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Overall Equipment Effectiveness Improvement Strategy During Pandemic Covid19 Through the Integration of DMAIC And SMED Method

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ABSTRACT: Indonesian car sales have dropped dramatically by 44% at the end of 2020 due to the impact of COVID-19 outbreak. It is make all car manufacturers to find a strategy to survive the business. The goal is to reduce losses in all production lines including the manufacturing process of components (parts) at all suppliers. The stamping process is the first process in car assembly. This process involved a high cost process, because it is associated with purchasing raw material, machinery and dies investment to make car bodies or components. Therefore, the effectiveness of stamping machine performance is very important to reduce cost. Overall Equipment Effectiveness (OEE) is known as a tool to overcome both cost and quality issues. This study aims to determine the causative factors as well as increase the OEE value on the 800T stamping machine at PT XYZ, through DMAIC (Define, Measure, Analyze, Improve, and Control) as frame work and the SMED (Single Minutes Exchange of Dies) method to reduce setup and adjustment losses. This integration successfully reduced dies change over time from 17.1 to 11.2 minutes and increased OEE from 62.4% to 78.2%.

KEYWORDS: Overall Equipment Effectiveness, Single Minute Exchange of Dies, DMAIC

INTRODUCTION

Pandemic (Covid-19) 'punch' the Indonesian automotive industry. This condition caused total domestic and export car sales at the end of 2020 dropped dramatically until 44%. Based on Gaikindo (Indonesian Automotive Industry Association) data provided in Figure 1, it shows that a sale for year 2020 is the lowest in the last ten years [1](Gaikindo, 2020).

Figure 1 Domestic and export car sales (2010-2020)

This condition makes all domestic car manufacturers and their supplier's to make efficiency and cut operational costs. The tough challenges that automotive companies facing during pandemic Covid19 are reducing costs and maintaining quality ([2] Rozak, et al,. 2020; [3]Jaqin[1], et al., 2020). Overall Equipment Effectiveness (OEE) is known as a tool to overcome both, cost reduction and improve quality ([4]Ahuja & Khamba, 2008; [5]Ahuja & Khamba, 2009; [6]Prabowo et al., 2015; [7]Prabowo, 2019). One of the processes in car manufacturing that requires high cost and productivity is the stamping process. By improving the Overall Equipment Effectiveness (OEE) value on a stamping machine it will reduce losses (cost). One way to reduce losses is to improve working methods and historical data analysis ([6]Prabowo et al., 2015). Similar research that observed the same product have found that by increasing availability value from 63.3%

to 67.8%, OEE can be increased from 60.7% to 65.3% ([3]Jaqin[1] et al., 2020). Various investigative frameworks to solve the problem have been carried out. DMAIC method in the automotive industry is capable to increase profit more than 165,000 won per year ([8]Costa et al., 2017). SCOR and DMAIC methods, makes the supply chain increased by up to 93% in chemical industry ([9]Hasibuan et al., 2018). There is several improvement methods used to increase the OEE value. 5S concept and SMED method can reduce setup time up to 18% ([10]Agung, 2019). Kaizen activity can be increase OEE to 82% in the cylinder block machining line ([11]Rozak et al., 2019). The purposes of this study is to improve OEE value by integrating DMAIC and SMED methods.

SIX BIG LOSSES

In the company there are several losses associated with equipment, which are called the six big losses ([12]Prabowo and Adesta, 2019; [7]Prabowo, 2019). Research by [13]Mardono et al. (2018); [14]Herry, et al., (2019) and [7]Prabowo, (2019) said six big losses can be categorized into three types, namely Downtime losses, Speed losses, and Defect losses. The three categories of losses above can be translated into:

- Downtime losses consist of two kind of losses, namely **breakdown** and **setup adjustment.**
- Speed losses consist of two kind of losses, namely **idling, minor stoppages** and **reduced speed.**
- Defect losses consist of two kind of losses, namely **defect in process** and **rework losses.**

Based on the above categories, there are three types of losses that must be anticipated, namely losses that affect the level of availability, losses that affect the level of performance, and losses that affect the level of quality ([15]Nakajima, 1988).

OVERALL EQUIPMENT EFFECTIVENESS (OEE)

Overall Equipment Effectiveness is a hierarchical matrix invented by Seiichi Nakajima in the 1960s that can evaluate and indicate how effective a machine [15](Nakajima. 1988). In this case, what is said to be effective is a process that only produces good output in the fastest possible time without any downtime. [16] Nayak et al. (2013) said that OEE is a way to monitor and improve efficiency in the manufacturing process. [17] Kumar et al. (2013) and [7] Prabowo (2019) states that OEE is a total measure of equipment performance and this OEE consists of three parameters, namely availability, performance and quality. Formula for calculation describe in below.

OEE = Availability x Performance x Quality	(1)
$\text{Availability} = \dfrac{\text{Loading time} - \text{Down time}}{\text{Loading time}} \text{ x } 100\%$	(2)
$\text{Performance} = \dfrac{(\text{OK Product} + \text{Rework} + \text{NG}) \text{ x ideal cycle time}}{\text{Loading time} - \text{Breakdown time}} \text{ x } 100\%$	(3)
$\text{Quality} = \dfrac{\text{OK Product}}{\text{OK Product} + \text{Rework} + \text{NG}} \text{ x } 100\%$	(4)

In measuring OEE, three main parameters are used according to the JIPM (Japan Institute of Plant Maintenance) standards, namely:

- If OEE = 85%, the production is considered world class. For many companies, this score is a suitable score to serve as a long-term goal.
- If OEE = 60%, production is considered reasonable, but indicates that there is significant room for improvement.
- If OEE = 40%, production is considered to have a low score, but in some cases it can easily be corrected by direct measurement.

