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Effect of Combined Processing Lines on Production Efficiency and Productivity

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Abstract: The production process usually involves several processes that are divided into production lines. The processes in this production line affect the costs incurred by the company. From the analysis results, the costs arising from production line activities are very high. Therefore, the company strives to reduce production costs by paying attention to the aspects that result in the emergence of waste. The method used is by combining the process on the machining line. This study was conducted to find out the effect of combining process lines on production efficiency. The results of this study are expected to be an input in determining production planning in the enterprise. This study didn't use sampling. From the results of the study, there was an increase in the daily production of gear A (0.86%) and gear B (1.12%). From this merger, the company was able to optimize manpower and cut production WIP storage areas.

Keywords: Production process; Waste, Machining line; Combining process

1. Introduction

Companies are required to set the right strategy to win the competition in the era of globalization. To support this strategy, it can be done through efficiency and productivity by defining the right production system [1-5]. For example, in a manufacturing company that produces components for motor vehicles, the production system available within the company is very important. If the demand for production is high, or there is a demand for new products, an effective system must be considered so that there are no delays. Production planning will influence the production scheduling process. Scheduling is a measurement tool for aggregate planning. Production scheduling in the industrial world, both the manufacturing industry and the agro industry has an important role as a form of decision making [6]. Some of the aspects affected by the production process include cost, productivity, profitability, manpower and equipment. To produce the best output and maximize production results, a lean manufacturing approach can be used. In principle, lean focuses on eliminating waste and reducing Non-Value Added activities in the process, while at the same time maximizing activities that provide Value Added to the final product in accordance with customer demand [3, 7, 8].

A manufacturing company involved in the manufacture of automotive components (Gear & Shaft) conducts research on the production line. From the analysis results found several problems, namely in the production process of Gear A and Gear B there are many points in the process that do not provide added value, the difference in cycle time of each production process causes WIP between machining process and inefficient operator performance. The idea proposed by the production department is that several line processes on the machining line become one track [9]. This idea is believed to increase the effectiveness and productivity of line machines. Non-value-added activities will be reduced or eliminated, storage and manpower will be optimized. With this idea, it is hoped that all problems will be solved and the production process can be more controlled. The basic objective of this research is how companies can increase production volumes through optimization and efficiency of human resources [10]. This goal will be achieved if with this merger the company can eliminate waste, increase productivity and production efficiency [8]. This study only discusses process liner merging on special line machining of gear A and gear B. The data used are data layout, cycle time, and operators involved in the work before and after track merging.

2. Methodology

Total Productive Maintenance (TPM) is an approach that is in line with the Lean Manufacturing philosophy. This approach is the most effective method of significantly increasing a company's productivity through the elimination of waste, including any activities, processes or investments that do not add value to a product [1]. The lean approach is expected to reduce waste from the production process and minimize costs [11, 12]. Lean can identify time in each production activity to improve productivity and quality [13]. Cycle time is important for companies to increase profitability and competitiveness by eliminating waste [14, 15]. In an effort to improve productivity and quality, workstation balance in the production process is a common problem in the Manufacturing Industry. Problems of late delivery, long queues, and high inventory in the process, improper use are fundamental problems that often occur in the industry resulting in increased overall production costs [6]. Small to large scale production processes require adjustment of production flow by going through different processes according to the process speed [16]. Reasons for the implementation of the TPM include; improve machine reliability and capacity; fulfillment in providing continuity of production processes; job safety; preventive measures; support the fulfillment of customer demands; reduce the causes of failure; good engine control; and process improvements [17, 18].

