Reducing dandori processing time using the single minute exchange of die method in swaging areas in automotive rubber components company

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Abstract. *The automotive component company is engaged in the manufacture of automotive rubber components. Based on data obtained from field observations, it was found that the Dandori process on the swaging Nox machine, especially TA090 type, had the highest downtime compared to another component. Based on these problems, research uses the Single Minute Exchange of Die (SMED) method to reduce Dandori downtime in the TA090 swaging process. The SMED method was carried out in three stages: 1. identify internal and external setup, 2. Converting internal to external setup, and 3. Streamlining aspects of operation. In addition, it also used data processing tools, namely SMART, fishbone, and 5W+1H as support to solve this problem. Improvements were made by converting internal work elements into external ones and streamlining aspects of operation by improving on man, method, and machine/tools categories. The result of these improvements was a decrease in downtime of 39 minutes 48 seconds and the improvement efficiency achieved was 81.2%.*

Keywords: automotive component, dandori, SMED, set-up

1. Introduction

Industrial development is entering a new era where companies are required to improve their performance to be able to compete in the global market (Fathia et al., 2016). One of them is the automotive manufacturing industry which produces automotive components. The condition of business competition in the automotive manufacturing sector in the global market is getting tighter (Ibrahim et al., 2020). In 2022, world car sales will continue to increase, dominated by the Chinese market with 27 million units. Meanwhile, Indonesia itself is in 10th place for car manufacturers in 2022 (Pratama et al., 2019; Suryaprakash et al., 2020).

The Automotive component company is engaged in the manufacture of automotive rubber components. This company has 5 manufacturing plants including a mixing plant, a hose (Tango) plant, a molded (V3) plant, a Bushing Torque Rod (BTR) plant, and a Rubber Vibration Insulator (RVI) plant. Products produced include automotive components, namely torque rod assy, bush rod assy, molded rubber parts, rubber bonded with metal parts, function hoses, and rubber vibration insulator parts. Field studies conducted in the Engineering Department, this research include the development of new products and inter-departmental tooling.

The RVI plant is a place for manufacturing and assembling rubber vibration insulator parts for truck vehicles. Based on the manufacturing and assembly processes, the process at the RVI Plant uses machines such as Injection, Painting, Bonding, Wire Brush, and Press Swaging. Dandori is a term that comes from Japan, it means changing models. Manufacturing companies often encounter the term Dandori. The Dandori process starts from production planning until the product is declared to have passed production. Dies Dandori is an activity of changing the type of dies on a press machine. Based on data obtained from field observations on three swaging machines, Nox, Takoton 1 and takoton 2. It was found that the Dandori process on swaging Nox had the highest downtime compared to swaging Takoton 1 and Takoton 2, namely 2129 minutes during the last 2 months in 2022. In the swaging process of Nox, it was also found that the TA090 swaging process had higher downtime compared to another type of products, NA 140 and TA 101, namely 833 minutes.

Based on these problems, we need a proven improvement methode to reduce Dandori downtime on Swaging Nox machine, especially for TA090 type of product.

Research (Hien N. Nguyen & Nhan H. Huynh, 2019) uses Single Minute Exchange of Dies (SMED) to reduce setup time in the assembly manufacturing industry. SMED has succeeded in reducing production losses in Industry A (Fathia et al., 2016). SMED is an improvement method from Lean Manufacturing that is used to speed up setup time or production changes (Ikatrinasari et al., 2018) (Sahin & Kologlu, 2022). From one type of product to another type of product (Setiawan & Hasibuan, 2021). The goal to be achieved from implementing the SMED method is to try to speed up the setup time (Supriyati et al., 2021; Arifin, 2018). Most companies spend more than 20 percent of their production time for changeover (Azwir et al., 2021). The basic concept of SMED is to reduce machine setup time, which significantly directly reduce the batch size for parts (Setyawan, 2019).This makes manufacturing companies able to produce according to customer demand (Runtuk & Sembiring, 2021). This study aims to reduce the time in the TA090 Dandori process on swaging Nox machine using the Single Minute Exchange of Die (SMED).

