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Improving Process Capability of The Electronics Component Company Through SMED

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A B S T R A C T

Every industry wants to increase the speed of the production process to meet customer needs. This paper aims to show the results that have been achieved after the implementation of SMED in the stamping department of an electronic component company. Steps to Define, Measure, Improve, Control, and Improve are methods to achieve this research's objectives. The Work-Study method is used to perform activity decomposition to facilitate the repair process. Implementing SMED in electronics companies can reduce change over time by up to 41%.

1. INTRODUCTION

The large number of competitors engaged in electronic components triggers strong competition to continue to make improvements to survive the competition. Thus, the electronics component industry needs to eliminate waste by making continuous improvements. Lean manufacturing provides the right tools to reduce waste to increase products' value, with the principle of controlling Value-Added (VA) activities and Non-Value Added (NVA) activities. Monitoring Value-Added (VA) activities and continuously reducing Non-Value Added activities is fundamental to reducing waste. (Teran-Somohano & Smith, 2013; Moreira & Pais, 2011; Sundar et al., 2014). Therefore, the industry needs to continue to make continuous improvements to reduce waste to increase product value.

The speed to produce a product taking into account the quality, cost, and delivery, is the goal of each company, so it takes the right selection of tools to meet this goal. Single Minute Exchange of Dies (SMED) is one of the lean manufacturing tools that has proven effective in reducing inventory (Demeter & Matyusz, 2011) and can also speed up the time for the process of change over from one product to another by changing the change over time of the machine or product from internal activities (when the machine stops) to external activities (when the machine is running) and then shortening the time of both (Dave & Sohani, 2012). In his research, Michels (2007) found that SMED application can improve and reduce the time for change over efficiently to reduce direct labor. In line with Cakmakci (2009), SMED can be integrated with 5S programs and equipment design in his research. Therefore, to accelerate the change over process can be done by developing supporting equipment design integrated with the 5S program effectively.

In a previous study conducted by Karam et al. (2018), it was found that SMED implementation can reduce the average change over time, and the standard deviation from the average time can be lowered. However, the value of the capability process has not been discussed more deeply. Therefore, the author is interested in researching the change-over process in the electronic component industry using the SMED method to increase its capability.

2. LITERATURE REVIEW

Single Minute Exchange of Dies (SMED) is a method that can accelerate the time of change-over activity from one product to another so that it becomes more efficient. Time Change over is the time used to produce good quality products at the end of production up to products of different types. Most of the time used is for the cleaning process, part change, and machine set up to do other product production processes. Improving the SMED method is the key to reducing setup time for batch type production so that the production process flow becomes more flexible (Dave & Sohani, 2012).

According to Shingo, the Single Minute Exchange of Dies can be done in single digits or under 10 minutes (Shingo, 1985). Currently, techniques for achieving single-digit transition time are obtained and applied in manufacturing areas to shorten and standardize waiting time between the two activities or groups by using different equipment (McIntosh et al., 2000). By observing the current methodology, separating internal and external activities, streamlining the change over the process, and continuous training, SMED measures will be achieved and implemented (Dave & Sohani, 2012). The result is expected to restore the value of economic benefits reflected in the increase in product output.

Beyond the VA's economic benefits, time reduction in the change over process does not increase the value of the NVA, such as increasing ergonomics, standardizing, teamwork, and equalizing the expected (Ribeiro et al., 2011). Integrating Overall Equipment Efficiency (OEE) is expected to increase the value of indicators by reducing the loss of time caused by the change over process (Cakmakci, 2009; Joshi & Naik, 2012).

3. RESEARCH METHOD

To achieve the research objectives, Define, Measure, Analyze, Improve, and Control structure steps are chosen as a method in applying SMED (Shingo, 1985; Roth & Franchetti, 2010).

3.1. Define

The research was conducted at an electrical and electronics component company located in Bekasi's Cibitung Industrial area. The products produced are terminals and connectors used in electronic and automotive equipment. From the production data taken for one year, productivity indicators are still low due to many frequencies for product turnover coupled with a long setup time. Each activity with the largest contribution to the overall production time is a change-over activity of over 65% (Fig. 1).