The data of this study was taken from one of the line machining machine manufacturing companies located in West Java - Indonesia. Research data collection methods were conducted in several ways, namely through observations, interviews, and literature study. Observations are made by making direct observations of the study object to ensure the conformity of the data listed on the line with the actual results of the work in line machining. The data collected in the observations included data on machine cycle time, available time, idle time, production volume, number of employees, and WIP volume. To complete and make data adjustments, interviews were conducted with leaders and several operators in line machining. The data collected is in the form of a resume from the data obtained and the detailed data obtained becomes the confidential data of the company. This study discusses the productivity of the production process of the manufacturing industry, so that the data format is appropriate to the method used. Interviews conducted on online operators cover the activities of online operators in carrying out their work in each process. The analysis in this study is aimed at processing time and the number of products processed. In this study, the efficiency of processing time is the main point and improvements to the production process method resulting in operator demand and labor costs are alternative improvements. The processing time used is the average obtained from several online operators in each process. To support this research, a library study was conducted by reading some literature, scholarly essays and other library materials related to this research. The data obtained are then processed and the results are analyzed until finally conclusions are obtained.

3. Results

In a manufacturing company, the production process is grouped into several production process lines when production demand continues to increase, companies are asked to make continuous increases so that large amounts of demand do not hinder production scheduling [19, 20]. One of the points targeted for improvement is waste in the production process. Since most of the activity is in the field of machining, the company conducts a study on the waste that arises in the flow of the production process in the machining lines. In the machining line, there are 2 types of products with high demand every month, namely gear A and gear B. Research is done by identifying the waste that arises in the machining process of these two products. The following is the production process flow for gear A and gear B before combining the process lines (Figure 1).

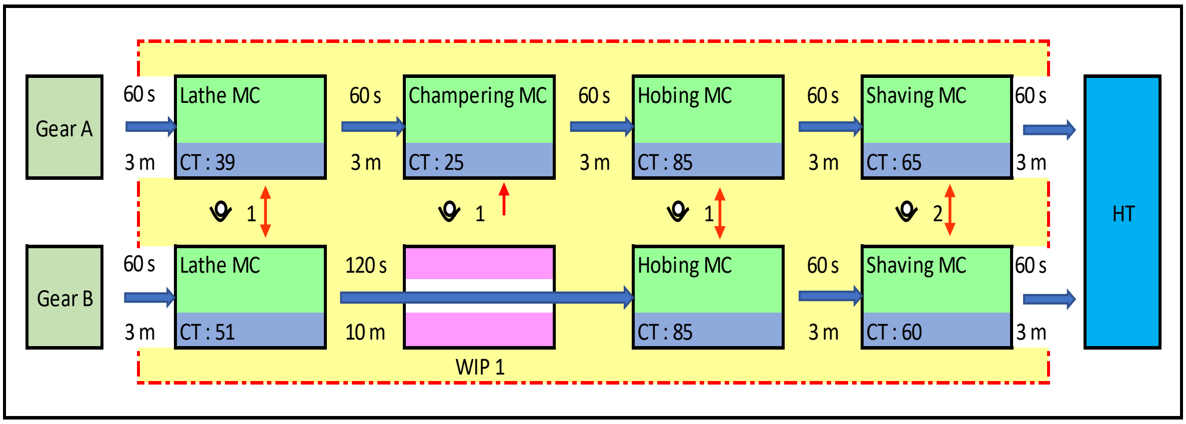

Figure 1. Initial machining lines layout

From the picture above, it can be seen that in the production process of gear A and gear B, there are several process strips with different machine rotation times. Time differences tend to cause wastage in the production process. The research was furthered by collecting data on the activities of machines and operators involved in the production. The following is data on machines and operators activity in each process line before making improvements.

a. Operator and Machine Activity in lathe MC

Base on Table 1, total idle time operator per day is 14880. Since there are 3 shifts on the lathe line, the inactive time for each operator is 14880/3 = 4960 s.

Base on Table 2, operation times is the result of the calculation of available times minus lost times (setting and tool changes). Machine Productivity is the result of calculating the operation times divided by the available times.