2. Methods

Setup operations consist of two fundamentally different types of operations, namely internal setup and external setup (Nurrizky et al., 2021). Internal (Inside Exchange of Die or IED) is an activity that can only be carried out when the machine is stopped such as installing or removing dies. The second type of operation, namely external setup (Outside Exchange of Die or OED), is an activity that can be performed while the machine is operating, such as transferring old prints to storage, preparing bolts for operations and so on. The following are the basic steps and conceptual stages of the SMED method (Sousa et al., 2018; Silva et al., 2021).

This research was conducted in an automotive company on the TA090 swaging process. This was done because swaging TA090 had the highest downtime. Primary data is obtained by measuring time directly with a stopwatch. Secondary data obtained from company reports. This study uses systematic stages so as not to deviate from the target. The following stages of problem solving can be seen in Figure 1.

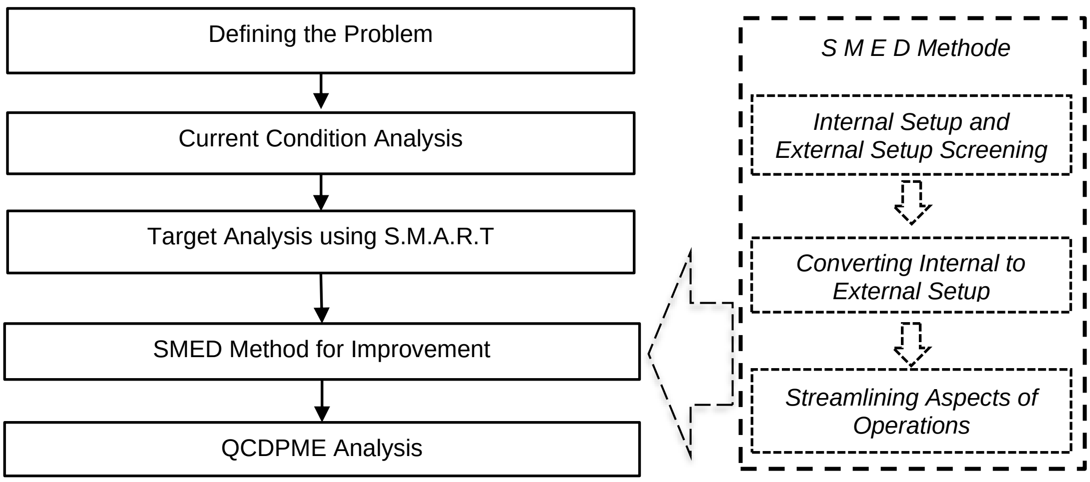

Figure 1 Study Framework

3. Result and Discussion

Defining the Problem

When carrying out the dies Dandori process at the RVI Plant, high downtime data was found, so it is necessary to secure Dandori activities. Observation time was carried out during shift 1 working hours. Data collection for Dandori processing time was carried out in line swaging. The following set-up time data can be seen in Table 1.

Table 1 Downtime Data of Dandori Plant RVI

Machine	Downtime (minute)		
	February	March	Total
Swaging Nox	1016	1113	2129
Swaging Tokoton 1	145	180	325
Swaging Tokoton 2	192	204	396

After obtaining Dandori downtime data, the next process is to make a pareto diagram which aims to select the production line area to be repaired to reduce Dandori downtime. Figure 2 is a pareto diagram which is the basis for improvement based on the highest downtime to select the production line area to be improved.

