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Supermarket and Water Spider Concept for Improving Door Sub-Assembly Productivity

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Abstract

This research is based on a case study at the door sub-assembly area of a German car manufacturer in Indonesia. The door sub-assembly area is responsible for assembling doors to be supplied to the specific station in assembly line that will assemble the finished doors to the car. The area had a problem in supplying the doors to the main assembly line on time. This means, the cycle time of door sub-assembly is higher than that of the assembly line. After observation, the factor that greatly contributes to the high cycle time can be identified, which is motion waste. Therefore, a unique approach is offered to overcome the situation, which involves re-designing work system and work area. The approach is to implement new working system by adopting lean tool water spider to significantly reduce motion waste. In the end, the initial and after condition will be contrasted to see the improvement made by this research. The results of this study could give the company several benefits: improved working efficiency of workers, reduced cycle time in door assembly and reduced fatigue of workers.

Keywords: lean water spider, shopping cart, sub-assembly, supermarket concept

1. Introduction

Many developed countries consider that the development of transportation is integrated with the development of the economy [1]. The role of transportation in the economy is as a benchmark in the economic development of an area. Transportation has played a vital role for the people of Indonesia, especially in the sector of personal transportation. Unlike some other countries in Asia, the development of a public transportation system in Indonesia that is convenient and reliable for the people has been very slow. Nevertheless, at the same time, the mobility of Indonesian people is significantly increasing due to various factors. In 2030, the number of passenger car is predicted to be around 25.420.757 units, and 188.611.352 units for motorcycles [2].

This trend is one of the factors that keeps the automotive industry in Indonesia growing. The automotive industry is often considered to be one of the most global of all industries. Its products have spread around the globe and it is dominated by a small number of companies with global recognition [3]. The demand for cars is constantly increasing along with the population and economy. Realizing the vastly growing market, many automotive manufacturing companies have begun to invest their capital in marketing their products in Indonesia. Consequently, competition between these car manufacturers is getting tighter. Also, in the premium cars segment, the competition is rising because now almost every big car manufacturer in Indonesia also offers the luxury model of their brand.

Assembly line is commonly used in the industry that produces homogenous product and mass product [4]. A workstation on an assembly line is a location along the assembly line at which one or more tasks are assigned to it to be performed by workers. Typically, a given workstations also include tools and equipment that are needed to perform works at that particular station [5]. In the company's daily production, there are two main assembly lines that each car must go through. The first one is the trimming line where all the electrical and interior parts will be assembled. After the car has reached the end, it will be moved to enter the first station of mechanical line, where throughout the line, all the mechanical parts including machine and axles will be assembled to the car.

In early 2019, the company made a massive improvement in its assembly line and since then it is able to produce as many as 13 units of cars per day. However, the sub-assembly area could not keep up with the new rate. Consequently, the sub-assembly area frequently fails to supply the finished doors by the time the assembly line needs them to be assembled to the cars.

Lean manufacturing is a way of thinking that strives to eliminate and minimize waste in all areas of production, including supplier systems, product design, customer

interactions, and plant management [6]. Lean manufacturing concepts can be categorized into three levels, which consists of lean manufacturing objectives and fundamental principles, prime management and manufacturing approaches and the implementation techniques that are the actions for applying and maintaining the stratagems [7, 8]. In Lean Manufacturing, there have seven types of waste targeted which is product defects, waiting time, processing waste, overproduction, motion waste, inventory, and transportation [6].

Based on observation, it is found that there were many waste activities during the process of assembling the doors, such as unpacking parts, over-processing, and movement, which is the biggest contributor to waste. The massive amount of movement that must be made to take door parts consumed a large amount of time, thus the high cycle time. To cope with the problem, the lean water spider and supermarket concept will be combined and proposed to create a new working system that will significantly reduce the amount of time and distance that will be required in taking the door parts.