DMAIC CYCLE

[18] Kuiper et al. (2014) stated continuous improvement of quality and productivity can be done with DMAIC cycle. The first step is Define the problem and determining a goal of this study.

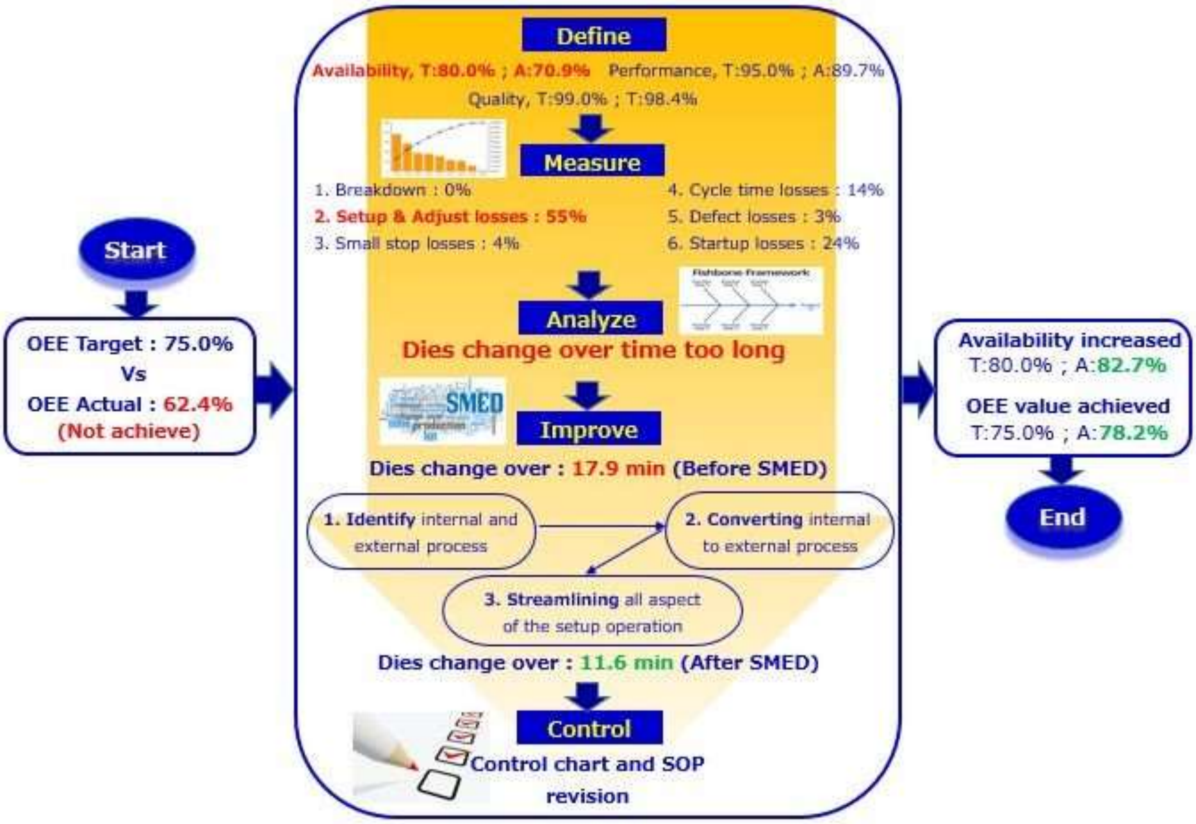
Meanwhile, the next stage is Measure stage, data collection related to the problems to find out the real cause of the problem. The Analyze stage is a stage for analyzing and identifying the causes of variations that affect process capabilities, determining the factors that most influence the process, the analysis is carried out to find factors that must be improved in order to improve the process. After the sources and root causes of quality and productivity problems are identified, it is necessary to determine an action plan to improve (Improve). Control is the final stage in the DMAIC method. Research by [19] M.S Hervian, and Soekardi, C. (2015) stated that equipment performance can be improved through the DMAIC approach. This research will be used DMAIC cycle, Pareto diagram, Fishbone diagram, and

SMED as one of improvement method to reduce setup time and to increase OEE of stamping machine.

METHODOLOGY

The data used in this study came from production reports consisting of loading times, downtime, and the number of OK and NG parts. This research framework uses the DMAIC cycle, as well as the Single Minute Exchange of Dies (SMED) method as a solution to increase the value of availability. Several kaizen ideas were also applied to reduce downtime so that the stamping machine's OEE value was increased and could reach the company target.

The detail of the methodology is provided in Figure 2.



T = Target; A = Actual

Figure 2 Research frameworks using the DMAIC cycle

RESULT AND ANALYSIS

The location of this research is at PT XYZ, which is one of the automotive component suppliers in Indonesia which supplies the stamping components as shown in Figure 3.

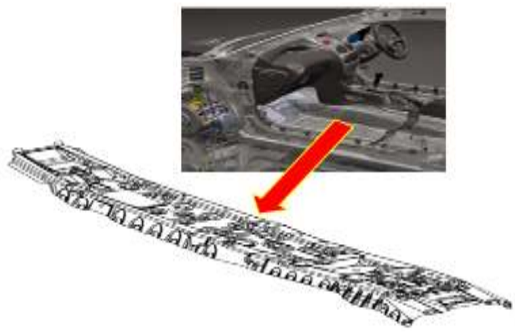


Figure 3 Examples of PT XYZ stamping components

Based on the production data of PT XYZ 800T Line A6 stamping machine, the results of the research can be explained using the DMAIC cycle as below.

