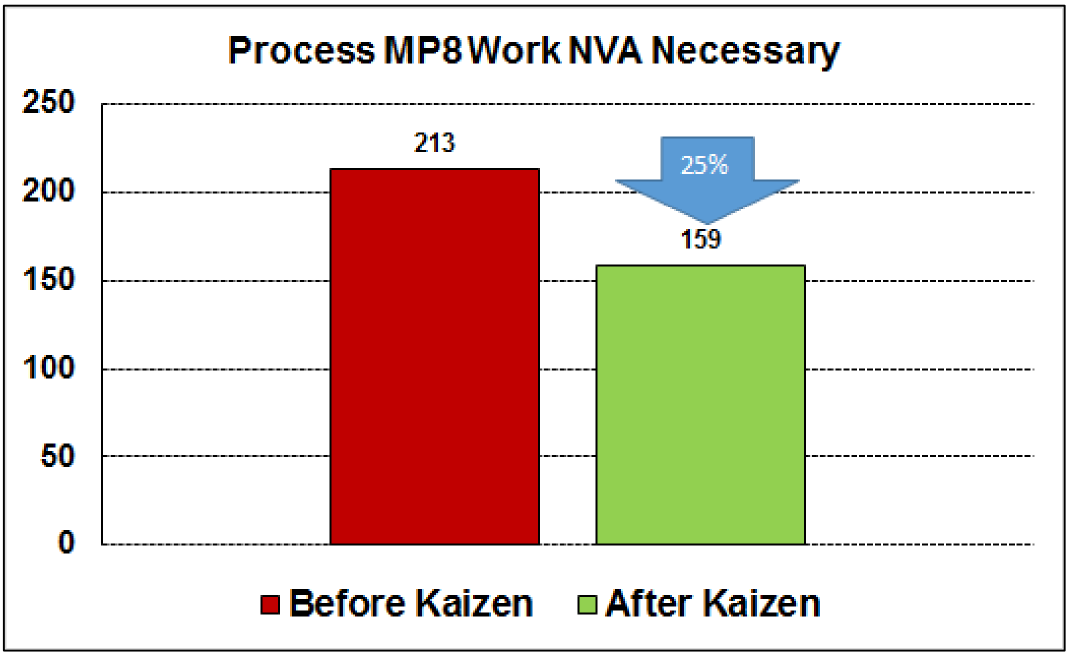


Figure 4.30 MP8 Work NVA Necessary Before and After *Kaizen*

The work flow of both activities also changing after *kaizen* implementation. The activities which are washing *inner retainer bearing* (*irb*) and supplying material to rear axle assembling line had been improved. The worker no longer need to walk far away to performing the activities. Figure 4.31 and figure 4.32 will show the movement of the worker after *kaizen* implementation of both activities.

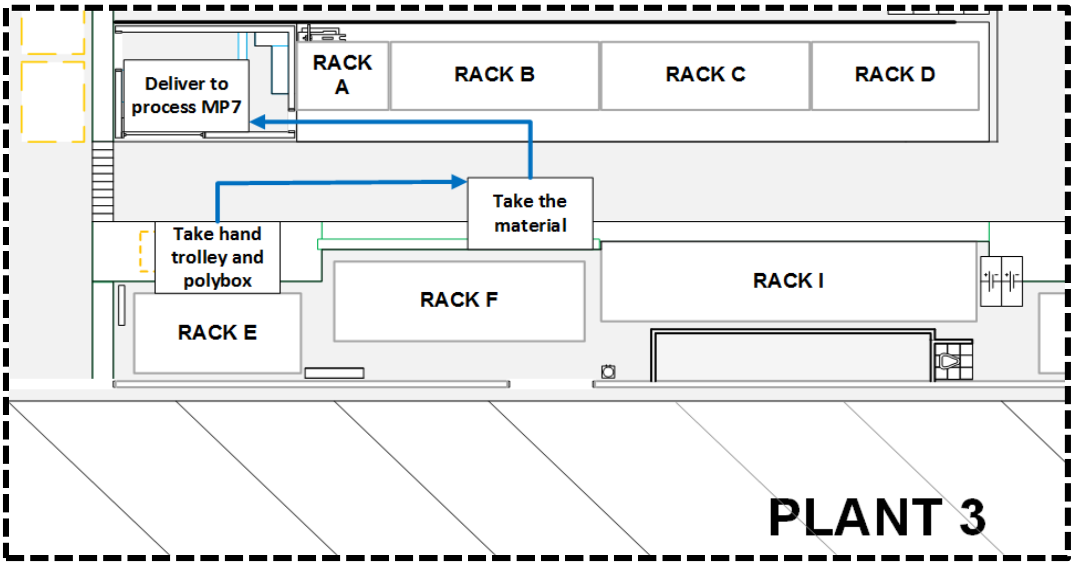


Figure 4.31 Washing *Inner Retainer Bearing* after *Kaizen*

Before improvement movement for washing *inner retainer bearing* is displayed in figure 4.23, show that the worker need to walk to washing machine on production plant 3. But, after *kaizen* movement which is shown in figure 4.31 show that the worker only need to take the material than directly delivered it to process MP7.