The lean water spider is a critical role in making continuous flow and a smoothly functioning Lean system a reality [9]. The "Water Spider" in Lean must be intimate with the process or operation they support, not just a pick-up-and-drop-off material handler [9]. A water spider facilitates flow. The water spider in Lean also keeps the flow in the factory or in the process clean and smooth by taking on the occasional tasks (tasks that do not happen every cycle, such as material and tool replenishment or making shipping containers). In addition, the spider ensures that JIT is happening, just the right number of materials and supplies at the right time in the right place [9].

Before delving deeper into the supermarket concept (along with its design), one must first understand the role of supermarkets in this study. Supermarkets are storage areas used as an intermediate warehouse for materials required the production or assembly line. They are usually constructed with storage equipment such as gravity racks, shelves, and trolleys to ease the job of a material handler in picking up materials [10].

Figure 1 shows the new working concept proposed. One of the workers (green) is given a new role of water spider. This worker will focus on supplying parts to the other workers that will assemble the doors. In supplying parts, his job will be helped by the arrangement of supermarket located near the assembling jigs.

Figure 2 shows the supermarket concept that will be created in the area. The water spider will use a designed shopping cart in gathering parts from the supermarket.

Figure 3 illustrates the movement of the water spider in gathering parts with the shopping cart through the supermarket gangway. To completely gather parts for one unit of door (four doors), the water spider must do the shopping twice. First for the parts of right-side doors (front and rear) and second for the left side doors (front and rear).

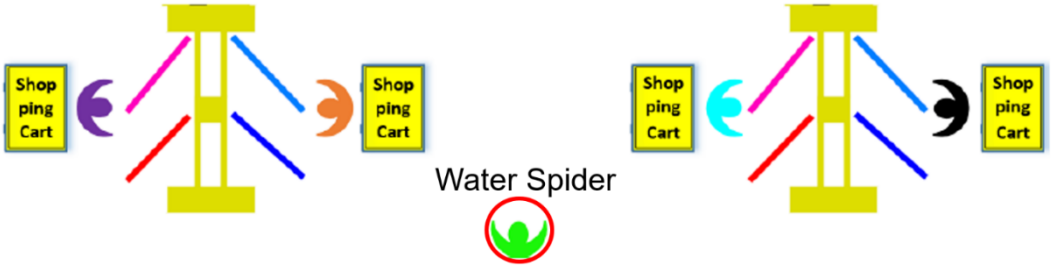

Figure 1. New Working Concept

Figure 2. Supermarket Concept

Figure 3. Water Spider Movement in Parts Gathering

As seen from Figure 3 the trolleys arranged in the supermarket are given name. Each of the trolley carries different parts of the doors which will be collectively gathered by the water spider until the trolleys are empty as the production continues. Since there are two jigs in the area, there will also be two supermarkets made in the area. Once the trolleys are almost empty, a material handler from the warehouse will deliver the new trolleys filled with the parts for the next units.

2. Methods

It is to be noted that "wasted time", in this study, is a combination of the three wastes: walk to the parts, taking parts, and handle parts, which need to happen every time workers move on to the next process.

Figure 4 shows the cycle time of finishing one unit of doors for 6 cycle. In each cycle, two units are being made in parallel on two different jigs, thus each cycle the area could produce two units. The area has five workers, where two workers work on the first jig, and the other three work on the second jig. The cycle time needs to be lowered to 54.75 minutes in order to produce 16 units of doors per day. To get deeper information on how much of the cycle time was spent on what activities, a time study was conducted.

3. Results

Table 1 shows the result of time study conducted for one unit in a cycle. The cycle time was about 70 minutes for both workers to finish the doors. In this cycle, each worker focuses on one side only. Worker one focuses on assembling left doors (front and right) and worker two focuses on assembling right doors (front and right). The average time wasted during the cycle was about 27 minutes which is about 38% of total cycle time. Note that VA stands for value-adding and NVAN stands for non-value-adding-necessary activities.