Define

The first step is to define the factors that cause the low OEE value/not reaching the target. The data in figure 4 is a comparison between the actual OEE values of the 800T stamping machine for the period January - March 2020 with the company's target.

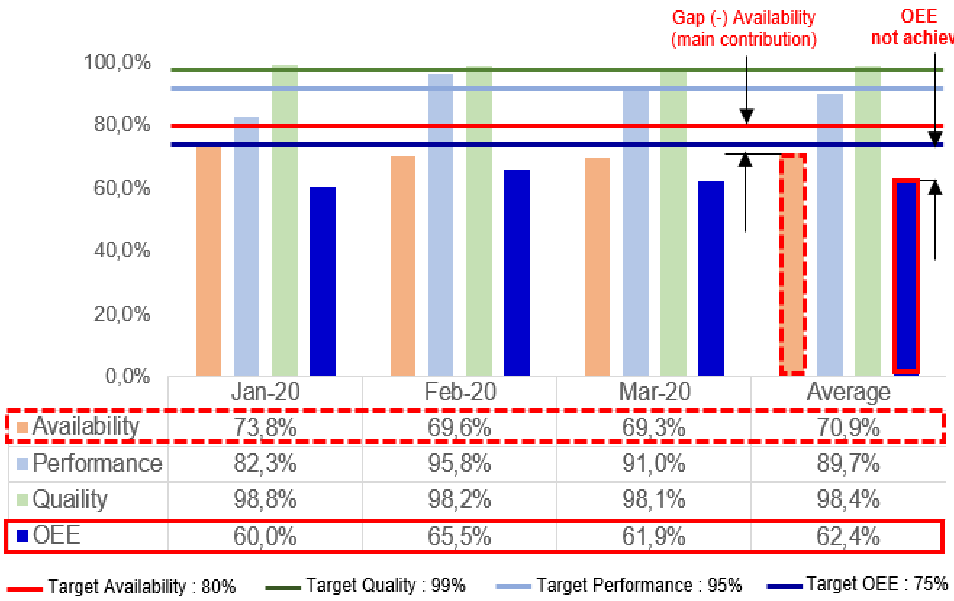


Figure 4 Comparison OEE factors with the company's target

Based on Figure 4 above, the low value of the Availability factor has become the main contribution to the low overall OEE value. Availability target is 80% while the actual achievement is 70.9% (9.1% gap from target). This resulted makes impact on actual OEE achievement only 62.4%, or 12.6% gap from company target which is 75%. Compared with the WCM (World Class Manufacturing) OEE target, the overall position of the OEE figures can be illustrated in table 1 below.

Table 1 Comparison of PT XYZ OEE and OEE WCM

	OEE Actual	OEE Target	OEE WCM
Availability	70.9%	80%	90%
Performance	89.7%	95%	95%
Quality	98.4%	99%	99%
OEE Value	62.4%	75%	85%

Measure

The achievement of the low Availability value on the stamping machine 800T above was caused by a lot of losses or downtime that occurred during production. Table 2 below is a detail of the problems that occurred during the production process from January to March 2020 period. To make it easier to analyze, the data is compiled based on the six big losses categories and then a Pareto diagram is made to determine which problem is the highest priority. Figure 5 in below is a Six big losses Pareto visualization of 800T Stamping machine.

Table 2 Six Big Losses Category 800T stamping machine

OEE Factor	Six Big Losses	Problem	(min)	[%]	Accu.[%]
Availability	Breakdown	-	0	0%	0%
	Setup & adjust	Dandori (Dies change over)	9.042	49%	49%
		Waiting internal pallet product	615	3%	52%
		Waiting raw material	541	3%	55%
Performance	Small stop	Scrap stuck	665	4%	59%
	Cycle time	Material / part handling problem	2.650	14%	73%
Quality	Defect	Part problem (Crack, wavy, etc)	548	3%	76%
	Startup	Quality confirmation	4.488	24%	100%