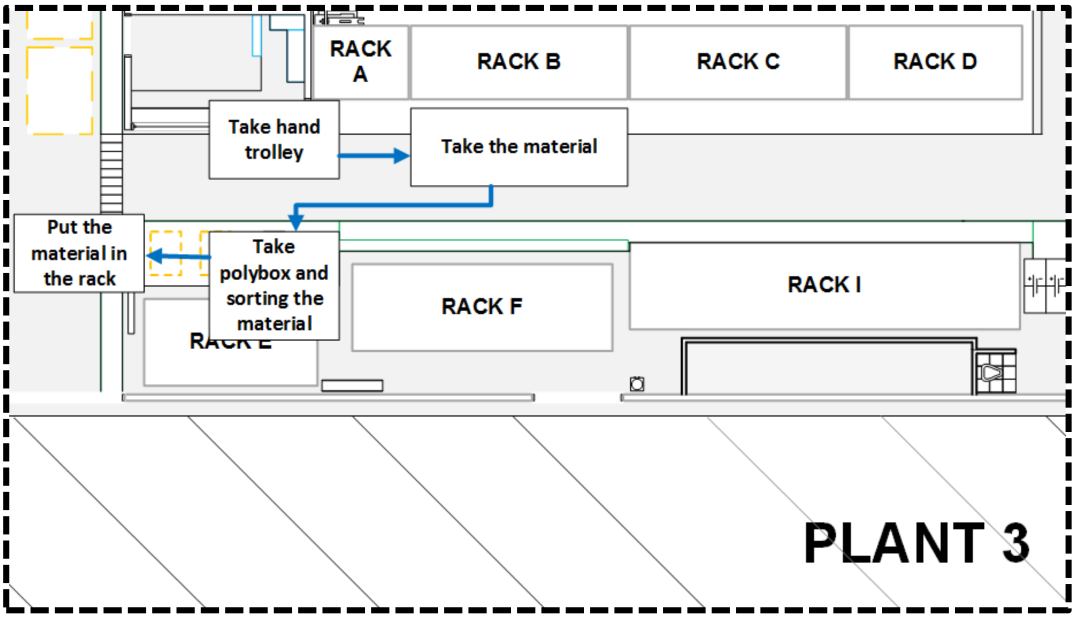


Figure 4.32 Supplying Material to Rear Axle Assembling Line after *Kaizen*

The movement of supplying material to rear axle assembling line is greatly reduced. The movement before *kaizen* which is shown by figure 4.24 required the worker to walking far away to supplying the material. After *kaizen* movement which shown by figure 4.32, only required the worker to picking and sorting material needed then put it into the rack. The worker will set the material in polybox following the production lot. Then, the production worker will give warehouse material order bill before take the material and carrying it to production line.

Kaizen had been implemented and it is successfully reduce non-value added activities in process MP4, MP5, and MP8. As shown by figure 4.33, the grouped *yamazumi* is different than previous one in figure 4.22. The non-value added activities of process MP4, MP5, and MP8 had been reduced. This is shown by table 4.11, average efficiency after *kaizen* is decreasing

Table 4.11 Efficiency Before and After *Kaizen*

Process	Before *Kaizen*			After *Kaizen*		
	Cycle Time (Min)	Efficiency Before	Utilization Before	Cycle Time (Min)	Efficiency After	Utilization After
MP1	378	72,00%	46,10%	378	72,00%	46,10%
MP2	**388**	**73,90%**	45,71%	**388**	**73,90%**	45,71%
MP3	377	71,81%	54,10%	377	71,81%	54,10%
MP4	362	68,95%	32,76%	278	52,95%	32,76%
MP5	380	72,38%	41,52%	294	56,00%	41,52%
MP6	376	71,62%	67,05%	376	71,62%	67,05%
MP7	386	73,52%	**71,05%**	386	73,52%	**71,05%**
MP8	381	72,57%	**40,57%**	**238**	**45,33%**	**30,29%**
MP9	**339**	**64,57%**	54,10%	339	64,57%	54,10%
Average	374	71,43%	50,33%	339	64,63%	49,19%

Table 4.11 show the process with highest efficiency after *kaizen* is still the same which is process MP2 with 73,90%. But, the process with lowest efficiency is changing from process MP9 with 64,57% to process MP8 with 45,33%. Process MP7 also still have the highest utilization among the process with 71,05%. In the other hand, after *kaizen* process MP8 still have the lowest utilization among the process with 30,29%.

Process MP4, MP5, and MP8 where *kaizen* had been implemented have their efficiency reduced. Process MP4 before *kaizen* has 68,95% efficiency, but after *kaizen* it is reduced to 52,95%. Next, process MP5 before *kaizen* has 72,38% efficiency, but after *kaizen* it is reduced to 56,00%. Lastly, process MP8 has 72,57% efficiency before *kaizen*, but after *kaizen* it is reduced to 45,33%.