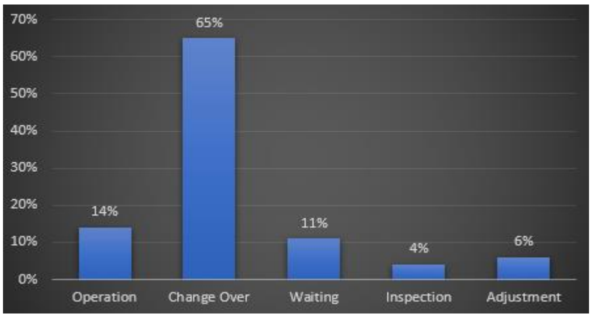

Fig. 1. Share production activity

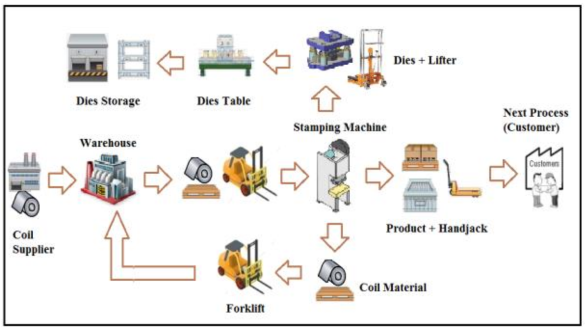

Fig. 2. Production flow process

So the chances of improvement are considerable. The production process starts from the receipt of coil material in the roll by the Logistic Control (Warehouse) department. Further distributed to the production part and used as a material supply on the stamping machine. After production and must change the product's type, the product is sent to the next process to be done plating process. Press die is returned in the press die storage area, as seen in Fig. 2.

3.2. Measure

The initial data is taken from secondary change-over-time data for the last six months from each operator who performs the change over process. The data is saved into Microsoft excel and then processed the data using Minitab 17. Data processing shows that the change-over activity process's ability is still not satisfied with a Cp value of 0.61 and a Cpk of 0.58. The histogram chart also found two hills showing two different populations, as shown in Fig. 3. The process capability results are transferred to the Z value to determine the capability index used as a management reference for carrying out the next continuous improvement process, as seen in Fig. 4. Current conditions of the technology process need to be improved to increase the change over process's speed.