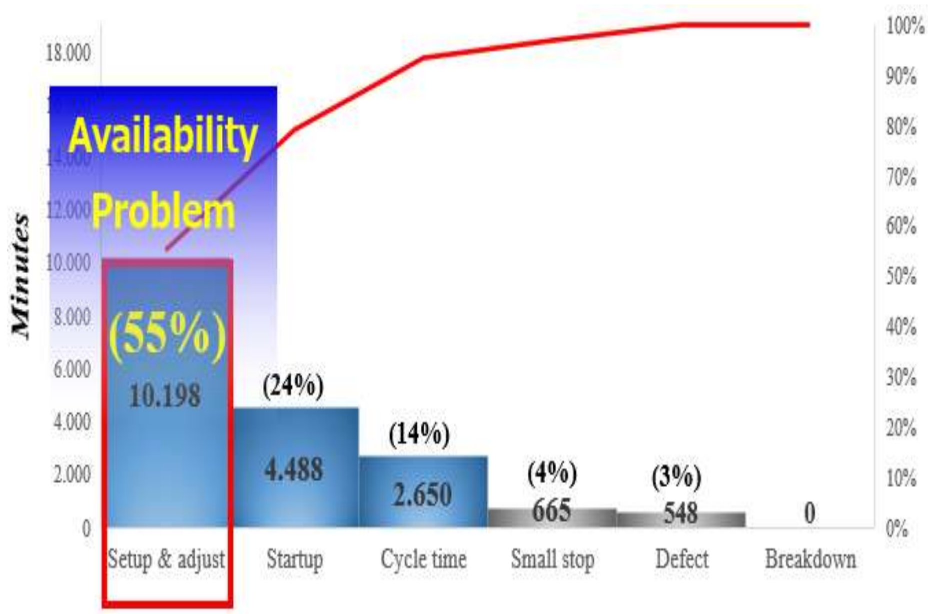


Figure 5 Pareto diagram of 800T stamping machine downtime

Based on the Pareto diagram, it can be concluded that the downtime dies changeover is highest contribute to reduce availability value. So, reduce the setup time (dies change over) is the first priority to improve the availability ratio. In addition, to further increase the OEE value of the 800T stamping machine, the startup and cycle time losses also need to be reduced.

Analyze

Referring to the data at the measure stage above, to find out the main causes and root causes of losses, the researcher formed an FGD (Forum Group Discussion) with the PT XYZ team to build a fishbone diagram, so that the results of the analysis related to the above problems would be much more objective. Based on the fishbone diagram in Figure 6, it can be seen that there are five factors that cause downtime loss on the dies change over.

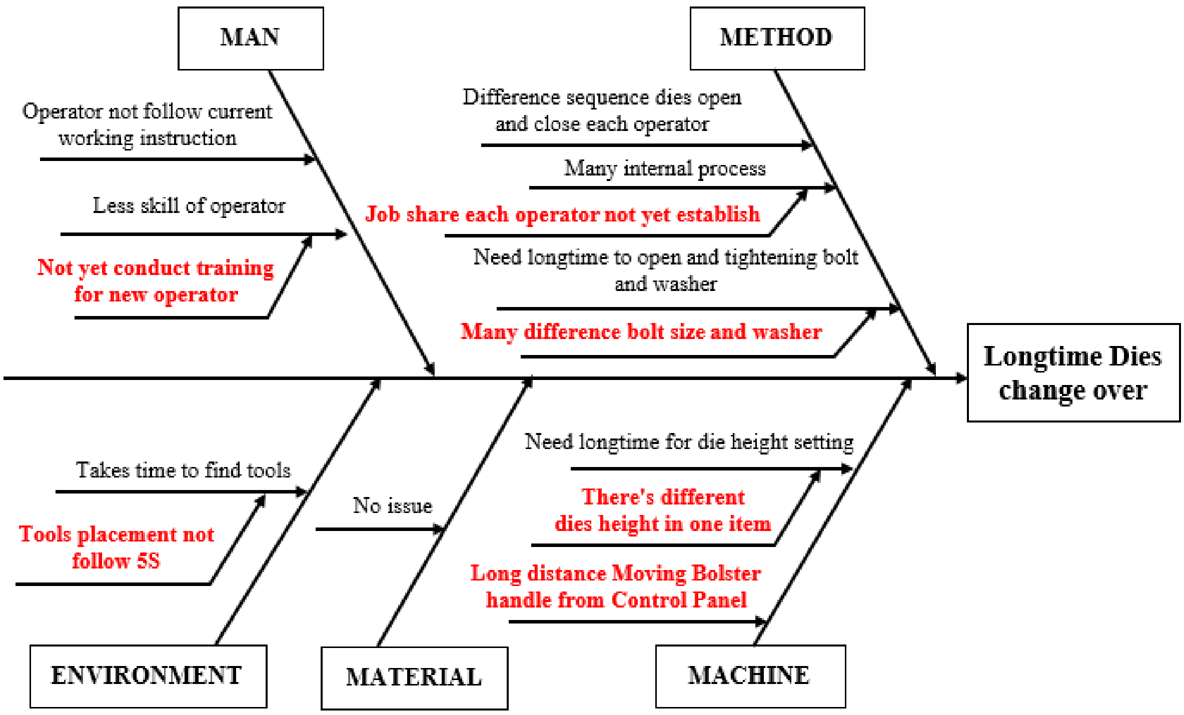


Figure 6 Fishbone diagram: longtime dies change over

Furthermore, to find the main root causes above, the RCA (Root Cause Analysis) tool is used. Table 3 below is the result discussion.

Table 3 Root Cause Analysis: Longtime dies change over

Category	Why-1	Why-2	Why-3
Machine	There's different dies height in one item	Dies height decision depend on parts size	
	Long distance between handle to Control Panel	Original spec. machine 800T	Common design with others machine
Methode	Job share each operator not yet establish	Current working procedure not detail	Engineer not prepare detail job
	Many difference bolt size and washer	Bolts / washer come from other machine	Don't have bolt / washer standard for 800T Machine
Man	Not yet conduct training	No item training for dies change over	
Environment	Tools placement not follow 5S	Not optimize 5S socialization	No 5S management control

Improve

Based on the results of the analysis above, it was found what caused the long time for the dies changeover was that the engineer had not made details of the work as well as the division of work for each operator. The data in Figure 7 below is a dies change over Gantt chart (before SMED).

