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Cycle Time Reduction in Automotive Manufacturing

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Abstract

Today, there are a lot of problems occur in the Automotive Component Manufacturer Company. Amongst them, work not standardized on each process is the most serious one. Standardization work can help reduce the amount of time to complete the task without defects by efficiently guiding the operators. Other related problems include machines fail to clamp semi-finished products to the next station, stopper loose, and rework process which cause the car carpet size to miss the standards. All these common problems increased the cycle time of the car carpet assembly line. So, this study was aimed to investigate how to reduce cycle time of the car carpet assembly line in the Automotive Component Manufacturer Company which located at Port Klang area. Data was collected through interview and observation. To reduce the cycle time of the car carpet assembly line, Kaizen activity and line balancing are implemented. Kaizen is the continuous improvement process. Line balancing is used to manage the workloads among assemblers, to determine number of workstation and to reduce production cost of the company. The derived results show that the cycle time of the car carpet assembly line is reduced from 313 seconds to 131 seconds. This proves that kaizen activities and line balancing do improve the productivity up to 58%. However, to achieve more successful and effective improvement, further work standardization on each process is needed.

Keywords: Cycle time; Kaizen; Automotive; Standardization.

1. Introduction

In today's, manufacturing industries utilize more resources to improve their productivity. It is more important to stabilize their work environment and resources allocation. They want to use tools to optimize its processes to attain satisfactory results to achieve the demand. They interest only on production with higher efficiency in less cycle time, but they must focus mainly on customer satisfaction (Rekha *et al.*, 2017). Furthermore, as stated by Giffi *et al.* (1990); "sustained competitiveness cannot be created overnight and will never be reached if manufacturers focus on only some of the elements in the manufacturing equations."

These day's manufacturers may have to introduce and prove the success of the products not only faster but also to deliver it to the end users at the right time (Saravanan *et al.*, 2018). Value stream mapping was used to find opportunity of implementation various lean tool in process. Map to analysis of what real thing on the production floor. After that Future State Map is design based on current state map for a new lean process flow (Shah and Suthar, 2018); (Aravinth and Rajenthirakumar, 2016).

Sriraam and Sridhar (2018), focuses on reduction of lead time in electrode manufacturing company by implementation lean techniques.by VSM concept area of opportunity to modification of plant layout is possible and overall reduction in lead time was 1880 minutes from 2160 minutes thus total 280 minutes was save. The production of electrode per year is increased about 19000.

In practice, there have a lot of problems in the Automotive Component Manufacturer Industry (Rohac and Januska, 2015). For example, work not standardized on each of the process is the most serious one. Without standardized work, continuous improvement activities are not manageable because processes which are in a constant state of change cannot be improved. Improving standardized work is a never-ending process. Basically, standardized work consists of three elements such as take time, which is the rate at which products must be made in a process to meet customer demand, the precise work sequence in which an operator performs tasks within take time and the standard inventory, including units in machines, required to keep the process operating smoothly. In other words, when process is performed unsystematically in different ways, then there can be no basis for comparison before and after. Without standard, it can't objectively tell what has changed or what has improved. Besides, over process on the sewing station is one of the wastes in the production line. The space of the sewing process too narrow due to high WIP stored at the workstation. It showed the layout not proper for the assembly line. Line not balanced is one of the reasons to cause the cycle time longer in assembly line. Operator workload is not balance leading to waste such as waiting and over production. Sometimes, the operators didn't follow SOP to finish the job. They work without standard operation procedures (SOP). Standard work is one of the most powerful but least used lean tools.

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Thus, previous condition is using batch production. When running this process, it may cause the quality issues on the part especially when changing model. The causes are due to the parts produce are not following the First In First Out (FIFO). When the first piece of part produced is found defect, many parts will also have the same defect because many products already been produced before they found the defect. Besides, when running batch production, the supervisor cannot saw the issues of the parts and the operator because too many WIP are in the line. In addition, technical problems indirectly get impact to the company. The machines sometimes fail to clamp semi-finished product to the next station. It takes time in the next station. Besides, the stopper loose also can affect the processing time. Rework process which cause the car carpet size to miss the standards.

In short, many problems currently occur in Automotive Component Manufacturer such as over process in production line, high WIP, layout narrow due to high WIP inventory, not enough skill operators, too much operator in charge of a process. These problems totally can increase the cycle time of the car carpet assembly line. It takes cost and time in the producing the finished products. So, implementation of Kaizen and line balancing was used to reduce cycle time on the assembly line and effectiveness Kaizen is a powerful tool to reduce the cycle time of the assemble line or production line (Anand *et al.*, 2009). Thus, this paper is aimed to address key elements of manufacturing strategy and the ability to compete on cycle time.

2. Cycle Time

Cycle time belongs to the most important variable which describes assembly line system and decides about the quality of the line balance. Cycle time is the period when tasks can be assigned to the workstation. In assembly line we can define the cycle time restrictions what means that the sum of time for all the tasks assigned to one station must not be greater than the cycle time. The cycle time value is strictly connected with market demand and customer orders. The output rate or production rate of the line equals the reciprocal of the cycle time.

