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Line Balancing with Reduced Number of Operator: A Productivity Improvement

A Hasta and Harwati[1]

Industrial Engineering Department, Universitas Islam Indonesia, Yogyakarta, Indonesia
[1]harwati@uii.ac.id

Abstract. The Objective of this research was to improve the productivity and efficiency in a line process of a case study. The observation showed that current efficiency was about 87% and operator productivity was about 13.3 pcs/hour/man power. Productivity improvement can be reached by three step. First, identification and reduction of non-added value activity. There are 13 non value added activities which are prioritized to be eliminated based on Pareto principles. Second, the reduction number of operators while doing the third step: reallocate the work of each operator after reduction. Operator reduction is done from 3 to 2 operators only. Then the job that is already efficient from the stepped operator is moved to two other operators. After repairing and balancing tasks for each operator, the efficiency value becomes 96% and productivity increases to 20.5 pcs/hour/man power and man power savings to two men power.
Keywords: Productivity, Line Balancing, Operator, Reduction, Reallocation

1. Introduction

PT.X is one of the automotive companies that has been established in 1982, which located in North Jakarta. As the development of automotive industry in Indonesia increases, PT X has started to improve its automotive business by establishing supplementary company. PT. X Group that located in Karawang has 2 plants, namely Plant PT. X Karawang Plant 1 A that produces Machining Fly Wheel and Hub Front for Light Passenger Car, Front Axle Parts for Light Duty Truck, Differential Case and Differential Carrier, while the PT X Karawang plant 1B produces Machining of Rear Axle and Propeller Saft for SUV and MPV. With various of products, PT. X has a vision to be able to compete with other companies to become worldwide Rear Axle & Propeller Shaft supplier and to become primary partners in Indonesia. Hence, to accommodate that vision, PT. X should have annual activity plan.

In 2018, the company has set several targeted activities, such as: focus to man power's competencies, Improved working environment and Strengthen Core Value, level up people to level up performance, dojo level up knowledge and skill, productivity improvement, improvement of management and target that correlated with financial, internal process, QCD excellence as well as learning and growth. From above several targets, PT. X is focused to productivity improvement that aims to improve the productivity since it becomes one of the aspects that determines the success of a company in the fiercer competition in the industrial world. The level of productivity that achieved by a company is the indicator of company's efficiency in combining its economics resources.

Productivity as a traditional formulation on the entire productivity, the ratio of output towards entire input [1]. Therefore, beside optimal output, productivity also depends on optimal input, which is, among others, man power productivity. Operator's productivity could be calculated by multiplying the total numbers of operator with working hour of each operator. In this case, to measure the productivity, numbers of operators could influence numbers of products that could be manufactured in one hour.

Later, to increase its productivity, PT. X keeps on persisting to create a target to establish its resources effectively and efficiently by reducing numbers of operators on each production process.

Target on operator's optimization to improve productivity in PT. X, is implemented also in fly wheel production that located in Blok B Plant 1 A. Initial condition recorded that there were 3 operators involved in production process with 40 outputs every hour. Numbers of operators will be reduced to 2 operators in accordance with productivity improvement in line of fly wheel 3. The cycle time will be improved with the reduction and yet the output will be diminished. Hence, a certain method is required to maintain stable output of 40 products/hour and stable cycle time with only 2 man powers. It could be achieved by decreasing the idle time, improving the efficiency and smoothing the production line by using line balancing. Line balancing is a methodology to increase the availability of the existing line. Line balancing results in maximum effectiveness of the equipment [2]. The operator reduction is one from five ways to solve line balancing problems [3]. The improvement of efficiency and productivity could be improved by reducing the waste activities.

The approach that can be used to eliminate waste and increase the productivity is Toyota Production System (TPS). TPS is a system that developed by Taichi Ohno in 1950 that has successfully applied in Toyota company. This system is one of the key factors that have made Toyota as a successful company. The main idea of Toyota Production System is to eliminate the waste activities to identify the potential issues by reducing the supplies. In order to explore real case and regulate it in organizational culture, TPS performs sustainable improvement. Two important factors on TPS is Just In Time (JIT) and Jidoka [4]. Toyota Production System has main goal to reduce cost or productivity improvement. The cost reducing and productivity improvement could be established by omitting the waste activities, such as excessive man powers. Later, Toyota Production System is an approach that will be applied as basic steps to improve productivity at the fly wheel 3 production.