In addition to time, the distance that must be travelled by the workers after being observed turned out to be surprisingly far. A spaghetti diagram, spaghetti chart, spaghetti model or also spaghetti plot is a method to view the movement of the object in the system with help of a line [11]. Spaghetti diagram was used to analyse the movement of the workers in taking parts to be assembled to the doors.

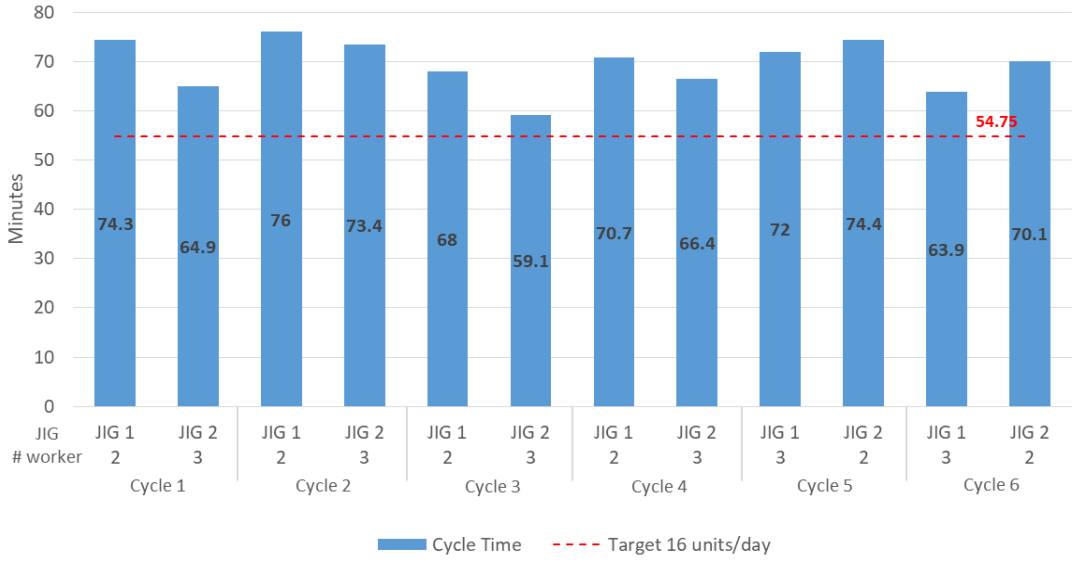

Figure 4. Cycle Time Before Improvement

Table 1. Time Study Result

	VA		Waste		NVAN		Total Duration
	Duration	%	Duration	%	Duration	%	
Worker 1 (Right)	0:38:58	56.04%	0:26:45	38.48%	0:03:49	5.49%	**1:09:32**
Worker 2 (Left)	0:40:00	57.21%	0:28:45	41.11%	0:01:10	1.68%	**1:09:55**

