IOP Conf. Series: Materials Science and Engineering **453** (2018) 012033 doi:10.1088/1757-899X/453/1/012033

Setup Reduction in Injection Moulding Machine Type JT220RAD By Applying Single Minutes Exchange of Die (SMED)

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Abstract. Injection Molding Machine Type JT220RAD is one of the machines used in the production process of fuel pump module variant 860L Gasoline, 800L Gasoline and D87A Set Plate in PT ANI. The machine is having problems with too much setup time in 99.93 minutes per variant turnover. Therefore, this study was made to reduce the setup time of injection molding machine type JT220RAD by 35%. The researchers applied the SMED (Single Minute Exchange of Die) method with 5 steps, identifying setup activities and measuring setup time, separating internal and external setup activities, converting internal setup to external, performing kaizen with streamlining setup process, evaluating kaizen done. The result of this SMED implementation is decrease setup time 37.66% (38 minutes per variant turnover) and increase productivity 3.17%.

Keywords: setup time, SMED, reduction, productivity

1. Introduction

Lean is known as a solution for identifying and eliminating waste, reducing non-value-added processes and enhancing value-added processes [1]. There are 7 types of waste identified by Shigeo Singo [2] namely overproduction, defects, excess inventory, process mismatch, excessive movement, waiting, and unnecessary movement. There are 12 techniques that can be implemented to create a lean manufacturing process [3] and one of them is Single Minute Exchange of Die (SMED) where this technique can reduce machine and equipment setup time up to single minute (<10 minutes) so the company can use of his time for more value-added work [4,5]. Setup time or changeover is the time required to replace the machine from the last part in a production lot to the first part of the next lot [6,7]. Setup time includes measurement and fine tuning. The setup time has a unit of minutes or hours, so it does not need to be multiplied by the number of people.

The application of SMED methodology in various industries has been widely studied. The practical implementation of SMED in shortening the changeover time in one shaft manufacturing industry 11.9% and increasing annual production 0.48% [8]. The applicability of SMED techniques was also tested for 8ton notching machine press changeover at the motor plant which led to reduction of 27.5% in the machine downtime without any significant investment [9]. Evaluation of SMED implementation in printing houses can reduce up to 73% of total control time [10]. In this journal, researchers will prove that SMED can decrease the total setup time of an injection molding machine between 30 - 50% according to the theory presented by Shigeo Singo [6] and result in an increase in monthly production capacity.

PT. ANI is a company engaged in the automotive manufacturing industry with a concentration on automotive control components on the vehicle. One of its products is fuel pump module for variant of

860L Gasoline, 800L Gasoline and D87aSet Plate. Currently the injection molding machine JT220RAD used to produce the fuel pump module requires an average setup time of 99.93 minutes / variant turnoverand exceeds the target set by the company (70 minutes / variant turnover).This research was conducted to shorten the setup time of injection molding JT220RAD machine by 35% on average during 2017 and increase productivity by 3%. To achieve the purpose of this research, SMED method will be applied consisting of 5 steps [11,12,13]. These steps are the identification and measuringthe setup activities, separate internal and external setup, conversion of internal to external setup, streamlining the setup process by waste identification and kaizen implementation, and evaluation of the impact of kaizen done.

2. Research Methodology

This research is conducted in five main stages in accordance with SMED methodology as follows:

1. Documenting and recording the activities in the process of setup or change of dies on the JT220RAD machine, the supporting tools used are stopwatch, stationery (pen) and paper.
2. Observation and documentation of the setup steps of the current state. (Separating internal and external activities).
3. Convert the internal setup to an external setup.
4. Do kaizen to accelerate lead time of internal setup
5. Evaluation of kaizen done

Data collection is done through direct observation and video recording to examine any value-added and non-value-added activities

3. Result and Discussion

3.1. Identification and measuring the setup activities

The recording of each activity is the standard of the setup process prior to the implementation of the SMED method, and the results of the records are arranged in Table 1.

