Application of SMED to Reduce Setup Change Loss

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Abstract - *The excellence in operations has been the need of this era. Due to high competition and customer expectation companies need to use various operation excellence technique in order to provide satisfaction to customer at lesser price. In order to satisfy this increasing demand, the companies need to improve productivity. To improve productivity, it is required to utilize the resources like manpower, machines, money, material, methods effectively and efficiently. Machine downtime is major concern for most of manufacturing industries. Setup change loss is one of major loss which affects availability and thus, OEE. Single Minute exchange of dies is most widely used lean manufacturing tools for reducing the machine downtime and improving OEE. The study presents application of SMED in a forging industry to reduce the setup change loss. For primary data collection, video of current method of die setup change have recorded. After elemental breakup of activities, internal and external activities were identified and separated. Using ECRS principle and improvements in procedure and design, the internal activities were either converted into external activities or reduced. The application of SMED has helped to reduce the setup changeover by 38%*

Key Words: Setup change loss reduction, Single Minute Exchange of Die, Internal and External Activities.

1. INTRODUCTION

As per Total Productive Maintenance philosophy, setup change loss refers to time loss occurred during making adjustments required for changing process from the last part of a production run to first good part of next production run. Producing high variety of parts in less quantity requires frequent setup change. As for different parts new setup is require with the respective part die . The setup change loss not only affects the availability and OEE, but also it leads to increase lead time. In past, to counter the problem of large setup change time industries used to produce product in large batch size to mitigate the effect of setup time on production rate. But producing products in large batch size is ineffective and inefficient idea as it tends to increase WIP and cost associated with it. This leads to need of small setup change time.

2. LITERATURE REVIEW

In the past, reduction in setup changeover time used to be achieved through skill and large-lot production. But, nowadays, the idea producing products in large lot size is uneconomical and infeasible. SMED is a scientific approach of reducing setup changeover time reduction which is applicable to any machine. The Setup change loss has been one of major cause behind large machine downtime in forging industries. Setup time consist of time from last good part of previous product to first good part of next product. In the past, reduction in setup changeover time used to be achieved through skill and large-lot production. But, nowadays, the idea of producing products in large lot size is uneconomical and infeasible. As per Shigeo Shingo's SMED philosophy, setup operation consist activities called internal activities and external activities, internal activities are those which carried out when machine is stop, external activities are those which carried out when machine is in running condition. After analysing the setup operations, such internal and external activities should be separated. Then, internal activities should be converted into external activities [1]. Joshi et al. used SMED philosophy to reduce setup time in automotive industry. They have used stopwatch time study to analyse the existing method of setup change. To eliminate time consuming errors during adjustments, poka-yoke principles were used. The implementation of SMED technique has helped to reduce setup change loss by 20% [2]. Raikar[13] has applied SMED technique and other lean manufacturing concepts to reduce setup time in automotive industry. In the case study, Raikar has used poka-yokes to eliminates errors during setup adjustments and better fastening tools to reduce the time consumed in fastening or loosening of bolts[3]. Singh et al. have improved productivity through setup time reduction in forging industry using SMED philosophy. He selected press with highest setup time as subject of study. For identifying the causes of high setup time, fishbone diagram was used. They have implemented concept of water spider (Mizusumashi) and assigned external activities such as information exchange between PPC, Store and setup team, die transportation to water spider. The implementation of SMED has reduced setup time by 24.5% [4]. Dhake and Kelkar have adopted SMED philosophy to solve high setup time problem in their forging industry case study. Fishbone diagram was used to solve the problem concerned with setup changeover. To reduce external setup activity time, they have made procedural improvement such as implementation of setup checklist, setup cart preparation. The problems faced during adjustments were solved by making mechanical improvements in design of die set. Using SMED philosophy, the setup time have been reduced by 64% [5]. Gavali et al.[16] have identified die heating as one of major reason of high setup time in forging industry and converted the activity into external activity by providing heating furnace to heat die set externally. Also, they have used better fastening tools to reduce internal activity time. To eliminate searching of packings, clamps, Tooling trolley was provided [6]. Shah et al. have made mechanical improvements in forging die set such as provision of pin locators, V locators to reduce the setup adjustment time[7]. Dhake et al. have employed water spider with responsibility of performing external activities in parallel with internal activities in setup change operation. Also, they have used alarming system as mean of communication between persons concerned with the setup change operation. To reduce time wasted in searching, retrieval of necessary tools, they have made improvements in workplace organization using 5S principles. SOPs of setup operations were formulated for clear definition of roles and responsibility of workers involved in setup changeover operation[8].