This research is focused on the productivity improvement by performing resources efficiency at the fly wheel 3 production process in PT. X. The researcher applies line balancing method using tools of Yamazumi chart and waste subtraction as well as work standardization with Toyota Production System approach. Those methods are expected to be able to assist PT. X in achieving one of its targets that described in activity plan 2018.

2. Research Question

The questions that should be answered in this research is how much improvements on productivity and line efficiency at the fly wheel 3 production process in PT. X by using line balancing method and Toyota Production System. Later, to response the question of the research, it is conducted to achieve below three objectives:

1. To identify actual condition at the fly wheel 3 production process in PT. X
2. To suggest the improvement to reduce *waste* and process improvement at the fly wheel 3 production process in PT.X
3. To perform efficiency at the fly wheel 3 production line as well as to identify the productivity condition and future line efficiency based on fly wheel 3 production process improvement in PT. X

3. Method

Line balancing is an adjustment towards work elements assignments from one assembly line to work station that addressed to minimize numbers of work stations and to minimize the idle time on all stations in the certain output level. Line balancing could enhance the process efficiency by minimizing work stations, work cycle and maximize working load as well as improving flexibility among work stations [5]. Efficiency of production line could be managed by using following formula [6].

$$\text{Line Efficiency} : \frac{\text{Total Work Station CT}}{\text{Takt time X Numbers of Workers}} x100\% \tag{1}$$

Efficiency covers two basic concepts, which are cost reduction followed by the elimination of waste activities and the full empowerment on man powers' capability [7]. Efficiency involves concept or cycle in reducing numbers of workers. The first step suggests the omission of useless operation, followed by operation reallocation. Final step advices the reduction of man powers.

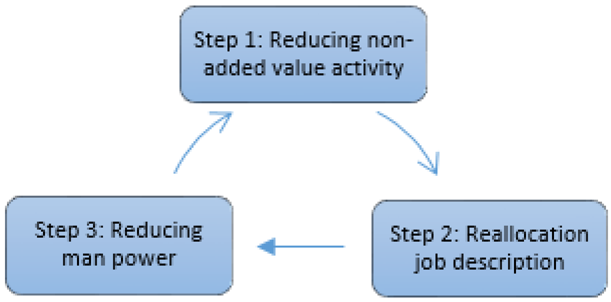

Figure 1. Cycle of Man Powers' Reduction on Toyota Production System [8]

The productivity improvement in this research is carried out through several stages, which are measurement on line efficiency and initial productivity, identification on value – non value activities towards each operator (man power), operator reducing and job reallocation. Eventually, final stage covers the measurement of line efficiency and productivity after treatment. Therefore, final condition could be compared with the initial condition.

4. Result and Discussion

4.1. Line efficiency and productivity in initial condition

Before calculating the line efficiency and initial productivity, initial production cycle time and operators' cycle time should be previously measured. Cycle time is derived from bottleneck time or the longest time at the fly wheel 3 production process. It is identified that the bottleneck at the fly wheel 3 production process occurred on the operator 2, with machine cycle time of 90 seconds. Thus, it can be concluded that the cycle time is 90 seconds.

The measurement of cycle time is conducted on each total 3 operators. The observation is carried out five times on that production process. Following is the result of observations on total cycle time for each operator:

Table 1. Cycle Time for Each Operator

Number Operator	Mode	Average
Operator 1	65	67.8
Operator 2	90	92.2
Operator 3	80	83.6
Total	235	

After initial cycle time is obtained from previous calculation, initial line efficiency and productivity could be formulated to be compared with targeted line efficiency and productivity after the implementation of proposed improvement.

$$1.\ \frac{Output}{hour} = \frac{3600s}{90s} = 40\ unit/hour$$

$$2.\ Operator\ Productivity = \frac{Output}{Operator\ Input} = \frac{40}{3} = 13.33$$

$$3.\ Line\ Efficiency\ (\%) = \frac{Total\ CT\ operator}{Longest\ CT\ xnumber\ operator} x100\% = \frac{235}{(90)x2} x100\% = 87\%$$

4.2. Identify Non value added activity

The efforts to enhance the productivity is began with the identification of non-value added activity on every operator. By eliminating non-value added activity will reduce cycle time. The omission of *waste* is conducted by identifying work elements to be value work, non-value work and walking. The examples of non-value added activities are part wiping, part picking up, component's marking, etc. Below is the identification result of value work, non-value work and walking on every operator.