As shown by table 4.11, after *kaizen* the process become unbalance. Before *kaizen* the range of different between highest efficiency process with lowest efficiency process is 9,33%, but after *kaizen* it become 28,57%. This condition is causing average efficiency of the warehouse decreasing. So, in order to equalize the efficiency of each processes, process balancing need to be conducted.

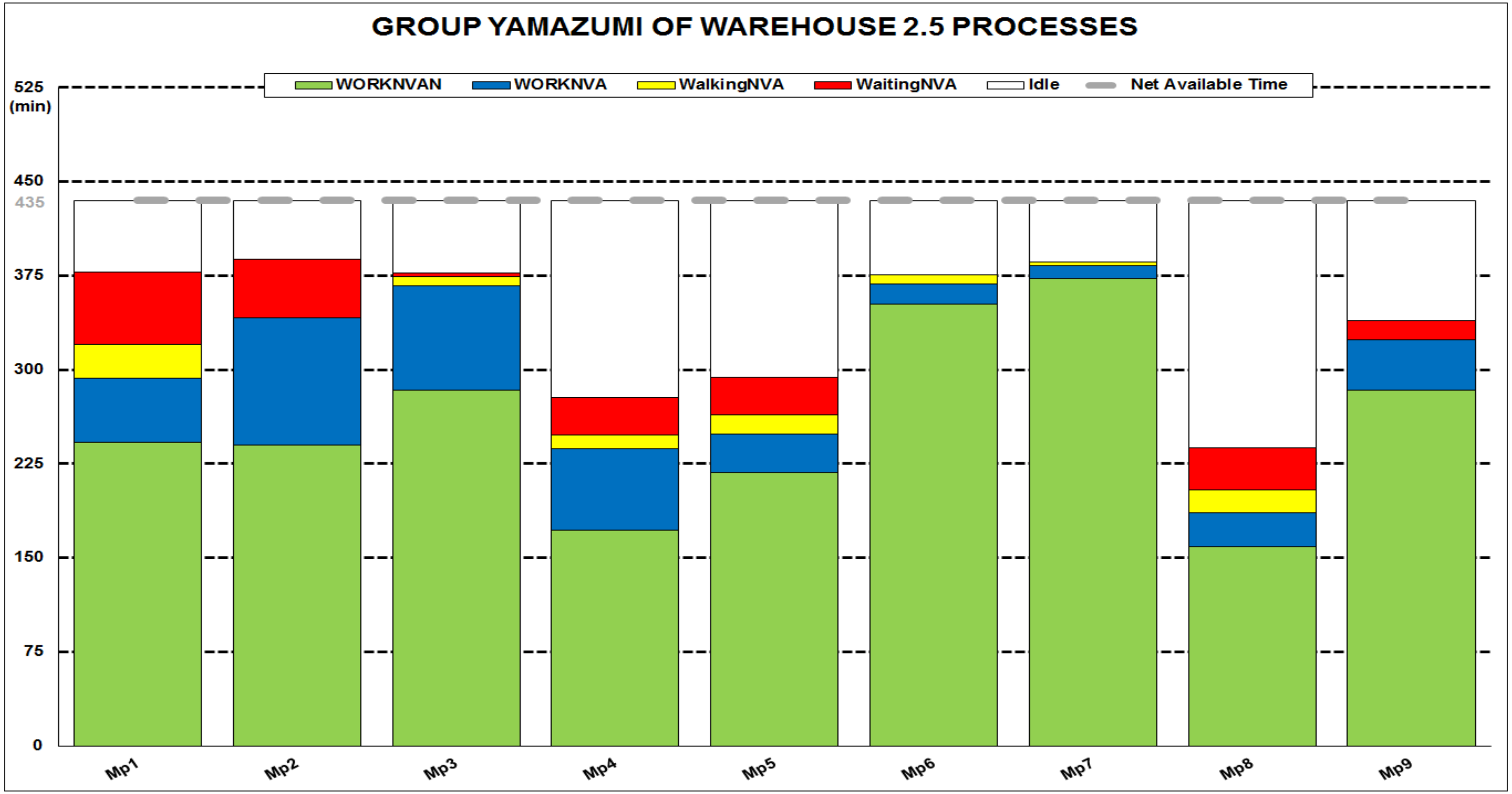


Figure 4.33 Grouped *Yamazumi* after *Kaizen*

4.5 Process Balancing

Process balancing is a procedure to equalize the process time required to accomplish. After *kaizen* the warehouse process efficiency have huge gap difference between each other. To equalize the process again, the work element of MP8 will be merged to process MP4 and MP5. Because, MP8 have the lowest efficiency after *kaizen*, the research decide to move the work element of MP8 to MP4 and MP5. Therefore, eliminating process MP8 and increasing efficiency of MP4 and MP5.

Individual *yamazumi* chart will be used to show the condition of MP8 after *kaizen*. It will give the information why MP8 work element is decided to be moved to process MP4 and MP5. The details of the individual *yamazumi* chart will be given below.