Table 1. Standard Setup Time Injection Moulding JT220RA Machine

No.	Activities	Time(s)
1	Purging cleaner	324
2	Spray mold to protect corrosive on dies A & B	25
3	Close upper dies meeting with lower dies	6
4	Open theclamp on Dies A & B+upper	6
5	Turn offhot runner	4
6	Open MTC tap and release the water on cooling dies	123
7	Take off the hydraulic hose and fill in the water to lower dies A&B	98
8	Take off the hydraulic hose and water in upper dies	38
9	Take off the air hose atlower dies A & B	44
10	Take off the air hose and hot runner cable onupper dies	52
11	Detach the connector on the socket table and Dies A & B + upper	294
12	Attach the jumper to the socket table	62
13	Remove the upper dies from station platen machine	19
14	Takes 2 empty trolleys for old dies	175
15	Pick up and operate crane hoist	41
16	Put hook hoist on the dies and trim the cable core on dies A	110
17	Operate hoist (lift and drop dies A to empty cart)	160

18	Clean table A with cleaning cloth	23

Table 1 [cont.]. Standard Setup Time Injection Moulding JT220RAD Machine

No.	Activities	Time(s)
19	Rotate the table until the B dies forward	10
20	Put the hook hoist on the dies and trim the core cable on the B and upper dies	121
21	Operate the house	179
22	Clean table B and stationery platen with cleaning cloth	45
23	Deliver 2 trolleys containing dies to dies station	399
24	Move the dies A from the trolley to the pallet with a hoist	119
25	Move the dies B + upper from trolley to the pallet with a hoist	142
26	Pick up and move new Dies A from pallet to trolley with hoist	130
27	Pick up and move the new Dies B + upper from pallet to cart with hoist	160
28	Bringing a new A dies from Dies Station to Engine	186
29	Bring a new B + upper dies from Dies Station to Engine	203
30	Put the Hook Hoist and move the new Dies B + upper from the trolley to the B table of the engine	202
31	Centre new Dies B+upper and detach the hook hoist	61
32	Clamp lower dies B on the table B	2
33	Input data program dies on monitor	10
34	Turn the table until A is forwarding	9
35	Attach the hook hoist and move the new Dies A from the trolley to table A of the engine	166
36	Centre new Dies A on the table and detach Hook Hoist	50
37	Clamp lower Dies A on table A	2
38	Unclamp lower Dies B and centre upper dies with stationery platen	63
39	Clamp lower Dies B & Upper Dies	4
40	Turn dies A toward upper dies	10
41	Unclamp lower Dies A and centrewith upper dies	66
42	Clamp lower Dies A and plug the hot runner cable into the upper dies	20
43	Turn on the hot runner	10
44	Remove the jumper on the socket table	54
45	Install the connector on the socket table and dies B&A + upper	316
46	Put the wind hose on the Dies B & A+upper	53
47	Put the hydraulic hose and water on upper dies	43
48	Attach the hydraulic hose and water on lower Dies B & A	120
49	Close water faucet and water input as cooling system on dies	131
50	Adjust the MTC parameter according to the type of running product	18
51	Check Abnormality (hose,connector, cooler, dies profile, etc.)	191
52	Cleaning the mould to protect from corrosive ondies profile	241
53	Returns 2 empty trolleys to dies station	172
54	Return Crane hosetothe hose corner	35
55	Purging newmaterial	301
56	Trial runs	348
TOTAL SETUP TIME (sec)		5996 [99.93 min]

The researchers also took machine cycle time data for the gasoline 860L type as amount 60.2 minutes and production hours as average 6.7 hours/shift.

3.2. Separating Internal and External Activities

At this stage the researcher separates the internal external type setup as shown in Table 2. The internal activity is the activity in the state of the engine stops while the external activity is the activity in a machine operating state [14].