Table 2. Recapitulation of *value work, non-value work* and *walking operator*

	Operator 1		Operator 2		Operator 3	
	Total Time in second	Total Time in %	Total Time in second	Total Time in %	Total Time in second	Total Time in %
Value Work	123	65.43%	228	71.70%	228	71.70%
Non-value work	60	31.91%	82	25.79%	82	25.79%
Walking	5	2.66%	8	2.52%	8	2.52%

Later, activities on every operator's work elements will be described in pareto diagram. It will be employed to recognize the activity that experiences the longest time. It will be applied as the basic of *waste* elimination and the improvement on designated activity. Below is the pareto diagram represented for each operator.

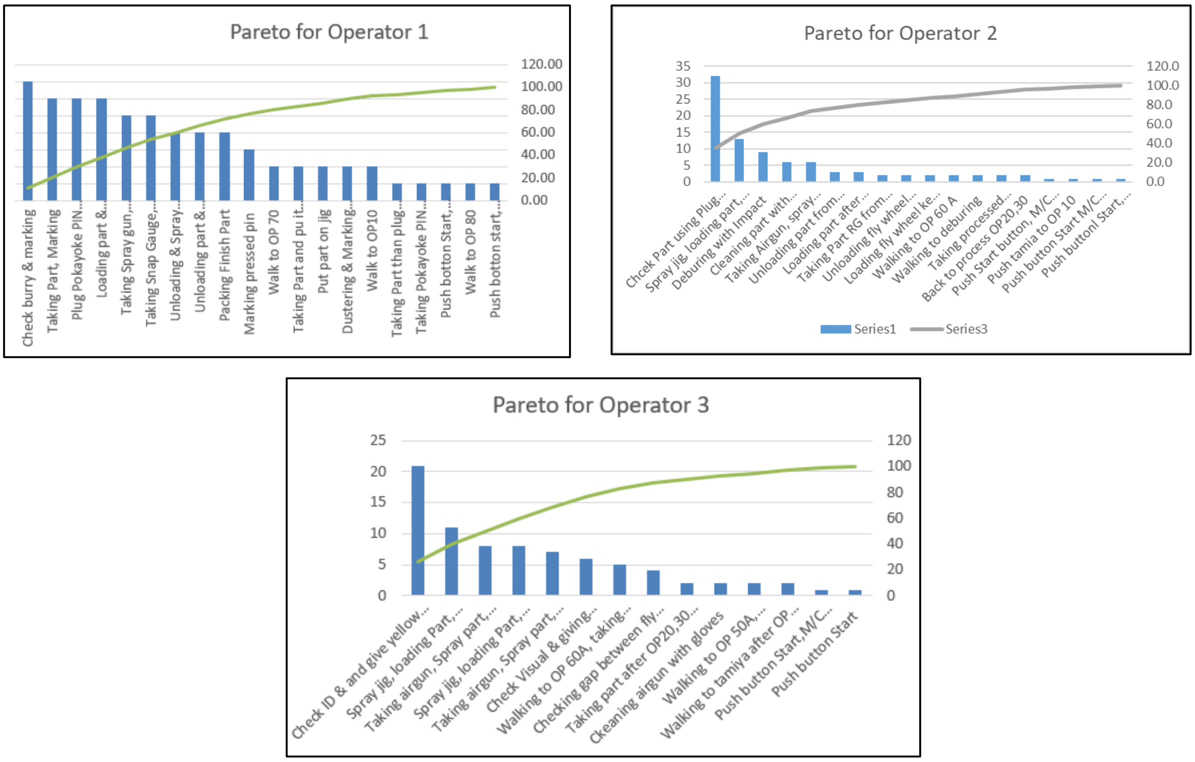

Figure 2. Pareto Diagram for Operator Non Added Value Activity

Productivity improvement is made by eliminating the non-value added activities using Pareto principles. For instance, operator 1 performs the biggest non value added activity on part marking that carried out manually during the time. Therefore, to eliminate it, stamp is suggested to be used in reducing marking time up to 2 seconds.