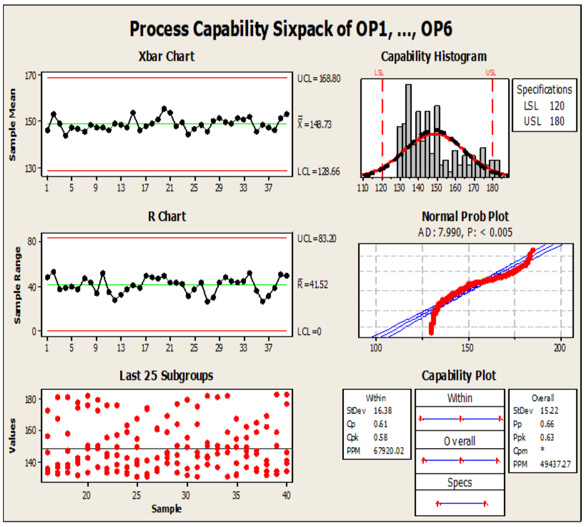

Fig. 3. Capabilities six-pack change over time activity

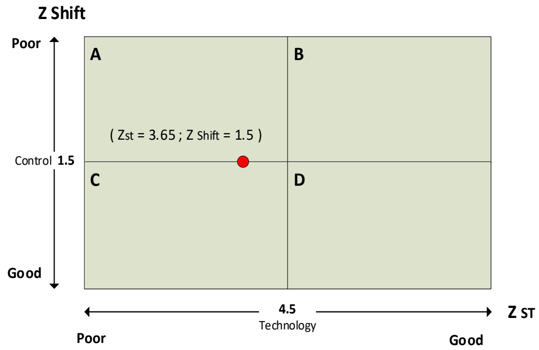

Fig. 4. Four block diagram change-over activity

3.3. Analyze

At the analysis stage, a more in-depth examination is carried out with direct discussions with all employees who conduct the change over the process and involve the production manager to determine the factors that become obstacles when doing the change over process. The real phenomenon of the change over the process will appear when a video is taken of the change over activity for each operator who performs the change over process. Videos can give the author insight into the consistency between self-assessment and observed behavior (Asan & Montague, 2014). Video footage of the subject's ongoing activities is a natural setting of progress (Holaday, 1977). This can help the author do movement analysis from the operator, which is then translated into Work-Study when changing over process activity. As seen in Fig. 5, grouping the change-over activity from the beginning of document inspection to product inspection is the end of the change over process. Furthermore, the author observes and analyzes every movement of operators who do the change over the process and sorted by using the frame time chart of change over activity against each change's duration, as seen in table 1. The change over activity table starts at 07:25 am and finishes at 1:42 pm or the total time needed during the change over process are 301.8 minutes.

Fig. 5. Flow process change-over activity

Table 1. Time frame chart change overactivity

	07:20	07:25	09:50	10:05	12:00	12:50	13:00	15:00	15:20	16:50	
Total Time	5	145	15	115	50	10	120	20	90		570
Working time		145		115			120		90		470
Break			15					20			35
Lunch					50						50
Meeting	5					10					15
Total Change Over Time		145		115			41.8				301.8
Check Record		3.5									3.5
Take out dies from storage		14.2									14.2
Change part		127.3		52.1							179.4
Remove dies from machine				24.1							24.1
Return dies to storage				7.2							7.2
Bring dies to the machine				9.3							9.3
Setting dies				22.3			5.6				27.9
Setting material							19.1				19.1
Check product							17.1				17.1
Total Change Over Time		145		115			41.8				301.8

Table 2. Work-Study change-over activity

No	Description	Time (s)	Distance (meter)	Symbol O	→	□	D	∇	Time (minute)	VA (minute)	NVA (minute)
	Change Part										
1	Take Part	8	9		•				0.13		0.13
2	Search part	306					•		5.1		5.1
3	Take Drawing	2	3		•				0.03		0.03
4	Search Drawing	90					•		1.5		1.5
5	Open cover tape	140		•					2.33	2.33	
6	Cleaning part	232		•					3.87	3.87	
7	Comparing	503				•			8.38		8.38
8	Walk to the microscope	10	3		•				0.17		0.17
9	Check part	93				•			1.55		1.55
10	Walk to the maintenance table	16	3		•				0.27		0.27
11	Assemble/ disassemble Dies part	2,104		•					35.07	35.07	
12	Search tools	2,000					•		33.33		33.33
13	Assemble/ disassemble Punch part	2,320		•					38.67	38.67	
14	Search tools	2,000					•		33.33		33.33
15	Taping part	830		•					13.83	13.83	
16	Walk to the maintenance table	20	3		•				0.33		0.33
	Total Time Change part	10,764							179.4	93.77	85.63
	Remove Dies from machine										
1	Take the Lifter	25	3		•				0.42		0.42
2	Move lifter to the machine	113	20		•				1.88		1.88
3	Open the soundproof box	18		•					0.3		0.3
4	Motor On	2		•					0.03	0.03	
5	Take the layout product	150		•					2.5	2.5	
6	TMB Press Die.	53		•					0.88	0.88	
7	Open eight bolts	152		•					2.53	2.53	
8	TMA Press Die.	49		•					0.82	0.82	

9	Slide press die to the lifter	35		•					0.58	0.58	
10	Close the soundproof box	21		•					0.35		0.35
11	Move lifter to the maintenance area	136	20	•					2.27		2.27
12	return the lifter	20						•	0.33		0.33
13	Set bolts four pc	60		•					1	1	
14	Lifting press die Punch section	80		•					1.33	1.33	
15	Turn over punch section	40		•					0.67	0.67	
16	Cleaning punch Press Die	60		•					1	1	
17	Cleaning dies	100		•					1.67	1.67	

Table 3. Work-Study change-over activity (continued)