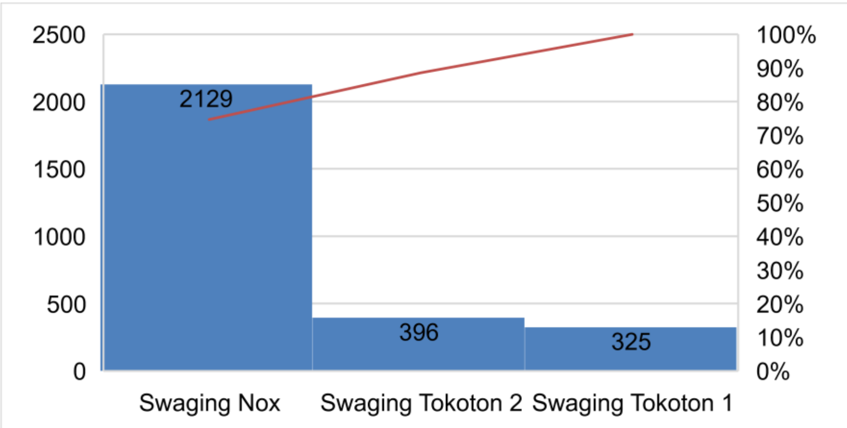

Figure 2 Dandori Downtime Pareto Diagram

Based on Figure 2, it can be seen that the swaging nox production line area has the highest downtime than swaging tokoton 1 and swaging tokoton 2, which is 2129 minutes. Based on the high downtime, it is necessary to analyze the problems that occur in the Dandori process in the nox swaging line production area. Swaging Nox machine produces several types of products, namely TA090, NA140, TA101. The Dandori data that was analyzed was in February 2022 and March 2022 as Dandori data samples. The following Dandori data for February can be seen in Table 2 and Dandori data for March can be seen in Table 3.

Table 2 February Monthly Data of Dandori Time and Frequency

Machine	Dies	February 2022		
		Frequency	Time (Minute)	Total Time (Minute)
Swaging Nox	TA090	8	49	392
	NA140	8	48	384
	TA101	5	48	240
Total		21		1016

Table 3 March Monthly data of Dandori Time and Frequency

Machine	Dies	March 2022		
		Frequency	Time (Minute)	Total Time (Minute)
Swaging Nox	TA090	9	49	441
	NA140	9	48	432
	TA101	5	48	240
Total		23		1113

Current Condition Analysis

Data collection of TA090 swaging Dandori time using a stopwatch tool directly taken on the nox swaging machine. Time is taken by the Dandori operator based on each work element. The following is the processing time data for Dandori work elements and the Dandori processing time can be seen in Table 4.

Table 4 Dandori Processing Time Data

No	Activity	Operation Times (s)	Holding Times (s)	Times (second) 1	2	3	4	5	Averages
1	Prepare tools	131		130	135	127	137	125	130,8
2	Loosen the clamping bolt on the lower plate	142		147	140	145	138	142	142,4
3	Loosen the clamping bolt on the upper plate	153		152	156	155	149	153	153
4	Remove the clamping on the lower plate	51		50	53	57	45	51	51,2
5	Remove the clamping on the upper plate	53		53	55	45	61	50	52,8
6	Move up the sliders	42		37	46	43	35	49	42
7	Take the hand forklift		44	44	45	36	49	46	44
8	Set the hand forklift height according to the machine base		64	65	63	69	60	61	63,6
9	Transferring dies from machine base to hand forklift		46	45	49	42	53	41	46
10	Bring dies to storage dies		116	115	120	117	111	118	116,2
11	Put the dies into storage dies		53	55	56	51	53	50	53
12	Looking for and taking the dies to be used		187	186	184	191	182	185	185,6
13	Carrying dies from storage dies to the machine		99	98	100	112	93	90	98,6
14	Set the hand forklift fork parallel to the engine		57	58	60	55	62	52	57,4
15	Transferring dies from hand forklift to machine base		52	53	50	48	53	55	51,8
16	Positioning the die with base and clamping sliders		34	32	36	39	31	30	33,6
17	Setting the machine slider sticks to the die	46		49	45	42	44	50	46
18	Install the clamping on the lower plate	54		51	59	55	53	51	53,8
19	Install the clamping on the upper plate	55		54	58	51	57	53	54,6
20	Tighten the clamping bolts on the lower plate	148		142	149	151	153	147	148,4
21	Tighten the clamping bolts on the upper plate	157		155	162	159	152	157	157
22	Set the moving setting calibration distance high pressure dies	213		210	219	211	216	210	213,2
23	Lubricate the dies	110		110	119	105	109	105	109,6
24	Conduct an initial trial (minimum 5 cycles)	108		106	109	110	112	104	108,2
25	QC verification	233		230	231	239	230	235	233
26	Looking for or calling the machine's manpower	152		150	157	155	147	152	152,2
27	Improving manpower working conditions	182		185	183	177	185	181	182,2
28	Returns the hand forklift to the original area		123	126	120	119	126	124	123
29	Return tools	84		88	78	83	89	81	83,8
Total		1983	875	2846	2902	2862	2848	2823	2856,2