YAMAZUMI SUMMARY SHEET

Process ID: MP8 State : AFTER *KAIZEN*

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Supplying: delivering required parts from rack to preparation area of MP7	41	7,8%	Work NVA Necessary
Supplying material *inner retainer bearing*	15	2,86%	Work NVA Necessary
Separating *bearing ball* from its *outer bearing* (for type L300 & TBR)	28	5,33%	Work NVA Necessary
Order picking material for rear axle's assembling line	30	5,71%	Work NVA Necessary
Replenishing shutter for rear axle parts	38	7,24%	Work NVA Necessary
Preparing part *snap ring* into polybox	7	1,33%	Work NVA Necessary
Inputing data of outgoing parts to warehouse computer	27	5,14%	Work NVA
Any Walking	18	3,43%	Walking NVA
Waiting for material to be picked by forklift, out of stock, etc.	34	6,48%	Waiting NVA
Worker idling	197	37,52%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		45,33%	EFFICIENCY
		30,29%	UTILIZATION

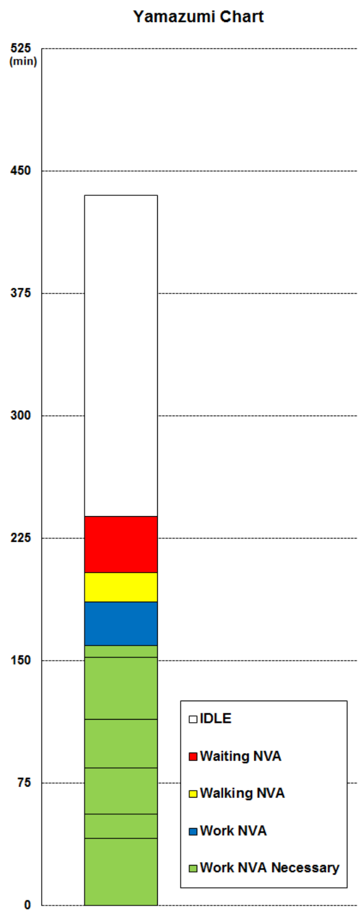


Figure 4.34 Process MP8 Individual *Yamazumi* after *Kaizen*

Figure 4.37 is individual *yamazumi* chart of process MP8 after *kaizen*. The reason why MP8 is chosen to be merged with process MP4 and MP5 because the process are in the same zone which is picking and sorting zone. Beside of that the Work NVA Necessary of process MP8 become 30,29% of total available time, it is the lowest from all of the process. Also, the process have high idling time after improvement with 37,52% of total available time. Furthermore, the efficiency and utilization of process MP8 is the lowest from all of the process with 45,33% and 30,29%. Therefore, by merging process MP8 to process MP4 and MP5 will their efficiency and eliminating one 'un-necessary' process. The individual *yamazumi* for process MP4 and MP5 will be given below.

YAMAZUMI SUMMARY SHEET

Process ID: MP4   State : After Balancing

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Pick And Put Material To Hand Trolly For Housing Line A	13	2,5%	Work NVA Necessary
Pick And Put Material To Hand Trolly For Housing Line B	29	5,5%	Work NVA Necessary
Pick And Put Material To Hand Trolly For Housing Line C	28	5,3%	Work NVA Necessary
Pick And Put Material To Hand Trolly For Housing Line D & E	93	17,7%	Work NVA Necessary
Replenishing Rack of Small Material For Housing	9	1,7%	Work NVA Necessary
Supplying: delivering required parts from rack to preparation area of MP7	41	7,8%	Work NVA Necessary
Replenishing shutter for rear axle parts	38	7,2%	Work NVA Necessary
Preparing part snap ring into polybox	7	1,3%	Work NVA Necessary
Inputing Material Picking Information To Computer, Fill In Material Picking Report, Checking Small Material Quantity Before Putting On The Rack, etc	78	14,86%	Work NVA
Any Walking	11	2,10%	Walking NVA
Waiting Forklift To Pick Up Material, Helping Other Worker, etc	30	5,71%	Waiting NVA
Worker Idling	33	6,29%	IDLE
	324	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		71,81%	EFFICIENCY
		49,14%	UTILIZATION