No	Description	Time (s)	Distance (meter)	Symbol					Time (minute)	VA (minute)	NVA (minute)
				O	→	□	D	∇			
	Remove Dies from machine										
18	Open Fix Stripper	80		•					1.33	1.33	
19	Assemble Fix Stripper	90		•					1.5	1.5	
20	Oiling	30		•					0.5	0.5	
21	Install Punch and Die	80		•					1.33	1.33	
22	Remove four bolts	50		•					0.83	0.83	
	Total time Remove Dies from machine	1,444							24.1	18.4	5.6
	Setting Press die										
1	Take the micrometer	100	9		•				1.67		1.67
2	Measure the center press die	250				•			4.17		4.17
3	Machine shutter setting	420		•					7	7	
4	Die height setting	44				•			0.73		0.73
5	Lifter up by hand	30			•				0.5		0.5
6	Insert press die to the machine by hand	37		•					0.62	0.62	
7	Guide material Setting	160				•			2.67		2.67
8	Guide carrier setting	190				•			3.17		3.17
9	Straightness setting	260				•			4.33		4.33
10	Set eight bolts	176		•					2.93	2.93	
	Total time Setting Press die	1,671							27.9	10.55	17.35
	Total Time top contribution	13,879							231.3	122.72	108.58

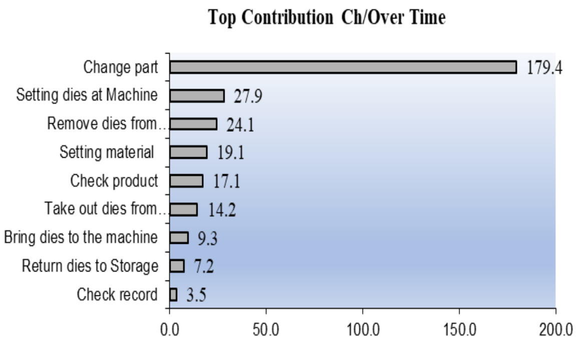

Fig. 6. Top nine contribution change-over activity

Table 1 shows that change part activity, setting dies at the machine, and removes press die from the machine are three activities that have the most contribution with a total activity share of 76.7%. As seen in Fig. 6, Top nine contributions change over time. As seen in table 2. the author uses a work-study chart to facilitate analysis of the movement of each operator then done decomposition of each activity so that it can be known the opportunity to make improvements to value-added activities (VA) or on activities that are not of added value (NVA). Work-study charts are taken on three activities that take the most time: change part, remove dies from the machine, and set press die.

3.4. Improvement

From the results of discussions with video recording media for change over activities, then carried out problem analysis by looking for the root cause of the problem, with method five-why analysis by asking five times or until there are no more questions. So, in the end, this method has resulted in a series of linear causal relationships and used the associated employees' experience to determine the main cause and the most appropriate solution (Dean, 2007), as seen in Table 3. After the discussion and determine the root of the problem, then continued with the submission of the idea of improvement so that the assets that have a large contribution can be reduced, table 4.

3.5 Control

To ensure the process runs effectively and efficiently, examining the change over process order is excellent and correct by eliminating additional activities that are not written in the change over process (Ulutas, 2011; Costa et al., 2013). Change over process activities are saved into Microsoft excel and graphed so that every change-over activity process can be viewed easily. For external activities (activities performed while the machine is still running) has been implemented.

Table 4. Five Why's analysis change-over activity

No	Why 1	Why 2	Why 3	Why 4	Why 5
1	Change part	The search for tools is not fast enough	Not easily seen and affordable	In the toolbox	There is no place yet
		Looking for drawing	drawing position is not fast seen	There is no specific indication	There are no standards yet
		Looking for parts	Part position is not fast seen	Mix parts	Parts nor organized
		Disassemble fix stripper	Difficult to disassemble	No slot area at the fix stripper	
2	Removes press die from machine	lifting and lowering the lifter	Manual lifter		
		Separate punch and die	Turn over the punch	lower punch stopper section	
3	Setting press die	Setting pitch	Repeated	By feeling	There are no tools
		Alignment setting	must be seen carefully	Difficult area to see	

