Single Minute Exchange of Dies as The Solution on Setup Processes Optimization by Decreasing Changeover Time, A Case Study in Automotive Part Industry

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Single Minute Exchange of Dies as The Solution on Setup Processes Optimization by Decreasing Changeover Time, A Case Study in Automotive Part Industry

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Abstract. Industrial competition nowadays demanding automotive manufacturers to increase productivity and organise lean production to meet all the targets. The rear axle manufacturer, one of the automotive industry in 2018, experienced production constraints that were unable to meet production targets. The Line Housing F as the object of this research had 9 machines that involved setup time for the changeover process out of 24 machines. The setup process was not being standardized, conducted manually and involved readjustment on the engine jig, which would, causes a long changeover time because the process was repeatedly carried out. This study aimed to optimize setup activities in order to reduce changeover time. The Single Minute Exchange of Dies (SMED) method was one of the applicable tools to reduce change over time, by changing the internal activities into external activities. In the final stage, SMED simplified the jig setting process by changing the jig design on the M16.3 machine and parallelizing the setup and process operations of the machine. The final results improved the 33% overall changeover time, from 58.36 to 39.22 minutes.

1. Introduction

The automotive industry was an industry that has had experienced significant development. This industry was one of the pillars of economic growth in Indonesia. According to the katadata.co.id site, several factors that drive the development of the automotive industry are seen from the high value of investment. This included the addition of production capacity and the opening of new factories. Data created by the Association of Indonesian Automotive Industries (GAIKINDO) regarding the comparison of production and market demand has an upward trend from 2004 to 2015.

In line with high and varied market demand, companies were required to be able to meet demand in a timely manner. Specific demand according to the colour, shape, size and model that the customer wanted to affect the specific machine that the company must also use for the production process. Specific requested would increase the level of difficulty, one of which was the changeover process. The changeover was an adjustment process when changing models in product A to product B. The process of adjusting the machine with the setup was a challenge for the production division to be able to create an effective and efficient process.

In the production process, changeover would not be spared from the engine setup for product replacement. A bad changeover system would cause problems and disrupt the time for production. Heizer and Render [1] argued that in recent years there had been a market trend that leads to mass customization, which was characterized by a high variation in product demand. The ability to adjust to

the demands of the demand must have been absolutely owned by the company in order to remain able to compete. The high change in variation in a production line created problems in terms of setup such as tool replacement and program change. The process must have been done quickly and precisely when the changeover process started.

The object of this research was the automotive part industry that produced car components, especially the rear axle. One of the main products was the rear axle or rear wheel drive. The rear axle had several components in it and one of them was housing. Housing or as a component house produced by the company itself had several types or models. The model was divided into Sport Utility Vehicle (SUV) and Multi-Purpose Vehicle (MPV) types.

The production housing had two production lines, namely C line housing and F line housing, where the two lines had differences in the type of model housing produced. The line housing F produced 3 types of model housing, namely kk10, kk20 and kk230. With the variation of the product housing model, it indicated the high demand in the market where the desired product was also specific. From the results of observation data, there was a decrease in the level of fulfilment of customer requests. In January to June 2018 the housing F production line could not meet customer demand. This indicated that there were problems in the production section, especially the housing F production line.

The results of observations in the field of the changeover process were one of the cases that dominated the problem of meeting production targets. Sixty minutes was the maximum limit set by the company for the changeover process. But in fact, in each process that occurred exceeds the target specified by the company. This study aimed to optimize the setup process to reduce changeover time.

Single Minute of Exchange Dies (SMED) was one of the improvement methods of the lean manufacturing concept that could be used as a solution to problems regarding setup time in order to achieve optimal time. The focus of the SMED method, which reduced setup time, was the right approach to this problem. The time of changing the setup is part of waste in a lean concept that must have been eliminated because it made the process inefficient and did not give added value to customers [2]. Some of the benefits in implementing this SMED method were setup time reduction, reducing production inventory, increasing machine work and production capacity, eliminating setup errors, improving quality, simplifying tool usage, reducing production costs, reducing operator preferences, and reducing production time [3].