Analysis of working conditions that occur, starts from the separation between each setup category. Dandori work elements have not been distinguished between internal and external setups. External activities are still carried out when the machine is off. There are advance activities, namely preparing tools, taking hand forklift, looking for and taking dies.

Target Analysis

The S.M.A.R.T method is used as a tool to analyze the target to be selected. The following SMART analysis results can be seen in Table 5.

Table 5 Analysis of S.M.A.R.T

Methods	Analysis
Specific	Reduced Dandori time on the TA090 Swaging die
Measurable	Dandori time down 47%
Achievable	Improvement Team
Reliable	Targets can be achieved using the S.M.A.R.T method
Time-Base	February – May 2022

Converting Internal to External Setup

This stage is carried out to find ways to change these activities into external activities. Table 6 is the change in activity from an internal setup to an external setup.

Table 6 Dandori time after converting internal to external setup

No	Activity Name	Average Time (s)		Sampling Time (s)				
		Internal	External	1	2	3	4	5
Preparation Process								
1	Prepare tools		131	130	135	127	137	125
2	Take the hand forklift		44	44	45	36	49	46
3	Looking for and taking the dies to be used		186	186	184	191	182	185
4	Lubricate the dies		110	110	119	105	109	105
5	Carrying dies from storage dies to the machine		99	98	100	112	93	90
6	Set the hand forklift fork parallel to the engine		57	58	60	55	62	52
Dies Down								
7	Loosen the clamping bolt on the lower plate	142		147	140	145	138	142
8	Loosen the clamping bolt on the upper plate	153		152	156	155	149	153
9	Remove the clamping on the lower plate	51		50	53	57	45	51
10	Remove the clamping on the upper plate	53		53	55	45	61	50
11	Move up the sliders	42		37	46	43	35	49
12	Move the dies down while raising the dies to be used	90		90	91	92	87	89
Dies Up								
13	Positioning the die with base and clamping sliders	34		32	36	39	31	30
14	Setting the machine slider sticks to the die	46		49	45	42	44	50
15	Install the clamping on the lower plate	54		51	59	55	57	53
16	Install the clamping on the upper plate	55		142	149	151	153	147
17	Tighten the clamping bolts on the lower plate	148		155	162	159	152	157
18	Tighten the clamping bolts on the upper plate	157		155	162	159	152	157
19	Tighten the clamping bolts on the upper plate	231		210	219	211	216	210

Streamlining Aspects of Operations

At this stage, the process of streamlining or improving each work process in the internal setup process is carried out. Table 7 is the result of streamlining work processes

Table 7 Dandory time after streamlining aspects of operations

No	Activity Name	Average Time (s)		Sampling Time (s)				
		Internal	External	1	2	3	4	5
Preparation Process								
1	Prepare tools		131	130	135	127	137	125
2	Take the dies to be used		35	35	38	34	33	35
3	Carrying dies from storage dies to the machine		55	56	51	54	59	55
4	Lubricate the dies		25	28	20	27	27	23
Dies Down								
5	Loosen the bolt on the punch	40		37	44	42	40	39
6	Removing the bolts and placing the punch on the work table	93		88	93	97	95	92