Table 5. Proposed action

No	Description	Root cause	Improvement
1	Change part	There is no place to put the tools yet	Make Display Tools
		No change-over drawing standard	Make change over guidance
		Part not organized	Layout spare part
		No slot area at the fix stripper	Make slot area at the fix stripper
2	Removes dies from machine	Manual lifter	Using electric lifter
		lower punch stopper section	Stopper standardized
3	Setting press die	There are no tools for setting the pitch	Using Jig
		Difficult area to see	Make stopper

4. RESULTS AND DISCUSSION

The active role of operators on the factory floor has a large role for change over. Participation in delivering suggestions, ideas, and thoughts that are then carried out the implementation is the determining factor for the successful implementation of lean manufacturing on the production floor. Lean manufacturing tools are designed in such a way that it is suitable by the current conditions. Implementing lean manufacturing using the SMED method on the production floor can solve high change-over-time in the stamping department with an average decrease of 179 minutes (41% down). As seen in Table 5, the change-over activity improvement can be completed before 12 noon or 34 minutes after the break at 10:05. Based on the process capability analysis, there is an increase in the previous Cp value of 0.61 to 1.52, as seen in Fig. 8.

Implementing the SMED method and making improvements by eliminating some waste processes can decrease change over time. It must be continuously accompanied by creating a standard work process and continuous communication between the operator and the supervisor .

Table 6. Time chart frame change-over activity

	07:20	07:25	09:50	10:05	12:00	12:50	13:00	15:00	15:20	16:50	Before	After	% Down
Total Time	5	145	15	115	50	10	120	20	90		570	570	0%
Working time		145		115			120		90		470	470	0%
Break			15					20			35	35	0%
Lunch					50						50	50	0%
Meeting	5					10					15	15	0%
Total Change Over Time		145		34							301.8	179	41%
Check Record		3.5									3.5	3.5	0%
Take out dies from storage		11.7									14.2	11.7	18%
Change part		98.8									179.4	98.8	45%
Remove dies from machine		18.7									24.1	18.7	22%
Return dies to storage		5.7									7.2	5.7	21%
Bring dies to the machine		4.1									9.3	4.1	56%
Setting dies		2.5		4							27.9	6.5	77%
Setting material				12.9							19.1	12.9	32%
Check product				17.1							17.1	17.1	0%
Total Change Over Time		145		34							301.8	179	41%

It can be seen that there is an increase in the process capability index to be satisfactory, with a Cp value of 1.52 and a Cpk value of 0.67. Although it can be seen from the data in Fig.7, there are two hills because each operator's speed of the work process still needs to be improved. It can also be explained in the hypothesis:
Ho: There is no difference in working speed of the new operator and old operator
H1: There is a difference in the operating speed of the new operator and the old operator

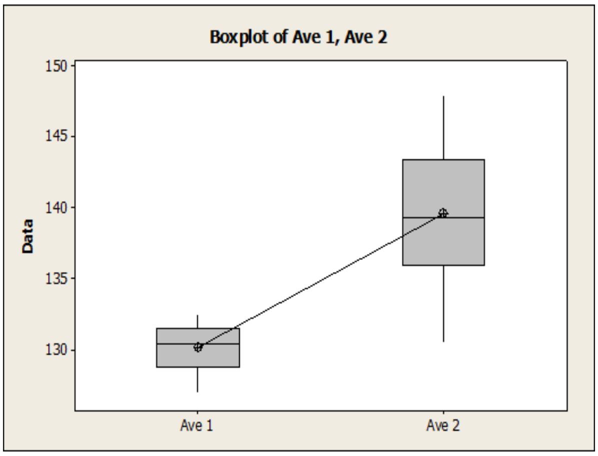

Fig.7. Box plot operator capability

In this study, it was found that the Ho hypothesis is rejected, or there is a difference in the operating speed of new operators and old operators, as seen in table 6. The box plot graph will make it easier to see each population of new and old operators' processing capability, as shown in Fig. 8. Implementing SMED by streamlining internal and external activities can increase the speed of change-over activities. Not only that, making improvements that focus on visualization techniques and incorporating new technologies such as replacing manual lifters replaced with electric ones also increases the speed of change-over activities. As shown in Figure 9, the four-block diagram of change-over activity shows an increase in the technology quadrant.