2. Literature

2.1. Lean manufacture

Lean Manufacturing was a process that consisted of five steps: defining customer value, defining value streams, making values continue to flow, letting customers attract value, pursuing perfection [4]. To become a lean company required the same way of thinking as the five steps, moreover, focusing on creating product flow through the process of adding value without the existence of one-piece-flow interruption. A pull system that flowed from customer requests and conducted for subsequent operations at short intervals and cultures where everyone strived to improve continuously.

2.2. Setup Time

Setup was the process of adjusting the machine or tool so that it was in accordance with the standard process that will be carried out. While the setup time when the changeover was calculated from the release of the last good product from the old model until the first good product came out of the new model. The minimization of setup time was an effort to reduce "interruption" in the production process. Setup time was the time needed to prepare the operating process. The set up time consists of time to set up machine components, the time of providing work equipment and others. The setup process was mostly done when the machine was not operating [5]. Setup was divided into 2 types, namely 1). major setup was a setup process that was performed to produce parts of different types of products, 2). minor setup was the setup process that was performed to produce parts of the same product type.

Table 1. Basic step of setup

Operation	Time Proportion
Preparation, adjustment to next process, and the checking of raw material, dies, jigs, measurement tools, etc	30%
Mount and release the knife	5%
Cantering, dimensions and other conditions settings	15%
Experiments and adjustments	50%

2.3. Changeover

Changeover was defined as the entire activity and time needed between the production of the last product of the old model to the production of the product in the next model with the normal conditions of efficiency or normal speed in the process of changing the type of product. All changeover activities were considered as waste because what they do did not add value to the final product and caused an increase in production costs, therefore it must had been eliminated or at least reduced to a minimum.

There were two opinions that could be used to reduce changeover time by reducing the changeover frequency or by reducing the time needed for changeover. Although there were studies that explain that, the first opinion was better in order to be able to reduce but the opinion was less preferred compared to the second opinion, namely by reducing the setup or changeover time itself **Error! Reference source not found.**.

2.4. Single Minutes Exchanges Dies (SMED)

SMED was an improvement technique that was part of the Lean Manufacturing concept and could be used to attempt to reduce Setup time to "single minute" or less than 10 minutes so that it could provide benefits to the company [6]. SMED was widely applied in companies to reduce setup time, so that changeover time could be minimized [8], [9], [10], [11], [12], [13].

The application of SMED could be done in 3 steps, 1). Separating internal and external activities, 2). Change internal setup to external [1], [14], 3). Simplifies all aspects of setup operations. This first step was a process for analysing in detail each basic operation. The second and third steps were not presented separately, both were almost simultaneously [2].

Performance rating was one of the time study methods for analysing operator performance. Performance rating was the most important step in the overall performance measurement procedure. This method was also the most critical step because it was based on experience, training, and assessment of observers of performance measurement. Experience and assessment were still criteria for determining rating factors [15]. Then regarding performance rating or what was called Westinghouse system rating, which had been recommended [15] because it could allow analysis that is more detailed. This method was one of the longest-used scoring systems which was later called levelling and was developed by Westinghouse Electric Corporation. The Westinghouse scoring system considered four factors in evaluating operator performance. 4 of these factors are: Skills, Effort, Condition, and Consistency

In the scoring process, these four factors were divided into six categories or classes. Please find the Westinghouse tables in the tables 2.

Table 2. Westinghouse Rating Factors

Westinghouse *Rating Factors*					
Skill			***Effort***		
0.15	A1	*Super Skill*	0.13	A1	*Super Skill*
0.13	A2		0.12	A2	
0.11	B1	*Excellent*	0.10	B1	*Excellent*
0.08	B2		0.08	B2	
0.06	C1	*Good*	0.05	C1	*Good*
0.03	C2		0.02	C2	
0.00	D	*Average*	0.00	D	*Average*

Westinghouse *Rating Factors*					
Skill			***Effort***		
-0.05	E1	*Fair*	-0.04	E1	*Fair*
-0.10	E2		-0.08	E2	
-0.16	F1	*Poor*	-0.12	F1	*Poor*
-0.22	F2		-0.17	F2	
Condition			*Consistency*		
0.06	A	*Ideal*	0.04	A	*Perfect*
0.04	B	*Excellent*	0.03	B	*Excellent*
0.02	C	*Good*	0.01	C	*Good*
0.00	D	*Average*	0.00	D	*Average*
-0.03	E	*Fair*	-0.02	E	*Fair*
-0.07	F	*Poor*	-0.04	F	*Poor*

3. Method

This research was carried out by the automotive part industry by taking samples at line F. Several types of model housing were included kk10, kk20 and kk230. On this line production there were 24 machines with 9 machines that were setup when the changeover process was carried out.