Table 1. Lathe MC operator activity

Lathe Operator (1 Person/Shift) Operator Activity / Day (7 hours x 3 shift = 75.600 s)						
Activity	MC L1			MC L2		
	Qty	Time Unit (s)	Total (s)	Qty	Time Unit (s)	Total (s)
Take material	6	60	360	6	60	360
Loading	9	900	8100	7	900	6300
Setting	3	1800	5400	3	1800	5400
Inspection	9	300	2700	9	300	2700
Tool Changes	3	600	1800	2	600	1200
Unloading	3	4200	12600	3	4200	12600
Transfer to next line	8	60	480	6	120	720
Total activity					60720	
Idle					14880	

Table 2. Lathe MC machine activity

	Lathe MC			
	MC L1		**MC L2**	
Available Times	75600	s	75600	s
Setting	5400	s	5400	s
Tool Changes	1800	s	1200	s
Operation Times	68400	s	69000	s
MC Productivity	90%		91%	
Cycle time	39	s	51	s
Available Product	1754	Pcs	1353	Pcs

b. Operator and Machine Activity in Chamfering MC

Base on Table 3, total idle time operator per day is 21120. Since there are 2 shifts, the inactive time for each operator is 21120/2 = 10560 s.

Base on Table 4, operation times is the result of the calculation of available times minus lost times (setting and tool changes). Machine Productivity is the result of calculating the operation times divided by the available times.

Table 3. Chamfering MC operator activity

Chamfering Operator (1 Person/Shift) Operator Activity / Day (7 hours x 2 shift = 50.400 s)			
Activity	MC C1		
	Qty	Time Unit (s)	Total (s)
Take material	9	900	8100
Loading	3	600	1800
Setting	9	300	2700
Tool Changes	1	3600	3600
Unloading	3	4200	12600
Transfer to next line	8	60	480
Total activity			29280
Idle			21120

Table 4. Chamfering MC machine activity

Chamfering MC C1		
Available Times	50400	s
Setting	1800	s
Tool Changes	3600	s
Operation Times	45000	s
MC Productivity	89%	
Cycle time	25	s
Available Product	1800	Pcs
Parts after Lathe	1754	Pcs
Processing Times	43846	s
Idle	1154	s

c. Operator and Machine Activity in Hobbing MC

Base on Table 5, total idle time operator per day is 19320. Since there are 3 shifts, the inactive time for each operator is 19320/3 = 6440 s.

Base on Table 6, operation times is the result of the calculation of available times minus lost times (setting and tool changes). Machine Productivity is the result of calculating the operation times divided by the available times.

Table 5. Hobbing MC operator activity

Hobbing Operator (1 Person/Shift) Operator Activity / Day (7 hours x 3 shift = 75.600 s)						
Activity	MC H1			MC H2		
	Qty	Time Unit (s)	Total (s)	Qty	Time Unit (s)	Total (s)
Loading	3	4000	12000	3	4000	12000
Setting	3	1800	5400	3	1800	5400
Inspection	9	300	2700	9	300	2700
Tool Changes	1	1800	1800	1	1800	1800
Unloading	3	2000	6000	3	2000	6000
Transfer to next line	4	60	240	4	60	240
Total activity				56280		
Idle				19320		

Table 6. Hobbing MC machine activity

Hobbing MC	**MC H1**		**MC H2**	
Available Times	75600	s	75600	s
Setting	5400	s	5400	s
Tool Changes	1800	s	1800	s
Operation Times	68400	s	68400	s
MC Productivity	90%		90%	
Cycle time	85	s	85	Pcs
Available Product	805	Pcs	805	Pcs

d. Operator and Machine Activity in Shaving MC

Table 7. Shaving MC operator activity

Shaving Operator (1 Person/Shift) Operator Activity / Day (7 hours x 3 shift = 75.600 s)						
Activity	MC S1			MC S2		
	Qty	Time Unit (s)	Total (s)	Qty	Time Unit (s)	Total (s)
Loading	12	1200	14400	12	1200	14400
Setting	3	1800	5400	3	1800	5400
Inspection	9	1800	16200	9	1800	16200
Tool Changes	1	1800	1800	3	1800	5400
Unloading	12	2000	24000	12	2000	24000
Transfer to next line	4	60	240	4	60	240
Total activity				127680		
Idle				23520		

Base on Table 7, total idle time operator per day is 23520. Since there are 3 shifts and 2 operators per day, the inactive time for each operator is 23520/6 = 3920 s.