By the way, cycle time in manufacturing industry refers to the total time it takes to complete any specified manufacturing or allied operation. Cycle times can be used for many different types of operations. Production planning, productivity measurement and control, incentive payments, inventory planning and process design all are the uses of cycle time in manufacturing industries. Cycle time plays a very important role in planning and controlling activity ties in any industries. Cycle time is commonly categorized into:

1. Manual Cycle Time: The time loading, unloading, flipping/turning parts, adding components to parts while still in the same machine/process.
2. Machine Cycle Time: The processing time of the machine working on a part.
3. Auto Cycle Time: The time a machine runs un-aided (automatically) without manual intervention.
4. Overall Cycle Time: The complete time it takes to produce a single unit. This term is generally used when speaking of a single machine or process.
5. Total Cycle Time: This includes all machines, processes, and classes of cycle time through which a product must pass to become a finished product. This is not

Lead Time, but it does help in determining it.

3. What Is Kaizen?

Kaizen was created in Japan following World War II. The word Kaizen means “continuous improvement”. It comes from the Japanese word (kai) which means “change” or “to correct” and (zen) which means “good”. Kaizen is a system that involves every employee which from upper management to the bottom operator based on Imai (2012). Kaizen identifies a group of methods for making work process improvements.

When the kaizen approach is applied to manufacturing, it becomes CIM (continuous improvement manufacturing). CIM utilizes seven tools which is: Pareto charting, histograms, fishbone techniques, control charting, scatter diagrams, graphs and flowcharts, and check sheets to execute problem- solving activities in the company. The basic mechanism of the kaizen approach makes any possible improvements under the PDCA (plan-do-check-act) cycle, standardizes the improvements, and continues for another PDCA cycle.

Continuous improvement is defined as a systematic effort to seek out and apply new ways of doing work i.e. actively and repeatedly making process improvements. Continuous improvement (CI) is an ongoing activity aimed at raising the level of organization-wide performance through focused incremental changes in processes(Wu and Chen, 2006).

4. Line Balancing

Line balancing is commonly technique to solve problems occurred in assembly line. According to Heizer and Render (2008); line balancing is a technique to minimize imbalance between workers and workloads in order to achieve required run rate. Line balancing technique is used to manage the workloads among assemblers, to identify the location of bottleneck, to determine number of workstation and to reduce production cost of the company.

5. Steps in Solving Line Balancing

Based on G.Andrew (Heizer and Render, 2008); there are some steps to solve line balancing:

i. Drawing Precedence Diagram

Precedence diagram needs to be drawn to show a connection between a workstation. Certain process begins when previous process was done.

ii. Determining Cycle Time

Cycle time is longest time allowed at each station. This can be expressed by this formula:

$$\boldsymbol{CycleTime} = \frac{\boldsymbol{AvailableTime}}{\boldsymbol{DesiredOutput}}$$

This means the products needs to leave the workstations before its reach its cycle time.

iii. Assigning tasks to workstation

iv. The tasks allocations should be taken after completing a time cycle.

It's good to allocate tasks to workstation in the order of longer task times

$$\boldsymbol{No.Workstation} = \sum \frac{\boldsymbol{Task\ time}}{\boldsymbol{Desired\ Actual\ Time}} (1)$$

v. Calculating an Efficiency Line

This will have carried out to find how effectiveness the line. The formula is given by:

$$Line\ Efficiency = \frac{\sum Task\ time}{No.Workstation \times Desired\ Cycle\ Time} \times 100\% \quad (2)$$

6. Research Design

This study is designed to be a case study in a local SME company manufacturing and supplying automotive carpet parts to all the major car assembles in Malaysia. The product ranges of company are including door trim carpet, floor carpet, trim trunk side/boot trim, luggage (Bin Mat et al., 2016); boot lid trim and parcel shelf/hat rack. The company selected to be research target is an ISO/TS 16949 and ISO 14001 certified company. The policy is to produce quality products at competitive prices, prompt delivery, give solutions and guarantee customers' satisfaction and to provide excellent after sales service. The company focused is an original equipment manufacturer (OEM) in Malaysia, with core competency in the development, manufacture and supply of automotive carpets and carpet-based interior trims.

7. Data Collection

For this research, the interview was conducted about Five times separately with the senior manager of the Automotive Component Manufacturer Company. The senior manager pleased to answer all the questions as prepare before. The raw data is supplied from the senior manager to help completed the research study. Besides, the senior manager also gives a further explanation about the car carpet assembly line.

