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 D87a Set Plate. Currently the injection molding machine JT220RAD used to produce the fuel pump module requires an average setup time of 99.93 minutes / variant turnover and 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 measuring the 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.

| 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 the clamp on Dies A & B+upper           | 6       |
| 5   | Turn off hot 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 at lower dies A & B    | 44      |
| 10  | Take off the air hose and hot runner cable on upper 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     |

Table 1. Standard Setup Time Injection Moulding JT220RA Machine
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 centre with 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 on dies                         | 241     |
| 53  | Returns 2 empty trolleys to dies station                                    | 172     |
| 54  | Return Crane hose to the hose corner                                         | 35      |
| 55  | Purging new material                                                         | 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].

| 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 the clamp on Dies A & B+upper                                       | 6        | Internal         |
| 5   | Turn off hot 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

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           | 166      | Internal           |
|     | table A of the engine                                                    |          |                    |
| 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,     | 191      | Internal           |
|     | ejector, rotary table and parameter)                                      |          |                    |
| 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 hose to the 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 4 shows 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.

| 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      |
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:

\[ \text{Stage 3 + Stage 4} = 1686 \text{ sec} + (610 - 38) \text{ sec} \]

\[ = 2258 \text{ seconds} \]

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:**

\[
\text{working time} – \text{setup time} = \text{production time} \\
1200 \text{ minutes} – 99, 93 \text{ minutes} = 1100.07 \text{ minutes/day or 18, 33 hours/day} \\
\]

\[
\text{Qty Product/ hour} = \frac{\text{Cycle time Product}}{60 \times 60} \\
= \frac{60.2}{60} \\
= 59, 8 = 60 \text{ pcs/hour} \\
\]

Daily capacity=59, 8 pcs hour x 18.33 hours/day = 1096.4 pcs/day \(\Rightarrow\) **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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