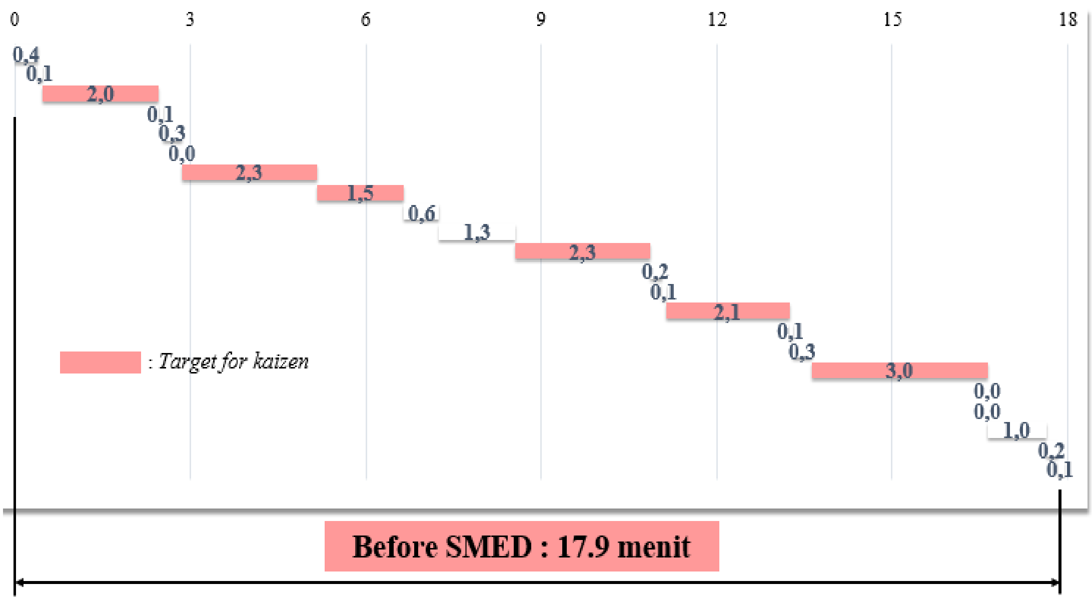


Figure 7 Gantt chart dies change over (before SMED)

Below is the following stages for implementing SMED:

- Identifying and separating internal activities and external activities

Table 4 below is the result of the separation of internal and external activities

Table 4 Internal and external activity of dies change over

Operator	Job	Min	Internal	External
A	Lower the upper slide "0" position	0.4	√	
A,B	Take out the screw release key	0.1	√	
A,B	Unscrew the bolt and washer clamp	2.0	√	
A,B	Put down the bolt release key	0.1	√	
A	Raise the upper slide 180 ° position	0.3	√	
Opt. Crane	Take out the remote crane	1.0		√
B	Moving bolster and dies out of the machine	2.3	√	
Opt. Crane	Lifting and placing dies into dies storage	1.5	√	
B	Clean the moving bolster from oil	0.6	√	
Opt. Crane	Puts the next dies onto the moving bolster	1.3	√	
A	Inserting the moving bolster into the machine	2.3	√	
A	Lower the upper slide "0" position	0.2	√	
A,B	Take out the screw release key	0.1	√	
A,B	Install and tighten bolts and washers	2.1	√	
A,B	Put down the bolt release key	0.1	√	
A	Raise the upper slide 180 ° position	0.3	√	
A	Shut height and pressure parameter settings	3.0	√	
A	Prepare the raw material table	2.5		√
A,B	Waiting for the forklift to pick up raw material	3.0		√
Opt. Forklift	Put the raw material on the table	1.0	√	
A	Unbinding raw material	0.2	√	
A,B	Stamping process for QC check	0.1	√	
		17.9		

➢ Converting internal to external activities

The second stage is to change the internal to external activities by conducting interviews with operators and checking procedures. There is a kaizen idea for changing internal activities to external ones based on table 5 below.

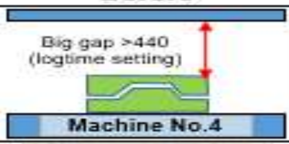
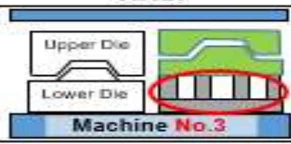
Table 5 Converting result internal to external activities

Operator	Job	Activity	Improvement
A	Lower the upper slide "0" position	Internal	
A,B	Take out the screw release key	Internal	
A,B	Unscrew the bolt and washer clamp	Internal	**Standardized bolt and washer**
A,B	Put down the bolt release key	Internal	
A	Raise the upper slide 180 ° position	Internal	
Opt. Crane	Take out the remote crane	External	
B	Moving bolster and dies out of the machine	Internal	**Moved handle MB closer**
Opt. Crane	Lifting and placing dies into dies storage	Internal	**New layout for dies next item**
B	Clean the moving bolster from oil	Internal → **External**	
Opt. Crane	Puts the next dies onto the moving bolster	Internal	
A	Inserting the moving bolster into the machine	Internal	
A	Lower the upper slide "0" position	Internal	
A,B	Take out the screw release key	Internal	
A,B	Install and tighten bolts and washers	Internal	**Standardized bolt and washer**
A,B	Put down the bolt release key	Internal	
A	Raise the upper slide 180 ° position	Internal	
A	Shut height and pressure parameter settings	Internal	
A → **B**	Prepare the raw material table	External	
A,B	Waiting for the forklift to pick up raw material	External	
Opt. Forklift	Put the raw material on the table	Internal → **External**	**Temporary area for material**
A → **B**	Unbinding raw material	Internal → **External**	
A,B	Stamping process for QC check	Internal	

➢ **Streamlining all aspect of the setup operation**

Focusing on kaizen in each work area is the final step in reducing setup time. Table 6 below is a kaizen list that is carried out to reduce the downtime that occurs when the dies change over.