3. PROBLEM STATEMENT

In forging shop, the time utilized in setup changeover activities is high. Average 18 setups are handled over press lines. It takes 140 to 176 minutes of time duration to produce 1st good quality part. This is directly affecting the Availability, OEE and thus, productivity. At the same time, it is also indirectly contributing in increasing WIP and cost associated with it.

4. APPLICATION SMED METHODOLOGY

4.1 Data Collection

In the industry, as per TPM philosophy, 16 losses on each machine are monitored on daily basis in order to measure the performance in terms of Availability and OEE.

The major losses affecting availability are shown in fig.1.

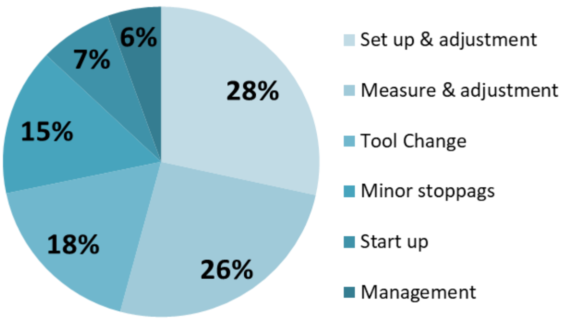


Chart-1: Major losses affecting press availability

In order to select the press and product as subject for study, Press-wise and product-wise setup time data is then collected.

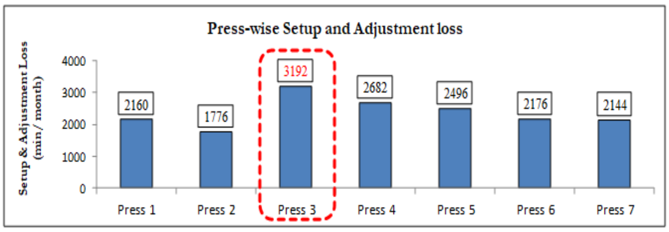


Chart -2: Line-wise Setup and adjustment loss

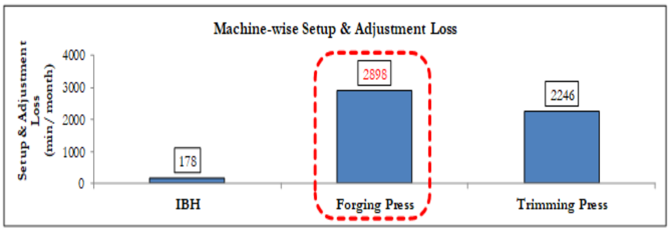


Chart -3: Line-wise Setup and adjustment loss

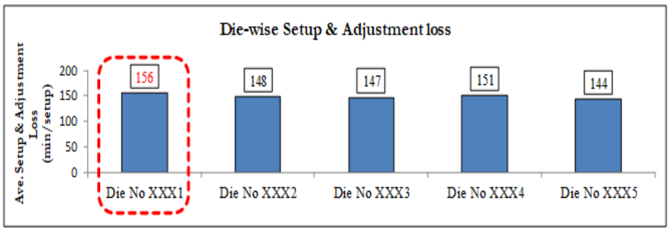


Chart -4: Line-wise Setup and adjustment loss

The setup and adjustment loss for press 3 was highest among all the press. On press 3, every month average 21 setups changeover takes place. The setup changeover time varies from 120 minutes to 160 minutes. After selecting press 3 as subject of study, the other process related information such as sequence of operations, timing and responsibilities of different activities, tools required for changeover, difficulties faced during the changeover, etc. gathered by interviewing the process owners, machine owners.