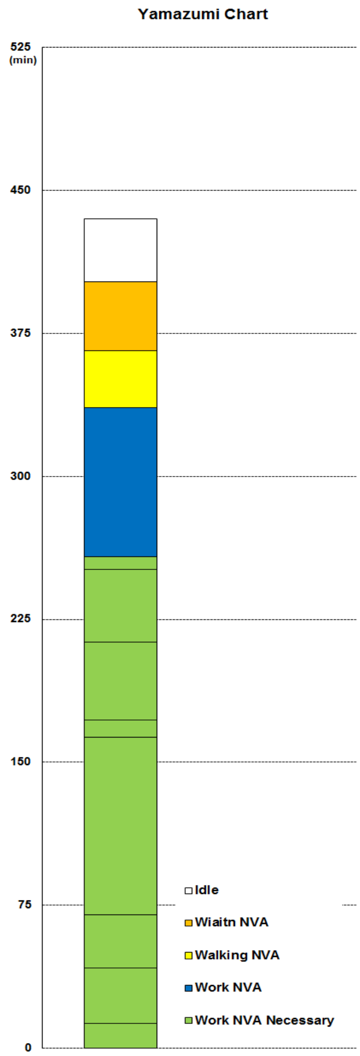


Figure 4.35 Process MP4 Individual *Yamazumi* After Balancing

Figure 4.35, show the process MP4 individual *yamazumi* after balancing. The work elements that moved from process MP8 to MP4 are supplying process MP7, replenishing shutter for rear axle's material, and order picking *snap ring*. The effect of merging with process MP8 is process MP4 efficiency increase from 52,95% to 71,81%. Therefore, increasing manpower efficiency of process MP4 by 18,86%.

YAMAZUMI SUMMARY SHEET

Process ID: MP5 State : After Balancing

YAMAZUMI SUMMARY

Work Description	Min	%	Work Element ID
Replenishing Shutter For Material Line Housing D & E	82	15,62%	Work NVA Necessary
Replenishing Shutter For Material Line Housing C	23	4,38%	Work NVA Necessary
Replenishing Shutter For Material Line Housing A	2	0,38%	Work NVA Necessary
Replenishing Shutter For Material Line Housing B	41	7,81%	Work NVA Necessary
Stacking And Maintain Empty Polybox On Designated Place	12	2,29%	Work NVA Necessary
Supplying material inner retainer bearing	15	2,86%	Work NVA Necessary
Separating bearing ball from its outer bearing (for type L300 & TBR)	28	5,33%	Work NVA Necessary
Order picking material for rear axle's assembling line	30	5,71%	Work NVA Necessary
Picking Material 5 Component For Line Machining	58	11,05%	Work NVA Necessary
Inputing Material Picking Information To Computer, Double Handling, Operating Cutting Machine, etc	31	5,90%	Work NVA
Any Walking	18	3,43%	Walking NVA
Waiting Forklift To Pick Up Material On The Rack	30	5,71%	Waiting NVA
Worker Idling	65	12,38%	IDLE
	435	525	TOTAL AVAILABLE
		90	BREAKS & MEETING
		70,48%	EFFICIENCY
		55,43%	UTILIZATION

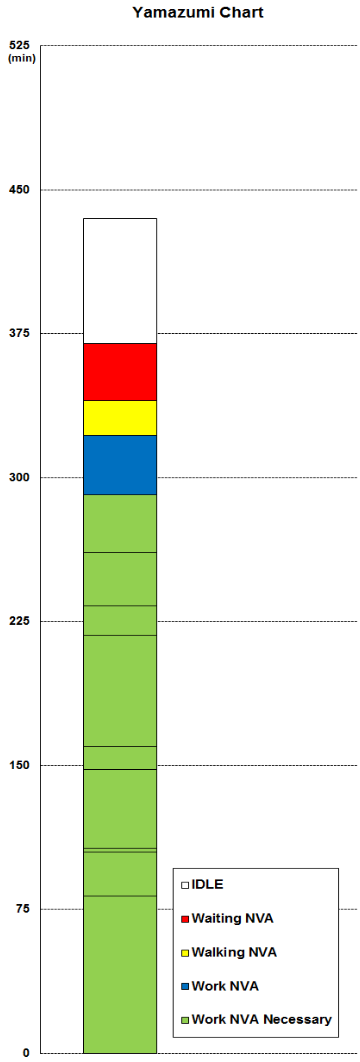


Figure 4.36 Process MP5 Individual *Yamazumi* After Balancing

Figure 4.36, show the process MP5 individual *yamazumi* after balancing. There are three work elements that moved to process MP5 from process MP8, which are separating *bearing ball* with *outer bearing*, order picking material for rear axle's assembling line, and supplying material *inner retainer bearing* to process MP7.

Merging process MP5 with MP8 causing efficiency MP5 to increase. The efficiency after *kaizen* is 56%, but after balancing it increase to 70,48%. Therefore, increase manpower efficiency of process MP5 by 14,48%.

Table 4.12 Efficiency Before and After Balancing

Process	Before Balancing			After Balancing		
	Cycle Time (Min)	Efficiency Before	Utilization Before	Cycle Time (Min)	Efficiency After	Utilization After
MP1	378	72,00%	46,10%	378	72,00%	46,10%
MP2	388	73,90%	45,71%	388	73,90%	45,71%
MP3	377	71,81%	54,10%	377	71,81%	54,10%
MP4	278	**52,95%**	**32,76%**	377	**71,81%**	**49,14%**
MP5	294	**56,00%**	**41,52%**	370	**70,48%**	**55,43%**
MP6	376	71,62%	67,05%	376	71,62%	67,05%
MP7	386	73,52%	71,05%	386	73,52%	71,05%
MP8	238	45,33%	30,29%	***Removed***		
MP9	339	64,57%	54,10%	339	64,57%	54,10%
Average	339	64,63%	49,19%	374	71,21%	55,34%