Table 8. Shaving MC machine activity

	Shaving MC			
MC S1	MC S1		MC S2	
Available Times	75600	s	75600	s
Setting	5400	s	5400	s
Tool Changes	1800	s	1800	s
Operation Times	68400	s	68400	s
MC Productivity	90%		90%	
Cycle time	65	s	60	s
Available Product	1052	Pcs	1140	Pcs
Parts after Hobbing	805	Pcs	805	Pcs
Processing Times	52325	s	48300	s
Idle	16075	s	20100	s

Base on Table 8, operation times is the result of the calculation of available times minus lost times (setting and tool changes). Machine Productivity is the result of calculating the operation times divided by the available times.

Results of the observations made above, it can be seen the points that result in wastage that affect the cost of the company. The following is the identification data on the process lines of gear A and gear B.

Table 9. Identification of machining process gear A per day

MC	Available Time (s)	Processing Time (s)	CT	Capacity (pcs)	In (pcs)	Out (pcs)	Idle (s)	WIP (pcs)
MC L1	75600	68400	39	1754		1754	-	-
MC C1	50400	45000	25	1800	1754	1754	43846	-
MC H1	75600	68400	85	805	1754	805	-	949
MC S1	75600	68400	65	1052	805	805	16075	949

Base on Table 9, process of gear A there are 2 units waiting machines (chamfer MC and shaving MC) and there is WIP before the hobbing and shaving process.

Table 10. Identification of machining process gear B per day

MC	Available Time (s)	Processing Time (s)	CT	Capacity (pcs)	In (pcs)	Out (pcs)	Idle (s)	WIP (pcs)
MC L2	75600	69000	51	1353		1353	-	-
MC H2	75600	68400	85	805	1353	805	-	548
MC S2	75600	68400	60	1140	805	805	20100	548

Base on Table 10, process of gear A there are 1 unit waiting machines (shaving MC) and there is WIP before the hobbing and shaving process.

Base on Table 11, it can be seen that the standby time (idle time operator) of the chamfering machine is more than on other machines. Conclusion above three data, it can be seen that there are several points that can be improved, namely in the area of WIP, operator and waiting times. Improvements are made by combining process lines into one machining process line. The following is the production process flow of product A and product B after combining the line process (Figure 2).

Table 11. Data of operator for machining process gear A and gear B

OP	Per Shift	Shift	Sub total	Idle per Line (s)	Idle per Operator (s)
MC L	1	3	3	14880	4960
MC C	1	2	2	21120	10560
MC H	1	3	3	19320	6440
MC S	2	3	6	23520	3920
	Total		14	78840	

4. Discussion

Next, we take data on machine activity and machine operators in the new machining lines as in previous data collection. Operator and machine activity data on the new machining line are as follows in Figure 2.