4.2 Analysis of Setup Change Operation

After selecting the press and die as subject of study, video of existing method of die changeover operation was recorded. The recorded video of existing method of setup changeover is thoroughly analyzed and whole operation was breakdown into small activity elements.

4.3 Separation of Internal and External Activities

After elemental breakdown of the whole setup change operation, internal and external activities identified. Internal activities are those activities which cannot be carried out without stoppage of machine, while external activities can be performed even if machine is running. The external activities such as preparation of dies, die maintenance, etch separated from internal activities to carry out these activities before press stops.

4.4 Conversion of Internal Elements into External Elements

Operations that performed as internal setup activities were critically examined to convert the internal activities to external activities.

4.5 Streamlining Internal and External Elements

By making improvements in procedure, design and mechanization, internal and external activity can be reduced further. In this step, various activity time reducing improvement ideas are generated through brainstorming. ECRS principles were used for reducing the activity time.

Table -1: Activity Analysis Sheet

Sr. No.	Elemental Activity	Existing		Proposed		Responsibility	Action
		E/I	Time (sec)	E/I	Time (sec)		
1	Raise Ram to TDC.	Internal	9	Internal	9	Forger	-
2	Unload new die from die pallet	External	317	External	60	Airman	Use of Magnetic block
3	Take torque gun and loose the die clamps' bolts and unload bottom die clamps	Internal	93	Internal	93	Forger	-
4	Bring the tie bar	Internal	9	Internal	0	Forger	Tool and required accessory preparation before setup change/ provision of trolley
5	Remove the bolts and bottom die clamps and side plates	Internal	65	Internal	65	Forger	-
6	Bring the wooden plank and place it.	Internal	9	Internal	0	Airman	Tool and required accessory preparation before setup change / provision of trolley
7	Place the plank on bottom die set and lower the ram	Internal	22	Internal	22	Forger	-
8	Remove the bolts of top die clamps and unload the clamps	Internal	94	Internal	94	Forger	-
9	Raise the ram to TDC	Internal	9	Internal	9	Forger	-
10	Bring the ladder to unload the die set	Internal	38	Internal	0	Forger	Use of scissor trolley/lift
11	Unload old die set from the bolster and place it in die pallet	Internal	397	Internal	60	Forger &Airman	Use of scissor trolley/lift
12	Clean the press bolster	Internal	200	Internal	60	Forger	-
13	Measure and search for packings required.	Internal	582	Internal	120	Airman	5S and Visualization/ coding for easy identification
14	Bring and place the bottom die set and packings on bolster	Internal	203	Internal	60	Forger	Use of scissor trolley/lift
15	Bring the top offset die and required packings	Internal	8	Internal	0	Airman	Tool and required accessory preparation before setup change/ provision of trolley
16	Place the top offset die on bottom offset die	Internal	15	Internal	15	Forger	-
17	Lower the ram, place the required packings.	Internal	37	Internal	37	Forger	-
18	Bring and put top die clamp, bolt and tighten it and raise the ram	Internal	37	Internal	37	Forger	Tool and required accessory preparation before setup change/ provision of trolley
19	Bring the top blocker die	Internal	15	Internal	0	Airman	Tool and required accessory preparation before setup change/ provision of trolley
20	Place the top blocker die on bottom blocker die	Internal	90	Internal	15	Forger	Modification in Die design
21	Bring the top finisher die	Internal	15	Internal	0	Forger &Airman	Tool and required accessory preparation before setup change/ provision of trolley
22	Place the top finisher die on bottom finisher die	Internal	12	Internal	12	Forger	
23	Lower the ram, place the required packings.	Internal	178	Internal	90	Forger	Coding for easy identification of packing size
24	Take and place the remaining die clamps	Internal	58	Internal	28	Forger	Provision of trolley
25	Tighten the top clamp bolts	Internal	212	Internal	212	Forger	-
26	Take and Place the bottom die clamp and side clamps	Internal	108	Internal	108	Forger &Airman	-
27	Tighten the bottom clamp bolts	Internal	50	Internal	50	Forger	-