Table 6 Kaizen list to reduce setup time (dies change over)

Root cause	Improvement	Before	After
Dies height base on each function (different dies height in one item)	Equalizing the height of the dies with the additional base holder and combine with previous process : Base holder position		
Common design with others machine (Long distance handle from Control Panel)	Change the position of the moving bolster handle closer to the operator and control panel		
Don't have bolt / washer standard	Standardized bolt / washer 		
No item training for dies change over	Conducted training on class & on site (SMED application)	-	
No 5S management control	Perform improvement and 5S Patrol in the stamping area (example: additional indication for dies layout)		

After all the kaizen was applied, the setup time (dies change over) decreased by 35% from 17.9 minutes to 11.6 minutes. The die change over Gantt chart (after the SMED implementation) can be seen in Figure 8 below.

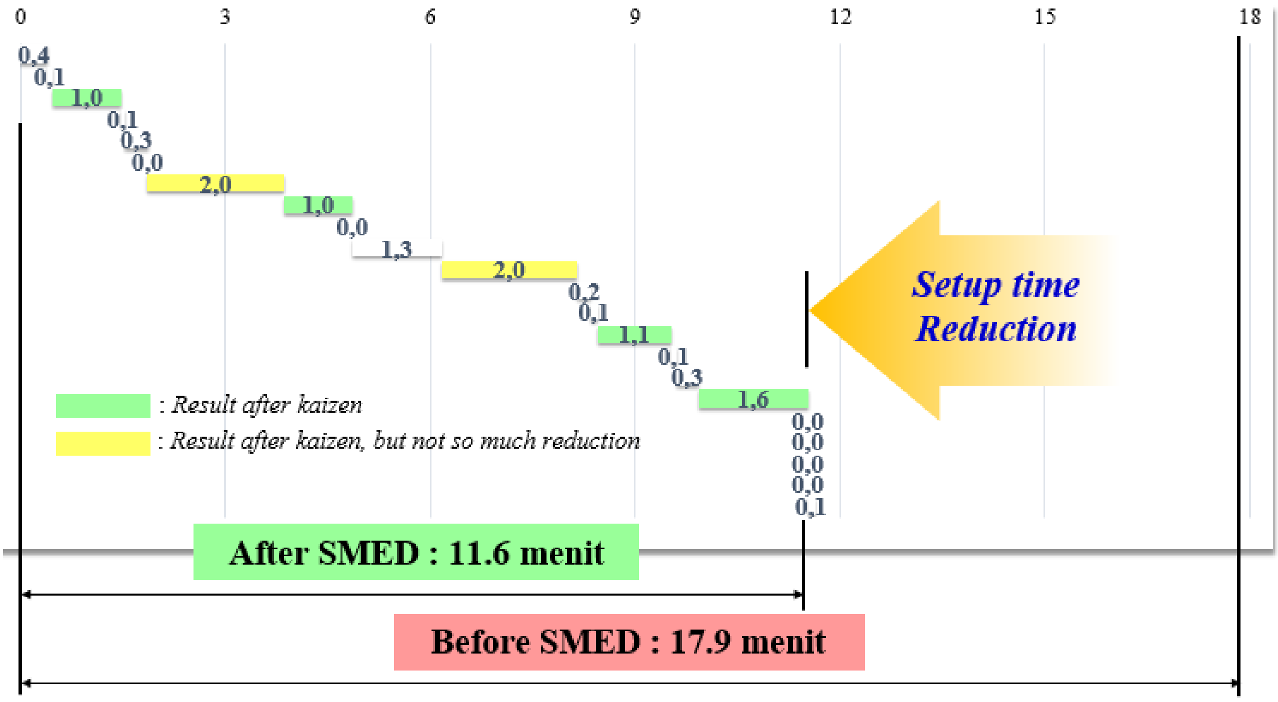
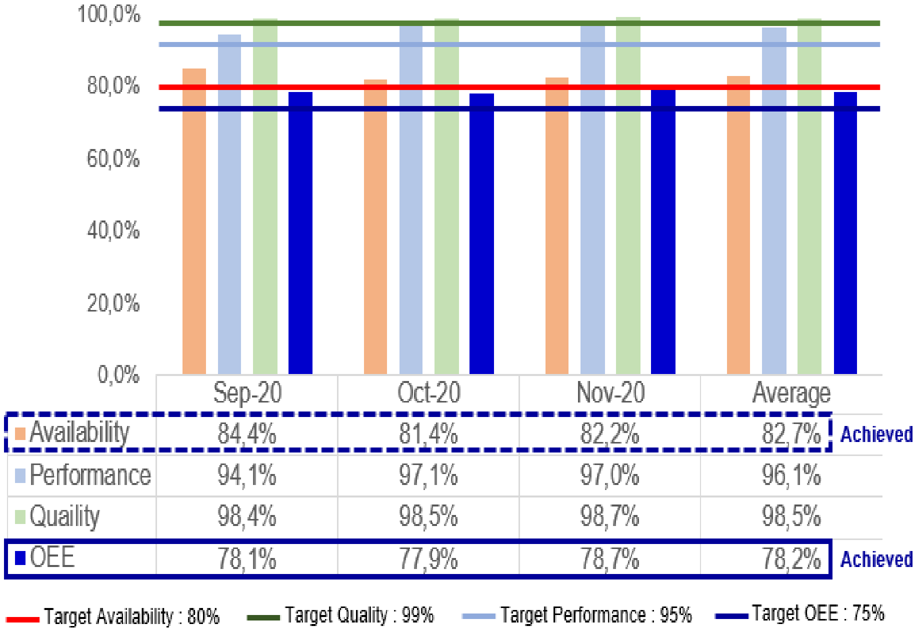


Figure 8 Gantt chart dies change over (after SMED)

Next is to recalculate the OEE value after improvement. The data in Figure 9 below explains that the actual average OEE value of the 800T Line A6 stamping machine for the period September - November 2020 has increased by 20.2% from the previous 62.4% to 78.2%, for the availability value increased from 70.9% to 82.7%.