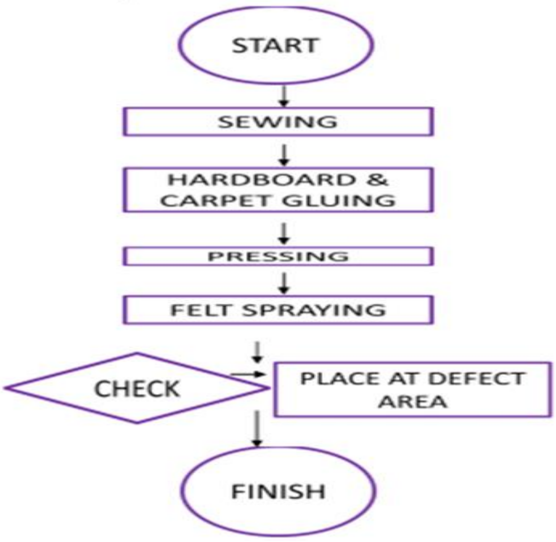
In the study, observation is conducted in the local SME Company which produces car carpet. The cycle time of the car carpet assembly line is collected. The type of collection data on the real study is more valid and reliable because of the direct involvement in the study area. The data collection focus on the before Kaizen activity and after Kaizen activity. Besides, the cycle time before line balancing and after line balancing also discussed and collected. Observations are divided into 2 phases. Phases 1 focuses on the car carpet assembly line process flow and phase 2 focus on the layout of assembly line in the plant. When interviewed with the senior manager, the observation is processed at the same time. The situation of the company was observed and the problems facing by the company is discussed.

8. Results and Discussion

8.1. The Process of the Car Carpet Assembly line

The product is a car carpet. This research deals with the movement assembly process of the hand setting assembly. The major process steps in manufacturing are sketched in the below figure. 7 stations with a continuous materials flow compose the assembly line. Each workstation has their desire cycle time where the longest time taken in the particular workstation become the total process cycle time. The process flows of car carpet assemble show in Fig1.

Fig-1. Process Flow Chart of the Car Carpet Assembly line.



8.2. Improving the Process Flow

Because of that, Kaizen attempts had been done to the process for improving the condition and indirectly minimize the loss time and reduce the operation cost.

8.2.1. Kaizen 1: Eliminate Waste

Waste is the work that does not add any value to the product. There are seven wastes in a process industry. Motion (i.e. the excessive movement of people or machines within the work cell), waiting (i.e. the time spent inactive waiting for work to arrive or to be told what to do), Defects waste (i.e. all processing needed to rework or repair), Overproduction (too great a quantity), inventory, and transportation, etc.

In practice, by adding rework table for technical operator it reduced the waste of transportation. Rework table can reduce the time to return back the semi-finished product to the production line. Reduce the movement that does not add value can increase the productivity of the products. This kind of unnecessary transport can be caused by poor standard work practices, poor process design and poor work area layout. Moreover, sprayed hard board was placed between spray jig and press machine to prevent returning the carpet to work place. The reduction of waste of motion, waiting and transportation is to avoid the unnecessary movements.

8.2.2. Kaizen 2: Line Balancing

Previous condition of production line is using batch production. It means the interval WIP are more than one piece between the processes with the next process. So, line balancing is implemented. Before line balancing was 1 sewing process, 2 line and 3 operators to finish an assembly car carpet processes. After line balancing is one-piece flow which includes 3 operators to operate the machine. By running this one-piece flow, the interval WIP between the processes with the next process will reduce to one piece only. So, after line balancing, it showed the cycle time of the car carpet assembly line is reduced. Start from the sewing process, as usual start with take the carpet from trolley, put on table, fold carpet, setting the carpet to sew, take scissor to cut then put scissor back. Finally take carpet to WIP. The results before and after line balancing, are shown in Table 1. From the cycle time results, the cycle time for felt and hard board assembly is reduced from 313 seconds to 131 seconds. This shows that it already improves the productivity by 58% through Kaizen activities.

Table-1. Results of Cycle Time before and After Line Balancing

Before			**After**		
Model	Process	Cycle Time(s)	Model	Process	Cycle Time(s)
D54T	sewing	148	D54T	Sewing	117
	Felt & Hard Board Assembly	313		Hard Board Assembly	126
				Felt Assembly	131

8.3. Capacity output

The capacity outputs are presented in Table 2. It shows the line efficiency. The comparison of both before and after results shows that it manages to increase output per man hour from 4.3 to 8.1 which improvement of 88.1 %.

Table-2. Results of capacity output before and after line balancing

	Before	**After**
manpower	2 operators	3 operators
Output per day	59 per line	194 per line
Capacity	4.3/line	8.1/line

9. Conclusion

To conclude, in term of cycle time, the after-line balancing is the best. The one-piece flow it reduce space utilization and easy to detect WIP. Add rework table to reduce cycle time and reduce working time by placing the hardboard between spraying glue jig and press machine. With reduced cycle times and implemented one-piece flow, quality improves too. Faster processes allow lower inventories which, in turn, expose weaknesses and increase the rate of improvement. Fast cycle time organizations experience more rapid feedback throughout. Assembly lines are a popular manufacturing structure. Assembly line balancing problem is known more than 50 years. There are hundreds of exact and heuristic methods. It is very important to obtain the feasible and acceptable results. It is very important to analyze and estimate the final results and to implement the best one.

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