Table 2. Injection Molding Setup Time Separation

No.	Activities	Time (s)	Internal/ External
1	Purging cleaner	324	External
2	Spray mold to protect corrosive on dies A & B	25	Internal
3	Close upper dies meeting with lower dies	6	Internal
4	Open theclamp on Dies A & B+upper	6	Internal
5	Turn offhot runner	4	Internal
6	Open MTC tap and release the water on cooling dies	123	Internal
7	Take off the hydraulic hose and fill in the water to lower dies A&B	98	Internal
8	Take off the hydraulic hose and water in upper dies	38	Internal
9	Take off the air hose atlower dies A & B	44	Internal
10	Take off the air hose and hot runner cable onupper dies	52	Internal
11	Detach the connector on the socket table and Dies A & B + upper	294	Internal
12	Attach the jumper to the socket table	62	Internal
13	Remove the upper dies from station platen machine	19	Internal
14	Takes 2 empty trolleys for old dies	175	Internal
15	Pick up and operate crane hoist	41	Internal
16	Put hook hoist on the dies and trim the cable core on dies A	110	Internal
17	Operate hoist (lift and drop dies A to empty cart)	160	Internal
18	Clean table A with cleaning cloth	23	Internal
19	Rotate the table until the B dies forward	10	Internal
20	Put the hook hoist on the dies and trim the core cable on the B and upper dies	121	Internal
21	Operate the house	179	Internal
22	Clean table B and stationery platen with cleaning cloth	45	Internal
23	Deliver 2 trolleys containing dies to dies station	399	Internal
24	Move the dies A from the trolley to the pallet with a hoist	119	Internal
25	Move the dies B + upper from trolley to the pallet with a hoist	142	Internal
26	Pick up and move new Dies A from pallet to trolley with hoist	130	Internal
27	Pick up and move the new dies B + upper from pallet to cart	160	Internal
28	Bringing a new A dies from Dies Station to Engine	186	Internal
29	Bring a new B + upper dies from Dies Station to Engine	203	Internal
30	Put the Hook Hoist and move the new Dies B + upper from the trolley to the B table of the engine	202	Internal
31	Centre new Dies B+upper and detach the hook hoist	61	Internal
32	Clamp lower dies B on the table B	2	Internal
33	Input data program dies on monitor	10	Internal

34	Turn the table until A is forwarding	9	Internal

Table 2 (cont.). Injection Molding Setup Time Separation

No.	Activities	Time (s)	Internal/ External
35	Attach the hook hoist and move the new Dies A from the trolley to table A of the engine	166	Internal
36	Centrenew Dies A on the table and detach Hook Hoist	50	Internal
37	Clamp lower Dies A on table A	2	Internal
38	Unclamp lower Dies B and centre upper dies with stationery platen	63	Internal
39	Clamp lower Dies B & Upper Dies	4	Internal
40	Turn dies A toward upper dies	10	Internal
41	Unclamp lower Dies A and centrewith upper dies	66	Internal
42	Clamp lower dies A, plug the hot runner cable into the upper dies	20	Internal
43	Turn on the hot runner	10	Internal
44	Remove the jumper on the socket table	54	Internal
45	Install the connector on the socket table and dies B&A + upper	316	Internal
46	Put the wind hose on the Dies B & A+upper	53	Internal
47	Put the hydraulic hose and water on upper dies	43	Internal
48	Attach the hydraulic hose and water on lower dies B&A	120	Internal
49	Close water faucet and water input as cooling system on dies	131	Internal
50	Adjust the MTC parameter according to the type of running product	18	Internal
51	Check Abnormality (hose,connector, cooler, dies profile, slide core, ejector, rotary table and parameter)	191	Internal
52	Cleaning the mould to protect from corrosive on Dies Profile A & B+upper	241	Internal
53	Returns 2 empty trolleys to dies station	172	Internal
54	Return Crane hosetothe hose corner	35	Internal
55	Purging newmaterial	301	External
56	Trial runs	348	External
	TOTAL SETUP TIME	**5996**	99.93 min

3.3. Conversion on Internal to External Setup

At this stage an internal setup process analysis can be turned into external, reducing the lead time of setup time as described in table 3.This stage can decrease 28% engine lead time setup.