No	Activity Name	Average Time (s) Internal	Average Time (s) External	Sampling Time (s) 1	2	3	4	5
7	Remove the die to be replaced on the base plate	18		15	20	18	22	15
Dies Up								
8	Installing the punch and bolts on the punch on the upper plate	54		51	59	55	53	51
9	Tighten the punch bolt	55		54	58	51	57	53
10	Install the die that will be used on the base plate	148		142	149	151	153	147
11	Conduct an initial trial (minimum 5 cycles)	144		142	145	143	143	147
12	QC verification							
5R Process								
13	Improving operator working conditions		122	125	124	128	122	126
14	Carrying dies from workbench to storage		68	70	66	68	67	69
15	Put the dies into storage dies		33	36	34	33	30	32
16	Return tools		84	88	79	83	89	81
Total Time (seconds)		552	553					

Cause and Effect Analysis

The fishbone diagram method is used to find out the root cause of all the data that has been analyzed. Fishbone diagram is structured diagram to visualized root caused of the problem. The problem or effect is displayed at the head or mouth of the fish. Possible contributing causes are listed on the smaller "bones" under various cause categories. This diagram was filled by involving production engineering team in brainstorming activity. The analysis is carried out by considering human factors, methods, machines, materials, money and the environment. However, the analysis is carried out only by human factors, methods and machines. This was done according to the problem. Figure 3 is the root of the problem based on the Fishbone diagram.

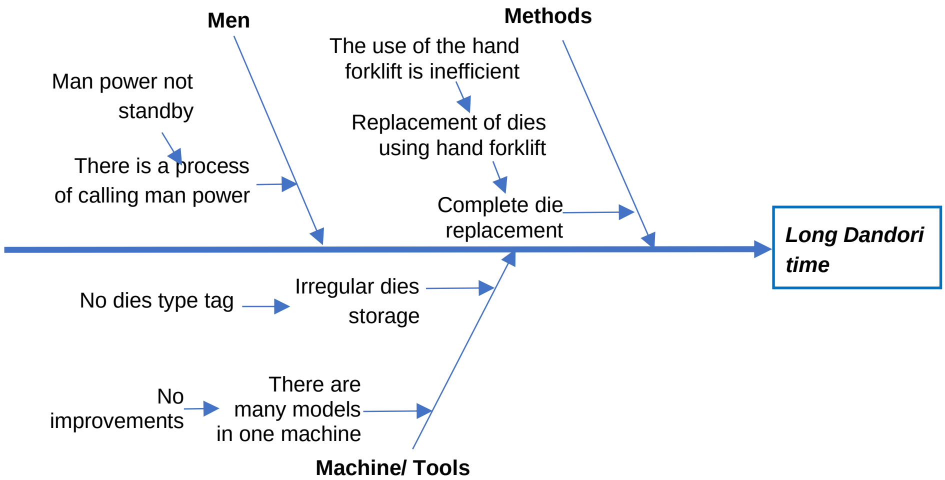

Figure 3 Fishbone Diagram

Improvement Process Planning

After obtaining the roots of the problem that occurs in the method, man, and tools factors. Then do the appropriate improvements from the root of the problem. Before carrying out these improvement, a countermeasures plan is made by answering what, why, who, when, where, and why (5W+1H) on the roots of the problem found on previous stage. Table 8 are improvements plan with 5W+1H.

Table 8 Analysis of 5W+1H

Factor	What	Why	How	Who	When	Where
Machine	Irregular dies storage	No dies type tag	Adding dies type tags on the dies storage rack	Team Improvement	May 2022	Area Swaging
	There are many models in one machine	No improvements	Make modifications to the dies so that they can be set without replacement	Team Improvement	May 2023	Area Swaging
Method	Dandori used the hand forklift	Setting up a hand lift that takes time	Remove dies after improvement	Team Improvement	May 2024	Area Swaging
Man	There is a process of calling man power	Man power not standby	Man power cannot leave the process when the Dandori is in progress	Team Improvement	May 2025	Area Swaging

Improvement Implementation

After the improvement plan is carried out, it is implemented. Improvements made include making tag type dies, making new model TA090 dies and changing the method of taking dies. After the implementation of improvements then obtained several changes in processing time. The following processing time after repair can be seen in Table 9.