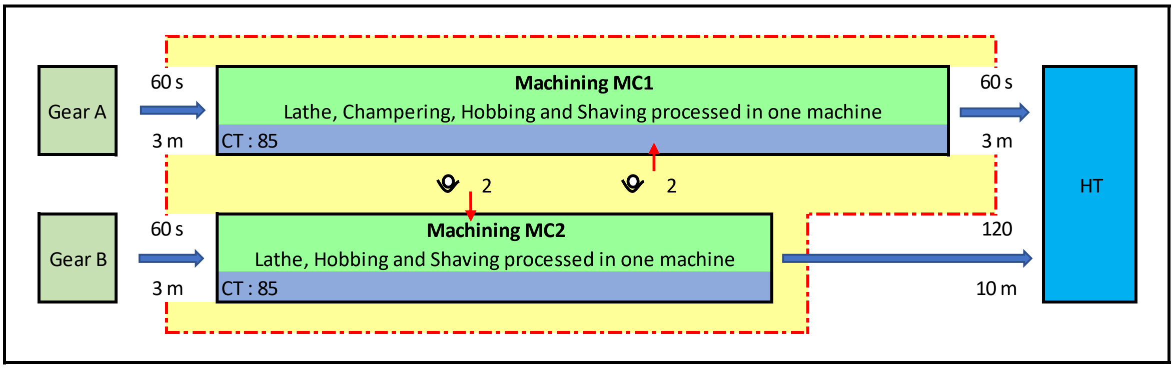

Figure 2. Machining line layout after combining line process

a. Operator and Machine Activity Machining gear A

Base on Table 12, total idle time operator per day is 27960. Since there are 3 shifts and 2 operators per day, the inactive time for each operator is 27960/6 = 4660 s.

Base on Table 13, operation times is the result of the calculation of available times minus lost times (setting and tool changes). Machine Productivity is the result of calculating the operation times divided by the available times.

Table 12. Operator activity machining MC gear A

Machining Operator Gear A (2 Person/Shift) Operator Activity / Day (7 hours x 3 shift = 75.600 s)			
Activity	Qty	Time Unit (s)	Total (s)
Take materials	5	60	300
Loading	9	900	8100
Setting	3	1200	3600
Inspection	9	3600	32400
Tool Changes	1	3000	3000
Unloading	18	4200	75600
Transfer to the next line	4	60	240
Total Activity			123240
Idle			27960

Table 13. Operator activity machining MC gear A

Machining MC Gear A		
Available Times	75600	s
Setting	3600	s
Tool Changes	3000	s
Operation Times	69000	s
MC Productivity	91.27%	
Available Product	812	Pcs

b. Operator and Machine Activity Machining gear B

Table 14. Operator activity machining MC gear B

Machining Operator Gear B (2 Person/Shift) Operator Activities / Day (7 hours x 3 shift = 75.600 s)			
Activity	Qty	Time Unit (s)	Total (s)
Take materials	5	60	300
Loading	9	900	8100
Setting	3	1200	3600
Inspection	9	3600	32400
Tool Changes	1	2800	2800
Unloading	18	4200	75600
Transfer to the next line	4	60	240
Total Activity			123040
Idle			28160

Base on Table 14, total idle time operator per day is 28160. Since there are 3 shifts and 2 operators per day, the inactive time for each operator is 28160/6 = 4693s.

Table 15. Operator activity machining MC gear A

Machining MC Gear B		
Available Times	75600	s
Setting	3600	s
Tool Changes	2800	s
Operation Times	69200	s
MC Productivity	91.53%	
Available Product	814	Pcs

Base on Table 15, operation times is the result of the calculation of available times minus lost times (setting and tool changes). Machine Productivity is the result of calculating the operation times divided by the available times.

On machining gear A and machining gear B, there is a change in the quantity of produce due to the change in the faster machine setting time so that the productivity of the machine also increases. The next step is to analyze the data before with the data after the improvement. The comparative analysis data obtained from this study are arranged in the following tables (Tables 16 and 17) and graphs (Figures 3 and 4):

c. Effectiveness Comparison Data on Machining Process Gear A

Base on Table 16, production process of Gear A shows that idle time of machine is eliminated and idle time of manpower has been reduced by 44.06%. Furthermore, WIP is disappears and the number of workers is reduced from 8 manpower to 6 manpower.

Table 16. Effectiveness comparison data gear A

No	Parameter	Gear A Before		After	
1	Output	805	Pcs	812	Pcs
2	Idle times of machine	59921	s	0	s
3	Idle time of manpower	49980	s	27960	s
4	WIP	949	Pcs	0	Pcs
5	Qty manpower	8	Person	6	Person