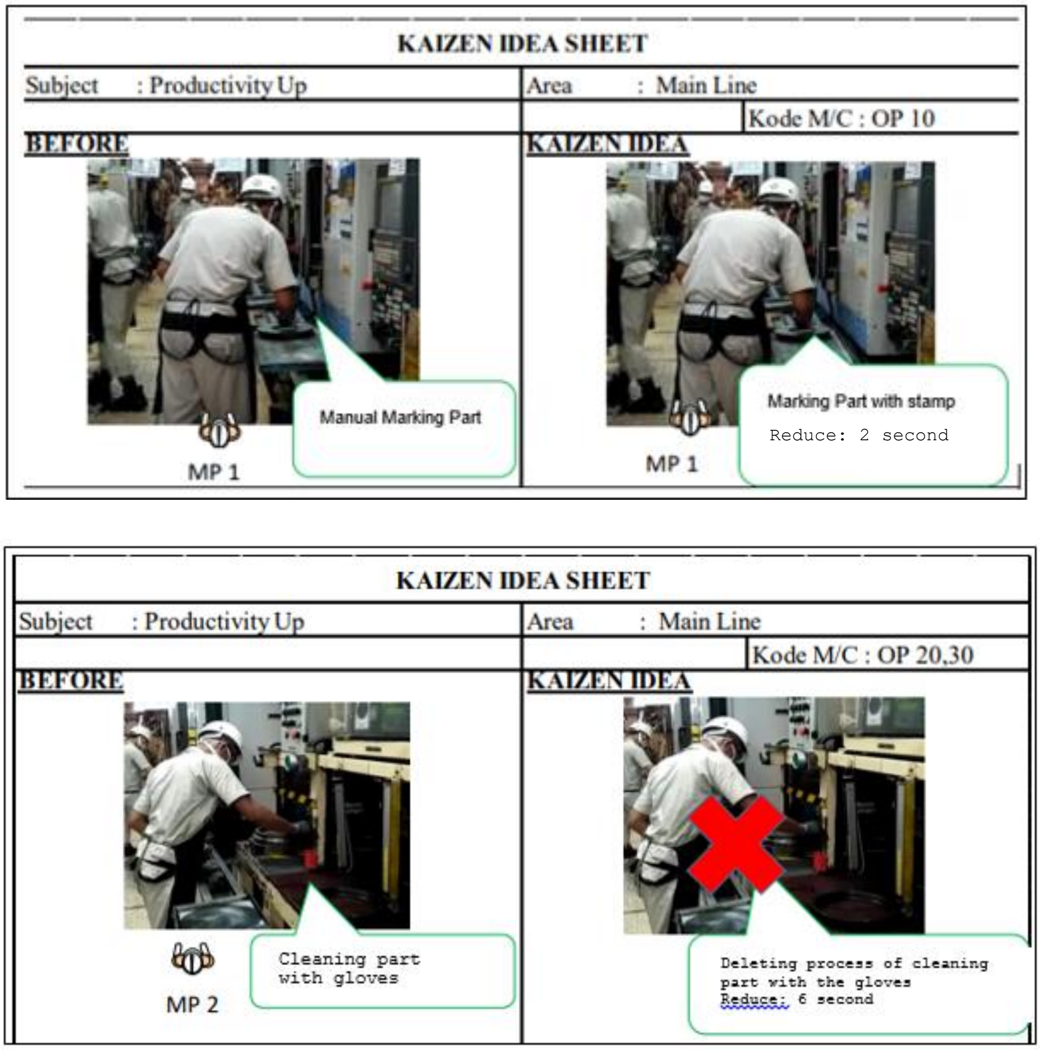

Figure 3. Sample of Improvement Activity

4.3. Operator Reduction

4.3.1. Yamazumi chart Operator current condition

Following is the *yamazumi* chart on the actual condition before improvement:

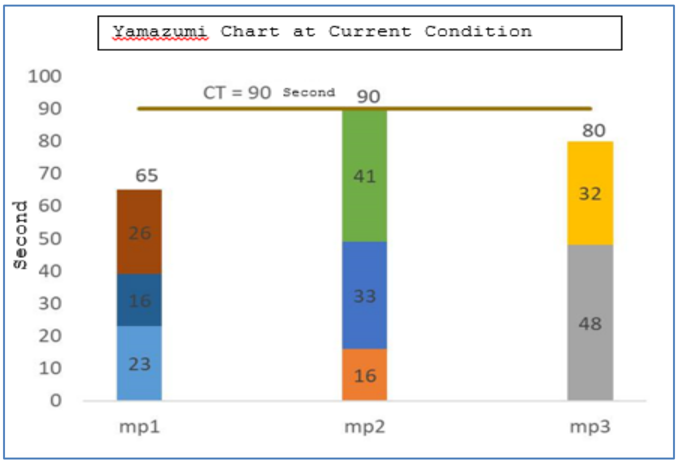

Figure 4. *Yamazumi chart Man power*

From the calculation of cycle time after *waste* elimination and process improvement, *yamazumi* chart could be implemented, the chart after *waste* elimination and process improvement are employed as tool for line balancing process. It could be performed by reallocating one of the operators on the next step.

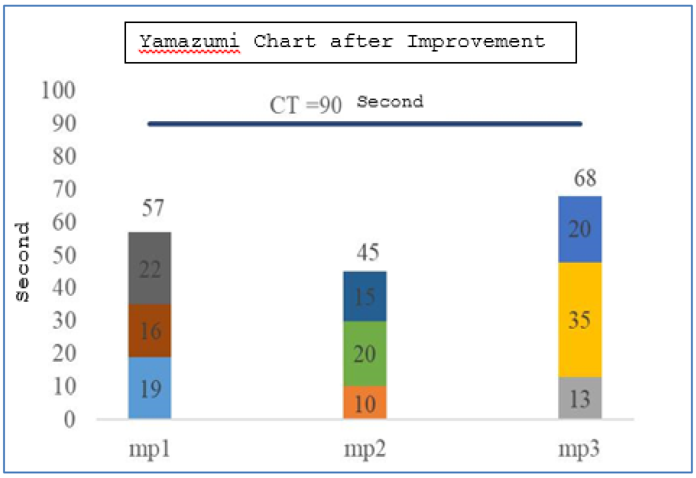

Figure 5. *Yamazumi chart after kaizen*

After *yamazumi* chart operator is identified once after the waste elimination and process improvement are carried out, later, operation reallocation could be performed from one operator to another operator. It could be seen from remaining time of initial targeted cycle time on each man power. The operator reallocation is conducted to balance the inter operator line in order to improve line efficiency. In this case, operation that conducted by operator 2 will be relocated to operator 1 and operator 3. Below is the operator reallocation plan described by *yamazumi* chart operator after improvement:

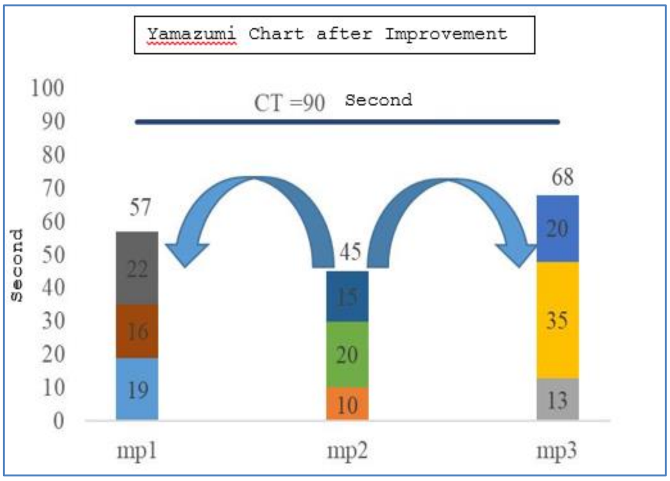

Figure 6. *Yamazumi* chart after reallocation

Work element and cycle time that already calculated will be later implemented in *yamazumi* chart to understand each operator's cycle time, whether it reaches targeted cycle time or not. Below is *Yamazumi* chart operator after improvement:

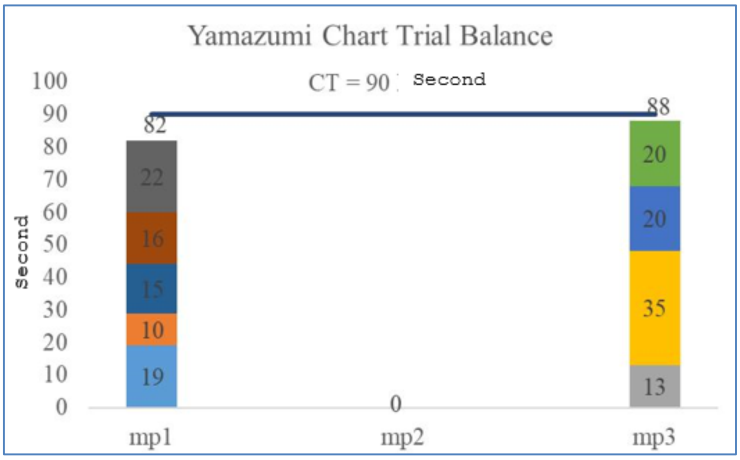

Figure 7. *Yamazumi chart Man power* after improvement

4.4. Line efficiency and productivity after improvement
Below is the calculation on efficiency line and operator productivity after improvement

1. $\frac{\text{Output}}{\text{hour}} = \frac{3600\text{s}}{88\text{s}} = 41\ \text{unit/hour}$
2. $\text{Operator Productivity} = \frac{\text{Output}}{\text{Operator Input}} = \frac{41}{3} = 20.5$
3. $\text{Line Efficiency (\%)} = \frac{\text{Total CT operator}}{\text{Longest CT xnumber operator}} \text{x}100\% = \frac{170}{(88)\text{x}2} \text{x}100\% = 96\%$

Below is the comparison graph between line efficiency initial condition and after improvement

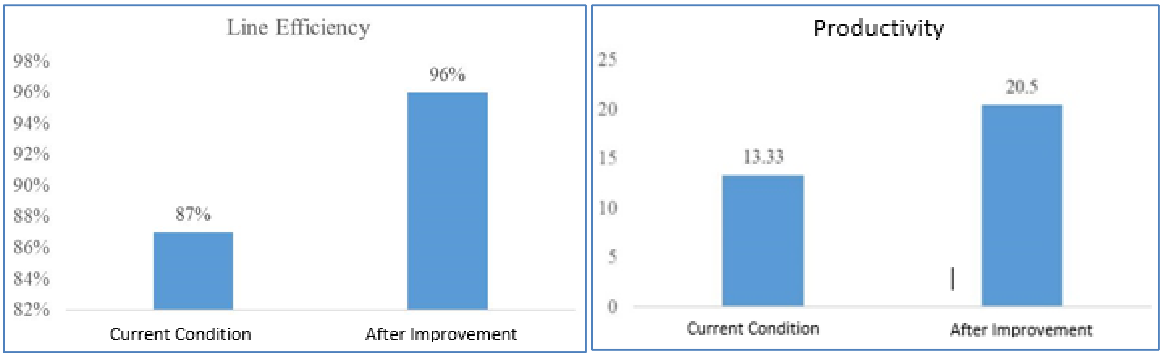

Figure 8. The comparison of line efficiency and productivity before and after improvement

From above figure, it can be notified that initial condition of line efficiency is 87% with 3 man powers employed. It experiences a raise to 96% with 2 man powers, it raises up to 9%. The improvement of line efficiency value is caused by the work elements balancing on every man power.

5. Conclusion
Hence, the conclusion could be drawn as follows:
1. The level of productivity before improvement is 13.33pcs/hour on every operator at the fly wheel 3 production process in PT. X and becomes 20,5 pcs/hour on every operator, after improvement
2. The level of efficiency at fly wheel 3 production process before improvement is 87% and raises to 96% after improvement.

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