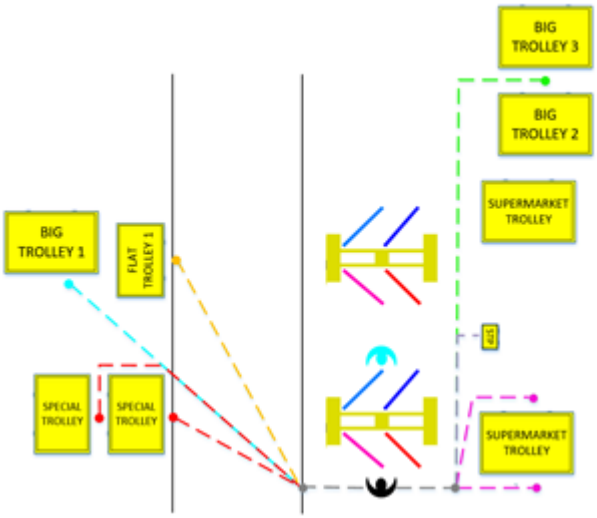

Figure 5. Spaghetti Diagram of Worker 1

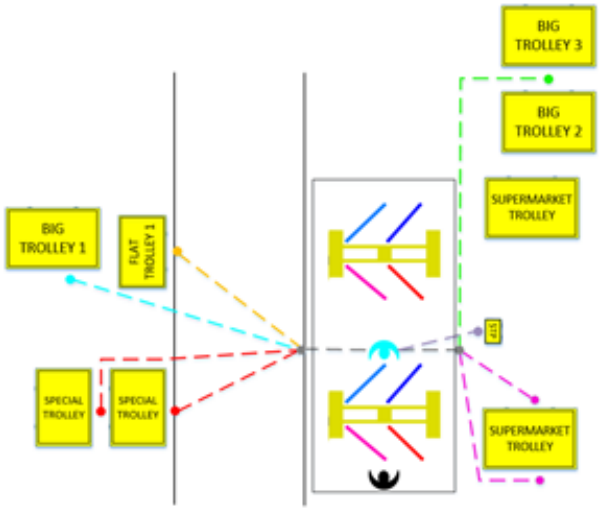

Figure 6. Spaghetti Diagram of Worker 2

Table 2. Distance Travelled by Worker 1

Worker 1					
Path	**Colour**	**Length (m)**	**Length + basic (m)**	**Frequency**	**Total (Back + forth) (m)**
Basic 1		1.7	-	-	-
Basic 2		2	-	-	-
Red 1		3.3	5	2	20
Red 2		7.1	8.8	2	35.2
Red 3		8.8	10.5	-	-
Blue		7	8.7	1	17.4
Green		11.6	13.6	2	54.4
Yellow		5.8	7.5	4	60
Purple 1		2.9	4.9	13	127.4
Purple 2		2.6	4.6	11	101.2
Dark purple		3.5	5.5	14	154
Total distance (m)					569.6

Figures 5 and 6 show the movement that must be made by both workers to take different parts to be assembled to the doors they are working on. Inefficient parts placement can be seen which requires the worker to walk long distance frequently.

Table 3 shows the distance travelled by the workers in taking parts. If added up, the workers travelled almost one kilometre every cycle. This condition could drain the workers' energy faster considering that some of the parts are heavy, which results in performance decrease of workers and ultimately lower productivity and throughput. This could also be the reason behind the unstable working performance of the workers. After the concept is completely designed, it is then implemented.

As seen from Figure 7, the cycle time is successfully reduced to be under the required cycle time to produce 16 units per day.

Table 4 shows the result of the time study after implementation compared with the previous condition. As seen from the wasted time column, the number decreased from about 28 minutes to about 13 minutes,

which is a 53% decrease. The cycle time is also decreased from about 70 minutes to 52 minutes, which is a 26% decrease. As a result of the improvement, the company is now able to produce 16 units of doors per day, which is a 23% increase from the previous condition of only 13 units per day.

Table 3. Distance Travelled by Worker 2

Worker 2					
Path	**Colour**	**Length (m)**	**Length + basic (m)**	**Frequency**	**Total (Back + forth) (m)**
Basic 1		1.7	-	-	-
Basic 2		2	-	-	-
Red 1		3.3	5	-	-
Red 2		6.1	7.8	2	31.2
Red 3		7.8	9.5	2	38
Blue		5.96	7.66	2	30.64
Green		9	11	2	44
Yellow		4.2	5.9	2	23.6
Purple 1		2.3	4.3	12	103.2
Purple 2		2.5	4.5	7	63
Dark purple		2.1	2.1	11	46.2
Total distance (m)					379.84