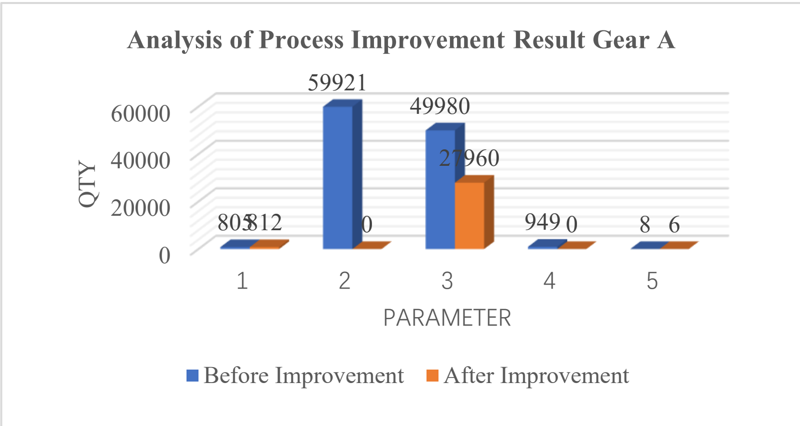

Figure 3. Effectiveness comparison chart gear A

d. Effectiveness Comparison Data on Machining Process Gear B

Table 17. Effectiveness comparison data gear B

No	Parameter	Gear B Before		After	
1	Output	805	Pcs	814	Pcs
2	Idle times of machine	20100	s	0	s
3	Idle time of manpower	28860	s	28160	s
4	WIP	548	Pcs	0	Pcs
5	Qty manpower	6	Person	6	Person

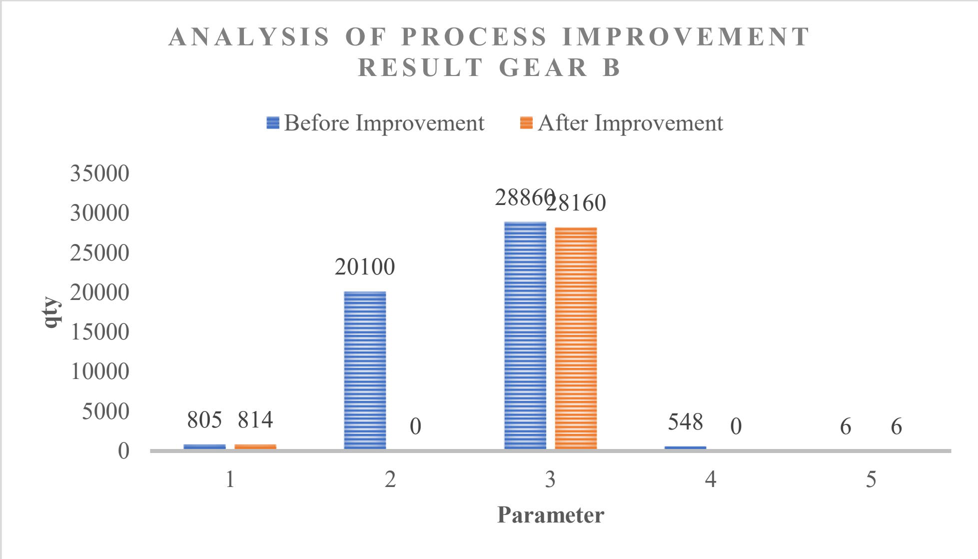

Figure 4. Effectiveness comparison chart gear B

Base on Table 17, production process of Gear A shows that idle time of machine is eliminated, idle time of manpower has been reduced by 2,42% and WIP is disappears.

5. Conclusions

Based on the results of the study, it can be concluded that the incorporation of these process lines is very influential on the effectiveness and productivity of production. The merger has successfully made changes to the effectiveness of production, use of area and manpower. In terms of productivity, there was an increase in daily production of gear A from 805 to 812 (up 0.86%) and gear B from 805 to 814 (up 1.12%). then with this change the company can also optimize the use of operators from a total of 14 people to 12 people (for 3 shifts). With this process line process also the company can use the area used for WIP goods so that the control process is easier, and the process flow is more organized. The mathematical model used is a standard calculation used to determine each activity time of each process. The Manufacturing Process of Gear A and Gear B cannot be combined due to machine limitations and the dimensions of each Gear. The results of this study will be used as input in determining production planning in the company.

Data Availability

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

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