Primary data needed was data related to research in the form of direct observation or field observations and interview data, where the data were: engine data type, housing F production line layout, engine cycle time, operator setup data, video changeover process, and interview data regarding the causes that were a problem when the machine setup was changed.

Processing data using the SMED method was as follows; documentation of setup steps, separating internal and external activities, changing internal activities to external, simplifying all aspects of setup.

4. Result and Discussion

4.1. Lay out of line housing F

In the housing F production line there were 24 machines (as shown in Figure 1) and were carried out by 5 man power (MP), where only 9 machines were changed over, namely: M16.2, M16.3, M16.4, M16.5 , M17.2, A17, A19.B21, M13 and M20.

Figure 1. Layout Line Housing F

In the line housing F layout there were 5 MPs with different tasks. Based on the analysis using the Pareto diagram help, MP 1 had the longest total setup time at changeover (83%), so that MP1 was the main target of repairs (working area MP 1, can be seen on figure 2). If viewed based on the machine setup time, it could be seen M16.3 had the longest setup time and the machine was in the MP1 work area (table 3).

Figure 2. Workflow MP1

Table 3. Setup time

Machine	M16.2	M16.3	M16.4	M16.5	M.17.2	A 17	A19.B21	M13	M20
Set up time	193	706	196	577	110	494	245	184	162

Table 4. Scoring Adjustment (in rating factor) for MP 1

***Rating Factor* MP 1**		
Skill	*Good* (C1)	0.06
Effort	*Good* (C2)	0.02
Condition	*Average* (D)	0.00
Consistency	*Good* (C1)	0.01
Total Value		0.09

Using the assumption of operator worked in normal condition, therefore the p score for MP1 was the score of p= 1+ rating factor, equals to 1 + 0.09 = 1.09.

Table 5. *Allowance* Score of MP 1

***Allowance* MP 1**		
Effort exerted	Very light	7.00
Attitudes	Stand on two both feet	1.50
Eye movement	Normal	0.00
Eye fatigue	Constant look with changed focuses	5.00
Temperature	Normal	5.00
Atmosphere	Enough	3.00
Environmental condition	Very Loud	3.00
Personal needs	Male	1.00
Total Allowance %		25.50

4.2. Internal and external activity classification

Based on analysis and interviews with experts, in the work area conducted by MP1, there were 73 activities consisting of 59 internal activities (81%) and 14 external activities (19%).

4.3. Replacement of internal activities becomes external

The process of replacing internal activities into external was intended as moving internal activities that had the possibility of being able to be moved into external activities (setup activities carried out when

the engine was still alive). So that it could be said that the changeover time was faster because the process was carried out when the other process was running. Based on expert analysis and interviews, there were changes in internal activities from 49 to 46 activities and external activities from 14 to 27 activities.

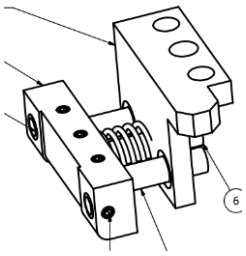
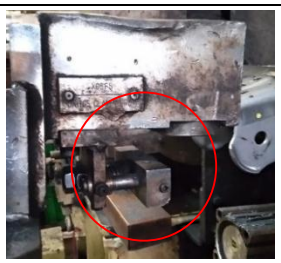
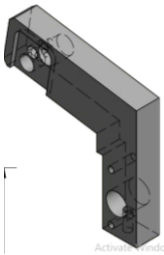
4.4. Simplification process

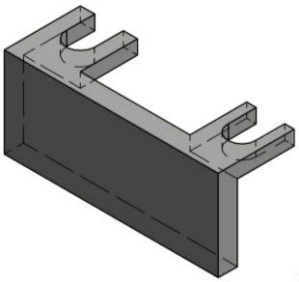
Base on analysis and interviews with expert, we get some activities setup time can be simplification. The activity that could be seen in table 6.