Table 4. Time Study Results After Implementation

		VA		Waste		NVAN		Total Duration
		Duration	**%**	**Duration**	**%**	**Duration**	**%**	
Before	Worker 1 (Right)	0:38:58	56.04%	0:26:45	38.48%	0:03:49	5.49%	**1:09:32**
	Worker 2 (Left)	0:40:00	57.21%	0:28:45	41.11%	0:01:10	1.68%	**1:09:55**
After	Worker 1 (Right)	0:37:08	71.43%	0:13:32	26.04%	0:01:19	2.53%	**0:52:00**
	Worker 2 (Left)	0:39:13	75.27%	0:11:26	21.94%	0:01:27	2.79%	**0:52:06**

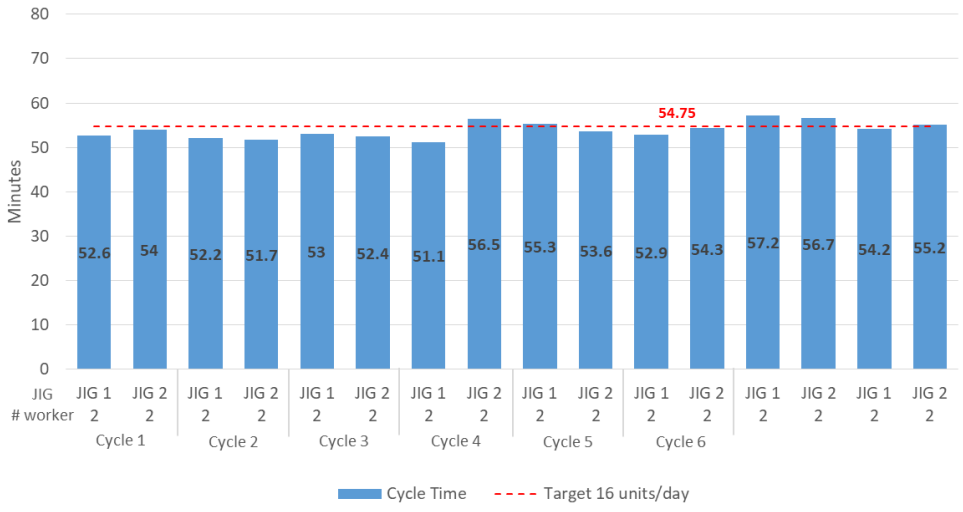

Figure 7. Cycle Time for E Class

Table 5. Comparison of Distance Traveled

Manpower	Distance (m)	Total (m)
Before		
Worker 1	596.6	949.4
Worker 2	379.8	
After		
Water Spider		
Gather parts for left side	8.04 + 1.6 + 8.04	35.36
Gather parts fo right side	8.04 + 1.6 + 8.04	

The distance that must be travelled by the workers in gathering parts to complete one unit of doors is also significantly decreased. As seen from Table 5, before the improvement, workers must walk almost one kilometer just to take parts. After the job of taking parts are taken by the water spider, the total distance that must be travelled to gather all the parts is decreased to only 35.36 meters.

4. Conclusion and Recommendation

Since the improvement on its main assembly line, the company has been able to produce 16 units of cars per day. This new rate turned out to be unmatched by the door-sub assembly area, which is responsible in assembling doors and supplying them to the assembly line. After observation, it is found that the high cycle time of door sub-assembly area is mainly caused by time wasted for taking the door parts to be assembled.

As a solution, water spider and supermarket concept are introduced to the area to enable the workers focusing only on value-adding activites, which is assembling. Working procedure and guidance in gathering parts are developed for the water spider. The workers that assemble doors do not have to walk to take parts anymore in assembling the doors. After implentation, the cycle time is successfully reduced to an average of 54 minutes and the area is now able to produce 16 units of doors per day, matching the rate of the assembly line.

Exploration on literature review indicates that the concept of supermarket has been deeply studied and this paper did not apply the concept with the same depth. This paper only adopt the idea of supermarket without considering other factors such as location and alignment with other business function. Thus, for the future research on the area, it is recommended to develop the supermarket concept further by aligning it with production planning and in-house logistic department to determine optimum replenishment schedule, optimum supermarket capacity, and possible optimum supermarket location.

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