To prove whether the above improvement ideas have an effect on increasing OEE, the researchers conducted statistical tests. To find out this, OEE data was collected before and after the improvement as much as 30 times. First, the OEE data was tested for normality and then analyzed 2 sample t-tests using Minitab software. The results of normality testing can be seen in table 7 below.

Table 7 Normality test result (before and after improvement)

Condition	Data Qty.	Average	P-Value	Distribution
Before improvement	30	62.40	> 0.05	Normal
After improvement	30	78.16	> 0.05	Normal

The results of the analysis of 2 sample t-tests using Minitab software show that the value of P - value < 0.05 and the value of T-value (count) > T-table. This shows that H1 is accepted, meaning that all improvements made to reduce setup time (dies change over) have a significant direct impact on increasing the value of OEE (Overall Equipment Effectiveness). In detail, the results above can be explained in table 8 below.

Table 8 Result of 2 sample t-test (before and after improvement)

Condition	Average	Deviation std.	P-Value	t-tabel	t-hitung
Before improvement	62.40	4.11	< 0.05	1.699	16.73
After improvement	78.16	3.12			

Control

After the improvement activities are carried out and get positive results, then the next step is to maintain these results and strive to improve the results that have been achieved well than before. Figure 10 below is an example of this stage, namely making a control chart of the OEE value of the 800T stamping machine at PT XYZ.

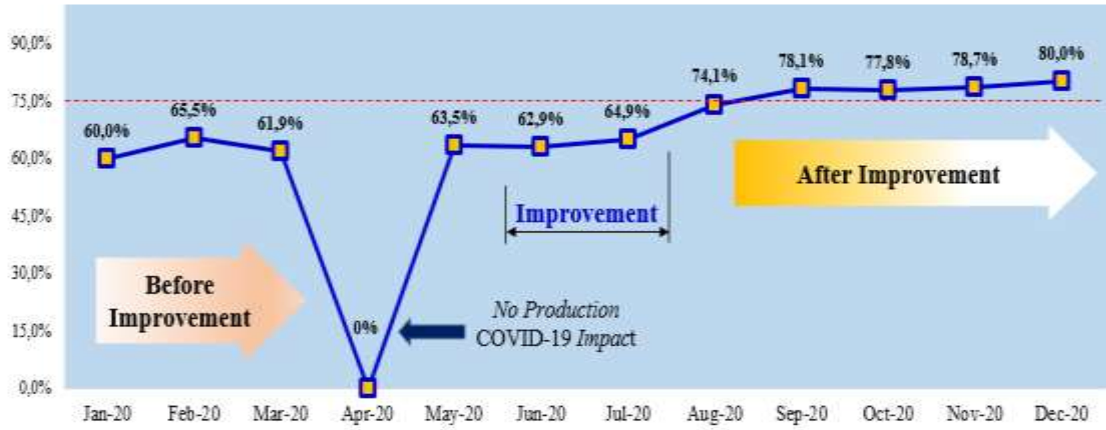


Figure 10 Availability and OEE value after improvement

DISCUSSION

This research was conducted at PT XYZ, which is one of the companies that supply stamping components for automotive car makers in Indonesia, which is located in Kawarang, West Java. The decline in production due to the Covid 19 pandemic has made all companies generally adopt a cost reduction policy, including PT XYZ. Reducing losses and increasing the OEE value in the stamping process is one of the activities to support this policy. The strategy used is to integrate the DMAIC framework with the SMED implementation in the set up process. With this integration, the OEE value of the stamping machine increased by 15.8%, from 62.4% to 78.2% as a result of the decrease in setup time (dies change over) by 35% or from 17.9 minutes to 11.6 minutes.

The results of this study are almost the same as that conducted by [20] Narses (2013) also on the 800T stamping machine. The difference is [20] Narses (2013) combines SMED with KAIZEN not with DMAIC framework. From the results of the research, with this integration, the OEE value of the stamping machine increased by 14.18%, from 39.32% to 53.50%. [21] Farida, et al (2018) also found that by reducing speed losses on the 2A stamping machine, the OEE value increased from 62% to 70%. Likewise, research conducted by [10] Agung (2019) revealed that the implementation of the SMED and 5S methods can reduce setup time by up to 18%. The use of DMAIC as a framework has also been carried out in various other studies, [19] M.S Hervian., & Soekardi, C. (2015) stated that OEE increased from 49.05% to 64.05% through the implementation of the SMED method and DMAIC as a framework but applied to different machines not a stamping machine.

The focus of this research is actually to increase the time availability (Availability) of the 800T stamping machine, where previously it was only 70.9% but by applying the SMED method it increased to 82.7%. Because the OEE value has a positive correlation with the availability value according to [22] Prabowo et al. (2018); [7] Prabowo (2019) so if the availability goes up, the OEE value will also increase. As a comparison, research conducted by [3] Jaqin[1], et al (2020) also indicates that the increase in the OEE value on progressive stamping machines from 60.7% to 65.3% is due to the increase in the machine's Availability value from 63.3% to 67.8%.