After balancing manpower efficiency of process MP4 and MP5 is increasing. Therefore, increase the process average manpower efficiency again to 71,21%. The grouped *yamazumi* in figure 4.37 show the process almost have equal cycle time. This can be achieved using methods and tools for noncyclical process. Standardized works for noncyclical process offer good data collection tools to analyzed noncyclical process in the warehouse. Then, through *kaizen* non-value added activities in the process can be reduced. Lastly, balancing the process by merging process with low efficiency to eliminate process with low manpower efficiency. Therefore, by eliminating one process in the warehouse decrease the required work force needed to run the warehouse process and saving cost to pay the worker salaries.

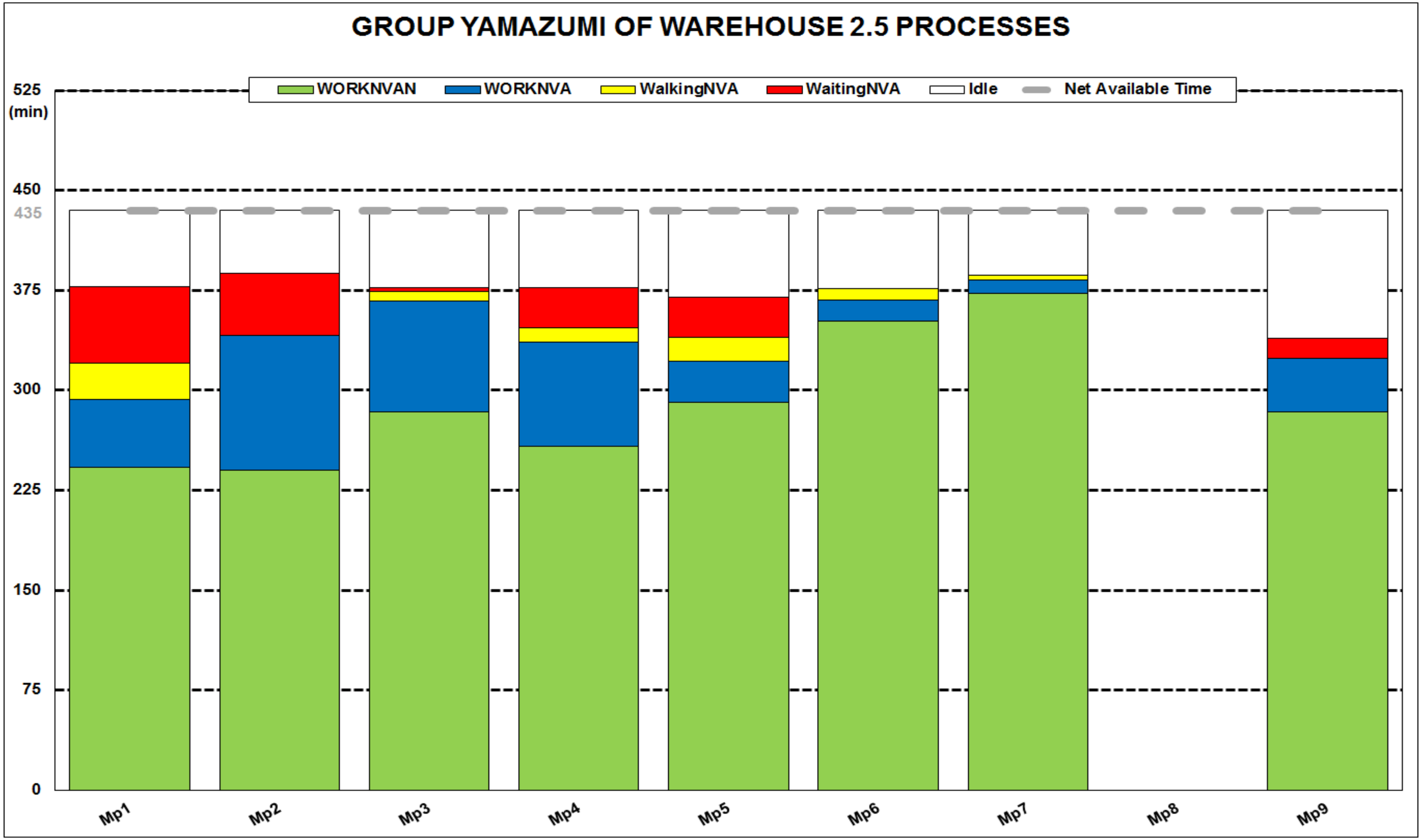


Figure 4.37 Group *Yamazumi* after Process Balancing

4.6 Cost Saving Calculation

Process MP8 has been merged to process MP4 and MP5, so the warehouse does not need work force to performing process MP8. Therefore, reducing number of worker in the warehouse. This condition can saving some production cost for the company. The cost saving calculation is shown below.