Table 9 Process After Improvement

No	Activity Name	Average Time (s)		Sampling Time (s)				
		Internal	External	1	2	3	4	5
Preparation Process								
1	Prepare tools		131	130	135	127	137	125
2	Take the dies to be used		35	35	38	34	33	35
3	Carrying dies from storage dies to the machine		55	56	51	54	59	55
4	Lubricate the dies		25	28	20	27	27	23
Dies Down								
5	Loosen the bolt on the punch	40		37	44	42	40	39
6	Removing the bolts and placing the punch on the work table	93		88	93	97	95	92
7	Remove the die to be replaced on the base plate	18		15	20	18	22	15
Dies Up								
8	Installing the punch and bolts on the punch on the upper plate	54		51	59	55	53	51
9	Tighten the punch bolt	55		54	58	51	57	53
10	Install the die that will be used on the base plate	148		142	149	151	153	147
11 12	Conduct an initial trial (minimum 5 cycles) QC verification	144		142	145	143	143	147
5R Process								
13	Improving operator working conditions		122	125	124	128	122	126
14	Carrying dies from workbench to storage		68	70	66	68	67	69
15	Put the dies into storage dies		33	36	34	33	30	32
16	Return tools		84	88	79	83	89	81
Total		552	553					

Aspects Analysis of QCDSMPE

Some of the improvements that have been obtained are then analyzed for the impact of the improvements. The impact of the improvements had been discussed with the production engineering team on quality, cost, delivery, morale, productivity, and environmental aspects (QCDSMPE). The improvement results have a significant effect on the company's improvement. The following is an analysis regarding the potential impact of QCDSMPE, which can be seen in Table 10.

Table 10 Analysis of QCDSMPE Aspects

No	Parameter	Impact
1	Quality	The quality of the TA090 product remains the same
2	Cost	Cost Savings from improvement amounted to IDR 362,344,320/year

No	Parameter	Impact
3	Delivery	Reducing Dandori time will improve delivery time of the products that will be sent to consumers
4	Safety	Eliminating the use of the hand forklift by the operator when collecting dies will reduce the risk of contact with the hand forklift. So the potential for accidents is small
5	Morale	A simple and practical work environment will increase operator morale
6	Productivity	The productivity of line swaging increased because the improvement of tools and methods using SMED reduced the Dandori processing time by 81% from 49 minutes to 10 minutes so that production results could increase. Productivity of line swaging increased by 2,496 pcs/month.
7	Environment	The results of improved tools and methods will make it easier for operators to carry out the Dandori process and make the work environment tidier and easier to clean

Based on QCDSM Analysis and production data, productivity has the most significant effect. After improvements, productivity of line swaging increased by 2,496 pcs/month after converting 39 minutes 48 seconds of time-wasting Dandori process to profitable productive time.

Implementation of Lean Principle such as SMED by converting internal activity into external activity as well as using pneumatic power tools and other tools at forging line helps setup time reduced by 40%. The previous setup time was 90 minutes is reduced to 54 minutes (Talekar et al. 2019).

4. Conclution and Suggestion

Based on the problem analysis and corrective actions using the SMED method, it can be concluded that improvements in Dandori process activities can reduce Dandori time. The initial time confinement was 48 minutes 55 seconds (2935 seconds) reduce to 9 minutes 12 seconds (552 seconds). The total time is reduced by 39 minutes 48 seconds (2383 seconds) so that the production line stop time is reduced by 81.2%. The results of this study contribute to the company where company get efficient production time and reduce process losses. Further research can be carried out by linking other movements so that the production process time can be optimally reduced.

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