CONCLUSION

The Indonesian automotive industry is one of the worst affected by the COVID-19 pandemic. The average production has decreased by more than 50%. It takes a variety of strategic efforts to overcome this problem, especially in relation to a more efficient and effective production time. This research proves one of the strategies that have succeeded in reducing the Dies set-up time and at the same time increasing OEE. Namely, with the integration of the DMAIC framework and the SMED method. This integration has succeeded in reducing the set-up time of the dies which has an impact on increasing availability ratio. With increasing availability ratio, the OEE value also increases.

REFERENCES

1. Gaikindo. (2020). https://www.gaikindo.or.id/indonesian-automobile-industry-data/
2. Rozak, A., Jaqin, C. and Hasbullah, H. 2020. Increasing overall equipment effectiveness in automotive company using DMAIC and FMEA method, Journal Européen des Systèmes Automatisés, Vol. 53, No.1, 55-60.
3. Jaqin[1], C., Rozak, A. and Purba, H. H. 2020. Case Study in Increasing Overall Equipment Effectiveness on Progressive Press Machine Using Plan-do-check-act Cycle, International Journal of Engineering, Vol. 33, No. 11, 2245-2251.
4. Ahuja, I.P.S. and Khamba, J.S. (2008), Total productive maintenance: literature review and directions. International Journal of Quality & Reliability Management. Vol. 25 No. 7, pp. 709-756. https://doi.org/10.1108/02656710810890890.
5. Ahuja, I.P.S. and Khamba, J.S. (2009). Investigation

of manufacturing performance achievements through strategic total productive maintenance initiatives. International Journal of Productivity and Quality Management. Vo.4 issue 2. https://doi.org/10.1504/IJPQM.2009.023184.

6. Prabowo, H.A, Farida., Indar, D. 2015. Improving the work effectiveness with overall equipment effectiveness as the basis for optimizing production. Jurnal PASTI Volume IX No.3, 286-299.
7. Prabowo, H.A. 2019. Total productive maintenance (TPM) implementation based on lean manufacturing tools. Kulliyah of Engineering, International Islamic University Malaysia.
8. Costa, T., Silva, F.J.G., Ferreira, P. L. 2017. Improve the extrusion process in tire production using Six Sigma methodology. Procedia Manufacturing, 13: 1104-1111.
9. Hasibuan, S. and Dzikrillah, N. 2018. Supply chain performance measurement and improvement for Indonesia chemical industry using SCOR and DMAIC method, Saudi Journal of Engineering and Technology, Vol. 3, 146-155.
10. Agung, D., & Hasbullah, H. 2019. Reducing The Product Changeover Time Using SMED & 5S Method In The Injection Molding Industry". SINERGI. Vol. 23, No. 3, 199-212.
11. Rozak, A., Shadrina, A., and Rimawan, E. 2019. Kaizen in world class automotive company with reduction of six big losses in cylinder block machining line in Indonesia". International Journal of Innovative Science and Research Technology, 4 (7), 339-344.
12. Prabowo, H.A., Adesta, E.Y.T. 2019. A Study of Total Productive Maintenance (TPM) and Lean Manufacturing Tools and Their Impact on Manufacturing Performance. International Journal of Recent Technology and Engineering (IJRTE). Vol. 7 issue 6S. pp. 39-43.
13. Mardono., Doto., Rohimah, A., & Rimawan, E. 2018. Six Big Losses Approach and Kaizen Philosophy Implementation to Improve Overall Equipment Effectiveness (Case Study: PT ABC, A Reinforced Steel Manufacturer). International Journal of Innovative Science and Research Technology. Vol. 3, Issue 6.
14. Herry, A., Farida., and Lutfia, N.I. 2019. Performance Analysis of TPM Implementation through Overall Equipment Effectiveness (OEE) and Six Big Losses. International Conference on Design, Engineering and Computer Sciences.
15. Nakajima, S. (1988). Introduction to TPM, Cambridge: Productivity Press.
16. Nayak, D. M., Naidu, G. S., Shankar, V., Manager A. and Manager, A. 2013. Evaluation of OEE in A Continuous Process Industry on An Insulation Line In A Cable Manufacturing Unit. International Journal of Innovative Research in Science, Engineering and Technology, Vol.2, No.5, 1629-1634.
17. Kumar, A. and Ram M. 2013. Reliability Measures Improvement and Sensitivity Analysis of a Coal Handling Unit for Thermal Power Plant. International Journal of Engineering, Transaction C : Aspects, Vol. 26, No. 9, 1059-1066.
18. Kuiper, A., van Raalte, M., & Does, R. J. 2014. Quality Quandaries: Improving the Overall Equipment Effectiveness at a Pharmaceutical Company. Quality Engineering, 26(4), 478-483.
19. M.S Hervian., & Soekardi, C. 2015. Improving Productivity Based on Evaluation Score of Overall Equipment Effectiveness (OEE) Using DMAIC Approach on Blistering Machine. International Journal of Science and Research (IJSR). ISSN: 2319-7064.
20. Narses, A. 2013. Case Study: Production and OEE Improvement for an 800 tons Stamping Press. School of Innovation, Design And Engineering, Sweden: Malardalen University.
21. F.N. Arief and Z.F, Ikatrinasari. 2018. Perbaikan Waktu Setup Dengan Menggunakan Metode SMED Pada Mesin Filling Krim, Jurnal Ilmiah Teknik Industri, Vol.6 No.1, 1-8.