Table 7. Hypothesis table

```
Two-Sample T-Test and CI: Ave 1, Ave 2

Two-sample T for Ave 1 vs Ave 2

        N    Mean   StDev   SE Mean
Ave 1  40  130.17    1.52      0.24
Ave 2  40  139.59    4.68      0.74

Difference = mu (Ave 1) - mu (Ave 2)
Estimate for difference:  -9.419
95% CI for difference:  (-10.969, -7.868)
T-Test of difference = 0 (vs not =): T-Value = -
12.10  P-Value = 0.000  DF = 78
Both use Pooled StDev = 3.4825
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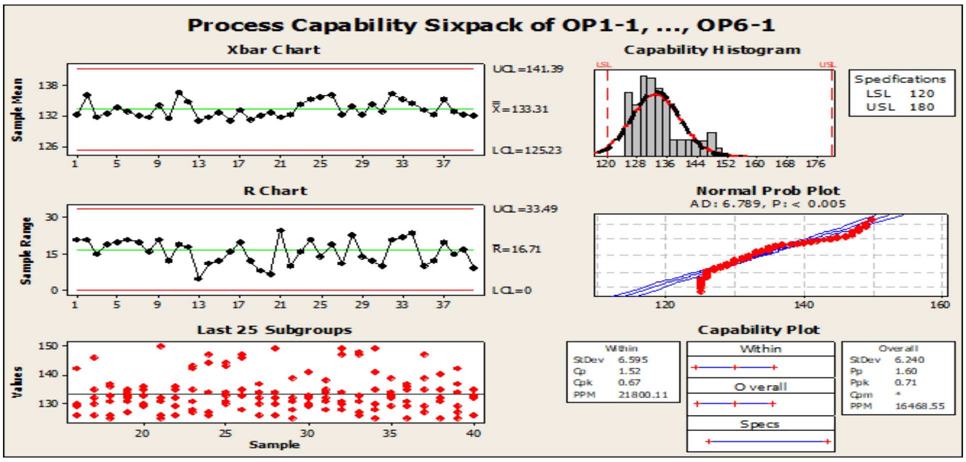

Fig. 7. Capability process change-over activity after the SMED method implemented

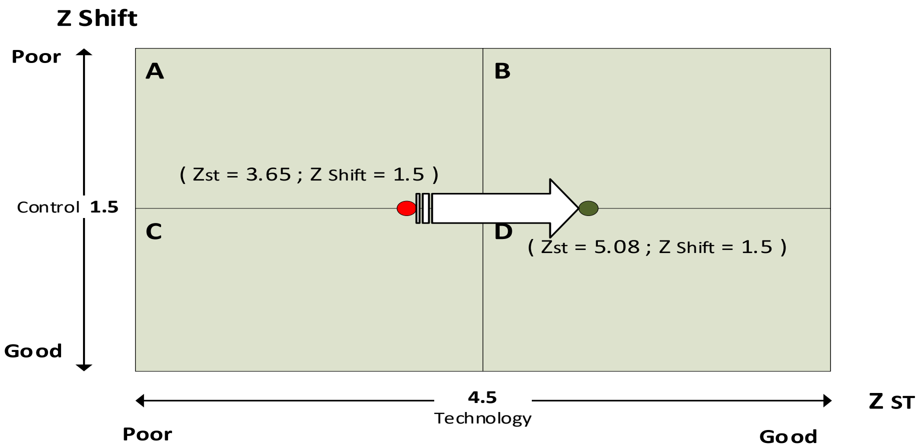

Fig. 8. Four block diagram change-over activity after SMED implementation

5. CONCLUSION

In this research, it can be seen that the implementation of SMED, which was carried out for six months in an electronic component company, has been successfully carried out. It is proven that there is a decrease in time for change-over activities by 41%. The capability process for change-over activities has also increased. However, it was found that there were differences in the speed of the change in the process of the operators so that the process capability index still needed to be improved.

Time differences between operators in change-over activities can be eliminated by incorporating technological elements to facilitate standardization of these activities, such as by implementing a hydraulic clamp system for press dies. Therefore, to continue improving process capability, further research needs to be deepened to find that activities carried out manually are converted to automation. Although, it is difficult to reach a single-digit time in the change process

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