Table 3. Conversion Activities on Internal to External Setup

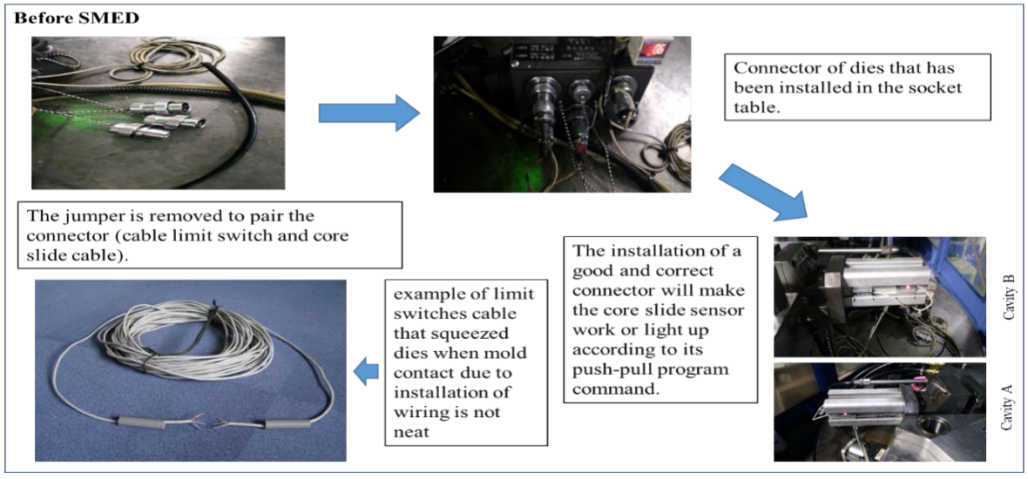
No.	Activities	Time (s)
14	Takes 2 empty trolleys for old dies	175
23	Deliver 2 trolleys containing dies to dies station	399
24	Move the dies A from the trolley to the pallet with a hoist	119
25	Move the dies B + upper from trolley to the pallet with a hoist	142
26	Pick up and move new Dies A from pallet to trolley with hoist	130
27	Pick up and move the new Dies B + upper from pallet to cart with Hoist	160
28	Bringing a new A dies from Dies Station to Engine	186
29	Bring a new B + upper dies from Dies Station to Engine	203
53	Returns 2 empty trolleys to dies station	172
	TOTAL SETUP TIME	1686 (28.12 min)

3.4. Streamlining the Setup Process

Stage 3 and stage 4 according to Shigeo Singo can be done simultaneously. If we make a scientific effort to examine how often the setup process is like an external setup, then the die time required for internal setup performed when the engine dies can usually be cut by about 30% -50% [6]. Table 4shows two internal activities selected for kaizen.Activities 11 and 45 show the longstanding discharging activity of the connector and often lead to the breaking of the limit switch cable and the core slide lower cable. The effect is that the slide sensor slides upside down and does not light up. If the wiring arrangement is not neat, it can also cause the connector of the cable limit switch and core slide cable will squeeze in the dies gap, so that when it used to produce part fuel pump module will cause product defects. To avoid this happening, researchers puts a connector on each dieso that the operator just simply pairs the connector on the socket table, without having to think about unloading the connector from the old dies to the new dies. Improvement of activity in terms of conditions before and after improvement is illustrated in Figure 1.