Total cost saved/ year = Minimum salaries x 1 worker x 3 shifts x 12 months

= Rp.3.100.000 x 1 x 3 x 12 = **Rp.111.600.000**

IJK Company is located in Jakarta region, the minimum salaries in that region is Rp.3.100.000. Then, process MP8 is performed by one worker per shift. There are three shift in one day, so total three worker performing this process in one day. So, total cost saved in one year is Rp.111.600.000 this calculation does not include medical insurance, life insurance, worker family support, transportation cost, etc. Actually the research is save more cost than stated above, because the research does not have enough data to calculate the job costing for each worker.

CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the result of this research, there three conclusions that can be answer the objective of this research:

- By using standardized works for noncyclical process data collecting tools which are noncyclic work summary sheet and *yamazumi* chart every process manpower efficiency and utilization of current process can be known. The efficiency and utilization data is presented in table 4.6. The overall efficiency of nine warehouse current process is 71,43% and overall utilization of warehouse current process is 49,19%.

- *Kaizen* does not increase the manpower efficiency and utilization of warehouse process. But, it help reducing non-value added activities in the warehouse. The process that is focused in reducing their non-value added activities in this research are process MP4, MP5 and MP8. This process was chosen, because they have the highest amount of non-value added activities than other process. The manpower efficiency and utilization after *kaizen* can be seen in table 4.11. The average manpower efficiency had been reduced, because *kaizen* reduce the warehouse process non-value added activities. It is reduced from 71,43% to 64,63%. In the other hand, utilization still have the average percentage in 49,19%. It is because *kaizen* did not directly reduce Work NVA Necessary in the process.

- After process balancing, process MP8 is merged with process MP4 and MP5, causing process MP8 to be removed. The purpose is to equalized the process cycle time and efficiency. Furthermore, average efficiency of warehouse process is back to 71,21%. Also, process MP4 and MP5 manpower efficiency is increase to 71,81% and 70,48% respectively. This condition also save production cost for the company, because its reduce number of worker needed to run the process from nine to eight workers. The company benefit is Rp.111.600.000, this cost is only calculate salaries and does not include insurance and other economic support. Actually, the company saved more costs than showed above because of lack of data the research cannot fully calculated the real cost that had been saved by this improvement.

5.2 Recommendation

The recommendation for future research as follows:

- Reduce non-value added activities in process MP2, MP3, and MP4.
- Another recommendation is to using standardized works for noncyclical process for other warehouse in IJK Company to maintain their warehousing process.

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APPENDICES

Appendices 1 – Chapter 4.3.2 *Yamazumi* Chart Percentage Calculation

Process MP1

$$\text{Work NVA Necessary} = \frac{242}{525} \text{ x } 100\% = \mathbf{46,10}\%$$

$$\text{Work NVA} = \frac{51 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{9,71}\%$$

$$\text{Walking NVA} = \frac{27 \text{ minute}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{5,14}\%$$

$$\text{Waiting NVA} = \frac{58 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{11,05}\%$$

$$\text{Idle} = \frac{57 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{10,86}\%$$

Process MP2

$$\text{Work NVA Necessary} = \frac{80 + 33 + 42 + 50 + 9 + 26}{525} \text{ x } 100\% = \mathbf{45,71}\%$$

$$\text{Work NVA} = \frac{101 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{19,24}\%$$

$$\text{Walking NVA} = \frac{0 \text{ minute}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{0}\%$$

$$\text{Waiting NVA} = \frac{47 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{8,95}\%$$

$$\text{Idle} = \frac{47 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{8,95}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 47 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{73,90}\%$$

$$\text{Utilization} = \frac{80 + 33 + 42 + 50 + 9 + 26}{525 \text{ min}} \text{ x } 100\% = \mathbf{45,71}\%$$

Process MP3

$$\text{Work NVA Necessary} = \frac{46 + 32 + 40 + 89 + 30 + 16 + 31}{525 \text{ minutes}} \text{ x } 100 = \mathbf{54,10}\%$$

$$\text{Work NVA} = \frac{83 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{15,81}\%$$

$$\text{Walking NVA} = \frac{7 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{1,33}\%$$

$$\text{Waiting NVA} = \frac{3 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{0,57}\%$$

$$\text{Idle} = \frac{58 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{11,05}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 58 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{71,81}\%$$

$$\text{Utilization} = \frac{46 + 32 + 40 + 89 + 30 + 16 + 31}{525 \text{ min}} \text{ x } 100\% = \mathbf{54,10}\%$$

Process MP 4

$$\text{Work NVA Necessary} = \frac{13 + 29 + 28 + 93 + 9}{525 \text{ minutes}} \text{ x } 100 = \mathbf{32,76}\%$$

$$\text{Work NVA} = \frac{120 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{22,86}\%$$

$$\text{Walking NVA} = \frac{11 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{2,10}\%$$

$$\text{Waiting NVA} = \frac{30 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{5,71}\%$$

$$\text{Idle} = \frac{102 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{19,43}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 102 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{63,43}\%$$

$$\text{Utilization} = \frac{13 + 29 + 28 + 93 + 9}{525 \text{ min}} \text{ x } 100\% = \mathbf{32,76}\%$$