Table 6. List of simplification processes

No	Machine	Item Setting	Time Setup
1	M16.3	Jig Control Cover	87
		Jig Upper Lh	167
		Jig Lateral Rod housing tube	73
2	M16.5	*Setting* V Block	295

Table 7. Proposed of repair processes

No	Before	Proposed	After
1.	The idea of improvement by jig lateral rod housing tube		
			
	The setting of jig lateral rod in M16.3 machine should switch the jig (loading unloading), so that it take a time		The setting of jig lateral rod in M16.3 machine become communize jig lateral rod in a short time, Changeover was done only in one setting
	Set up time 73 seconds	Reduce time in 20 seconds	Set up time 53 seconds
2.	The idea of improvement jig skid control cover		
			
	- When changeover, MP should setup shim and jig condition unwell, so that it take a time - Jig skid control has no locking lock		- There is locking lock - Changeover only needs to loosen the bolt center and remove the spacer, then tighten the bold center again,

No	Before	Proposed	After
			Changeover was done only in one setting
	Setup time: 87 second	Reduce time in 6 seconds	- Setup time: 81 second
3.	The idea of improvement jig skid control upper LH		
			
	Shim or spacer not standard		shim or spacer made according to size and dimensions, Changeover was done only in one setting
	Setup time: 167 second	Reduce time in 25 seconds	Setup time: 142 second
	Total reduce setup time 51 seconds = 0,85 minute		

In the table 7, it was explained the improvement made for performing the SMED and changed the internal setup into the external setup. The improvement made was the proposed, and the changed could be seen in the before and after columns.

Table 8. Comparison of total time, normal time and standard time

	Time Total			Internal			External		
	1	2	3	1	2	3	1	2	3
Total (minutes)	49.55	49.55	32.7	39.7	36.76	22.26	9.78	12.78	10.43
Normal time	54.009	54.009	35.64	43.34	40.07	24.27	10.66	13.93	11.37
Standard time	72.49	72.49	43.89	53.37	49.35	29.88	13.13	17.15	14.004

The improvements performed to the jig design, in order to change the internal setup to become external setup. The data obtained from the reduction time could be seen in the table 8. Various improvements on the time consumed before on the time total, then calculated for the internal setup, resulted in the various improvement on the reduction time for the setup. The standard time improvement was calculated and the reduction was around 30% of the total time. Based on this calculation, the SMED was applicable and improved the industrial system. This result was supported by the previous researches (62 % reduction time [16], time savings [17] and improvement of processes in industrial factories [18]).

5. Conclusion

The first, setup time needed for the changeover housing kk10 model to kk20 at MP 1 was 49.62 and for the entire changeover process based on standard time required 58.36 minutes.

Based on SMED identification, out of 56 total activities in the MP 1 setup process there were 45 total internal setup activities with 36.22 minutes and 11 external setups with 13.2 minutes. The total internal setup activity was 36 and 20 external setups with 2017 seconds internal setup time or 33.63 minutes and 926 seconds external setup or 15.44 minutes.

There were three simplified setup aspects that were setting the rod housing tube lateral jig, upper LH jig setting and jig skid control cover. With improvements to the jig design, it could shorten setup

activities performed. Then parallelized or made the setup and process operations of the machine run simultaneously, namely on the machine. The final result of the implementation of SMED could be seen from the reduced changeover time at one cycle of 19.14 minutes or 33%. Indicators in the application of the SMED method could be a step to reduce setup time by recognizing setup activities that were carried out in an internal setup or external setup. Then after recognizing that it could be converted or changed potential activities. For example, taking brackets, equipment and other components that could be done when the production process was still ongoing so that it would not add to the setup process when the changeover was done. There was readjustment, at the last stage, conducted two operations simultaneously

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