Table 4. Priority of Setup Activities That Need Kaizen

No.	Activities	Time (s)
11	Detach the connector on the socket table and Dies A & B + upper	294
45	Install the connector on the socket table and dies B&A + upper	316



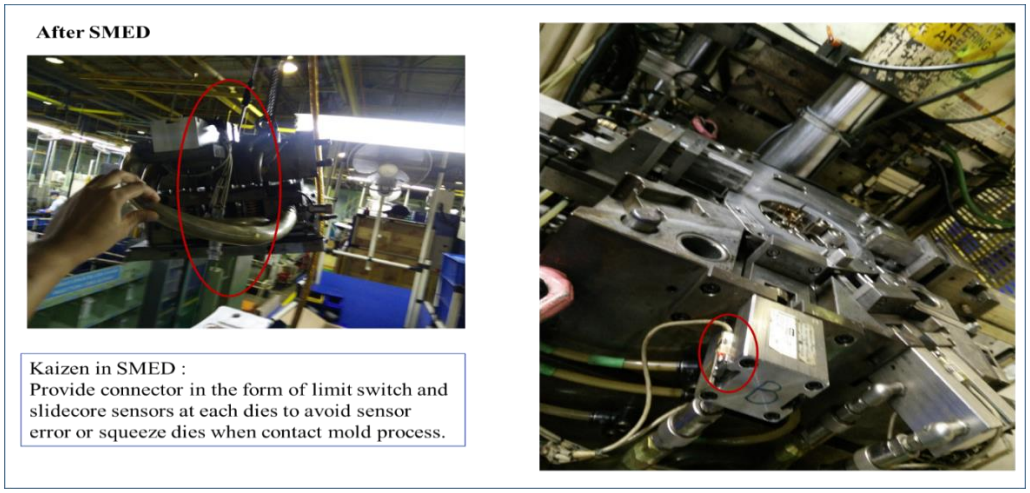


Figure 1. Before and After Condition of Kaizen Implementation

3.5. Evaluating the Impact of Kaizen Done

After the kaizen done, the researchers measured setup time for both internal activities and got the results in table 5.Based on stages 3 and 4, the total setup time reduced is:

Stage 3 + Stage 4 = 1686 sec + (610 – 38) sec
= **2258 second 38 minutes**

This 38 minutes or 37.6% reduction exceeds the 35% target set by the company.The next step is the researchers make workshop standardization based on the new setup time of 62.3 minutes.

Table 5. Measurement of Setup Time After Kaizen

No.	Activities	Before	After
11	Detach the connector on the socket table and Dies A & B + upper	294 sec	15 sec
45	Install the connector on the socket table and dies B&A + upper	316 sec	23 sec
	TOTAL	610 sec	38 sec

With a decrease in setup time there is an increase in production hours where the production hours play a role in determining the production capacity. It is known that working hours at PT. ANI is 480 minutes / shift with 400 minutes production hours / shift. While the cycle time fuel pump module 860L Gasoline is 60.2 seconds / pcs and the target / work order are 1200 pcs / day. If within 1 day there are 3 shifts, then the production time available is 1200 minutes.

Before SMED :

working time – setup time = production time
1200 minutes – 99, 93 minutes = 1100.07 minutes/day or 18, 33 hours/day

$$Qty\ Product/hour = \frac{60 \text{ x } 60}{\text{Cycle time Product}}$$

$$= \frac{60 \text{ x } 60}{60{,}2}$$

= 59, 8 ≈ 60 pcs/hour

Daily capacity=59, 8 pcs hour x 18.33 hours/day = 1096.4 pcs/day ⇒**1096 pcs/day.**

After SMED :

working time – setup time = production time
1200 minutes – 62,3 minutes =1137.7 minutes/day or 18,96 hours/day
Daily capacity =59, 8 pcs/hour x 18.96 hours/day = 1096.4 pcs/day ⇒**1134 pcs/day**

So there is an increase in productivity of = Production capacity after SMED – before SMED
= 1134 pcs/day – 1096 pcs/day
= 38 pcs/day (3.17%)

4. Conclusion

By applying the SMED method in this case study, there was a decrease in injection molding machine setup time of 37.63 minutes (37.6%) and the theoretical productivity increase of 3.17%.

5. Acknowledgments

This research was conducted independently by researchers from Mercu Buana University and students. The research team would like to thank the management of PT ANI who is willing to be the research's subject and also the support of fellow lecturers from UMB.

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