Process MP5

$$\text{Work NVA Necessary} = \frac{82 + 23 + 2 + 41 + 12 + 58}{525 \text{ minutes}} \text{ x } 100 = \mathbf{41,52}\%$$

$$\text{Work NVA} = \frac{109 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{20,76}\%$$

$$\text{Walking NVA} = \frac{31 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{5,90}\%$$

$$\text{Waiting NVA} = \frac{30 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{5,71}\%$$

$$\text{Idle} = \frac{47 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{8,95}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 47 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{73,90}\%$$

$$\text{Utilization} = \frac{82 + 23 + 2 + 41 + 12 + 58}{525 \text{ min}} \text{ x } 100\% = \mathbf{41,52}\%$$

Process MP6

$$\text{Work NVA Necessary} = \frac{106 + 200 + 46}{525 \text{ minutes}} \text{ x } 100 = \mathbf{67,05}\%$$

$$\text{Work NVA} = \frac{16 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{3,05}\%$$

$$\text{Walking NVA} = \frac{8 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{1,52}\%$$

$$\text{Waiting NVA} = \frac{0 \text{ minute}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{0}\%$$

$$\text{Idle} = \frac{59 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{11,24}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 59 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{71,62}\%$$

$$\text{Utilization} = \frac{106 + 200 + 46}{525 \text{ min}} \text{ x } 100\% = \mathbf{67,05}\%$$

Process MP7

$$\text{Work NVA Necessary} = \frac{14 + 359}{525 \text{ minutes}} \text{ x } 100 = \mathbf{73,52}\%$$

$$\text{Work NVA} = \frac{10 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{1,90}\%$$

$$\text{Walking NVA} = \frac{3 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{0,57}\%$$

$$\text{Waiting NVA} = \frac{0 \text{ minute}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{0}\%$$

$$\text{Idle} = \frac{49 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{9,33}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 59 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{73,52}\%$$

$$\text{Utilization} = \frac{14 + 359}{525 \text{ min}} \text{ x } 100\% = \mathbf{71,05}\%$$

Process MP8

$$\text{Work NVA Necessary} = \frac{41 + 69 + 28 + 30 + 38 + 7}{525 \text{ minutes}} \text{ x } 100 = \mathbf{40,57}\%$$

$$\text{Work NVA} = \frac{27 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{5,14}\%$$

$$\text{Walking NVA} = \frac{90 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{17,14}\%$$

$$\text{Waiting NVA} = \frac{51 \text{ minute}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{9,71}\%$$

$$\text{Idle} = \frac{54 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{10,29}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 54 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{72,57}\%$$

$$\text{Utilization} = \frac{41 + 69 + 28 + 30 + 38 + 7}{525 \text{ min}} \text{ x } 100\% = \mathbf{30,29}\%$$

Process MP9

$$\text{Work NVA Necessary} = \frac{56 + 103 + 106 + 5 + 14}{525 \text{ minutes}} \text{ x } 100 = \mathbf{54,10}\%$$

$$\text{Work NVA} = \frac{40 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{7,62}\%$$

$$\text{Walking NVA} = \frac{0 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{0}\%$$

$$\text{Waiting NVA} = \frac{15 \text{ minute}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{2,86}\%$$

$$\text{Idle} = \frac{96 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{18,29}\%$$

$$\text{Efficiency} = \frac{435 \text{ minutes} - 96 \text{ minutes}}{525 \text{ minutes}} \text{ x } 100\% = \mathbf{64,57}\%$$

$$\text{Utilization} = \frac{56 + 103 + 106 + 5 + 14}{525 \text{ min}} \text{ x } 100\% = \mathbf{30,29}\%$$

Appendices 2 – Chapter 4.4.6 Evaluate the Process Percentage Calculation

Process MP5

$$\text{Work NVA Reduced After Kaizen} = \frac{109 \text{ min} - 31 \text{ min}}{109 \text{ minutes}} \text{ x } 100\% \approx \mathbf{72}\%$$

$$\text{Walking NVA Reduced After Kaizen} = \frac{31 \text{ min} - 15 \text{ min}}{31 \text{ minutes}} \text{ x } 100\% \approx \mathbf{52}\%$$

Process MP8

$$\text{Walking NVA Reduced After Kaizen} = \frac{90 \text{ min} - 18 \text{ min}}{90 \text{ minutes}} \text{ x } 100\% \approx \mathbf{80}\%$$

$$\text{Waiting NVA Reduced After Kaizen} = \frac{51 \text{ min} - 34 \text{ min}}{51 \text{ minutes}} \text{ x } 100\% \approx \mathbf{33}\%$$

Work NVA Necessary

$$\text{Reduced After Kaizen} = \frac{213 \text{ min} - 159 \text{ min}}{213 \text{ minutes}} \text{ x } 100\% \approx \mathbf{25}\%$$