28	Clean the previously used dies	External	**300**	External	**300**	Airman &heater operator	-
29	Check the alignment of bottom and top die set	Internal	**48**	Internal	**48**	Airman	-
30	Bring heating arrangement	Internal	**34**	Internal	**0**	Airman	Preparation before setup start/ parallel activity
31	Bring LPG cylinder	Internal	**20**	Internal	**0**	Heater operator	Preparation before setup start/ parallel activity
32	Connect heating arrangement and start heating	Internal	**72**	Internal	**0**	Airman	Preparation before setup start
33	Die Heating	Internal	**1229**	Internal	**900**	Forger	Continuous Monitoring of die temperature
34	Place previously used dies and packings	External	**241**	External	**60**	Airman &heater operator	Use of Magnetic Block
35	Remove the heating arrangement	Internal	**39**	Internal	**0**	Forger	Parallel Activity
36	Wait for OK temperature billet	Internal	**215**	Internal	**0**	Heater operator	Start IBH 2 in before adjustment finish
37	Sample job production	Internal	**64**	Internal	**40**	Forger &Airman	-
38	Take Sample job for cooling	Internal	**74**	Internal	**20**	Heater operator	Provision of tray for hot sample part movement, Provision of water bath near hot inspection area
39	Sample job cooling	Internal	**188**	Internal	**180**	Heater operator	-
40	Take the jobs for hot inspection	Internal	**38**	Internal	**0**	Heater operator	Provision of water bath near hot inspection area
41	Hot inspection	Internal	**330**	Internal	**360**	Hot inspector	-
42	Take the required packings	Internal	**30**	Internal	**20**	Forger &Airman	5S and Visualization/ coding for easy identification
43	1st die setup adjustment	Internal	**275**	Internal	**240**	Forger	-
44	Wait for OK temperature billet	Internal	**111**	Internal	**0**	Heater operator	Start IBH 2 min before adjustment finish
45	Sample job production	Internal	**34**	Internal	**40**	Forger &Airman	-
46	Take Sample job for cooling	Internal	**72**	Internal	**20**	Heater operator	Provision of tray for hot sample part movement, Provision of water bath near hot inspection area
47	Sample job cooling	Internal	**182**	Internal	**180**	Heater operator	-
48	Take the jobs for hot inspection	Internal	**30**	Internal	**0**	Heater operator	Provision of water bath near hot inspection area
49	Hot inspection	Internal	**377**	Internal	**360**	Hot inspector	-
50	Take the required packings and plates	Internal	**45**	Internal	**20**	Forger &Airman	Coding for easy identification of packing size
51	2nd die setup adjustment	Internal	**252**	Internal	**240**	Forger	-
52	Wait for OK temperature billet	Internal	**158**	Internal	**0**	Heater operator	Start IBH 2 min before adjustment finish
53	Sample job production	Internal	**56**	Internal	**40**	Forger, Airman &heater operator	-
54	Take Sample job for cooling	Internal	**31**	Internal	**20**	Heater operator	Provision of tray for hot sample part movement, Provision of water bath near hot inspection area
55	Sample job cooling	Internal	**196**	Internal	**180**	Heater operator	-
56	Take the jobs for hot inspection	Internal	**42**	Internal	**0**	Heater operator	Provision of water bath near hot inspection area
57	Hot inspection	Internal	**444**	Internal	**360**	Hot inspector	-
58	3rd Die setup adjustment	Internal	**205**	Internal	**240**	Forger	-
59	Wait for OK temperature billet	Internal	**208**	Internal	**0**	Heater operator	Start IBH 2 min before adjustment finish
60	Sample job production	Internal	**87**	Internal	**40**	Forger, Airman &heater operator	-

61	Take Sample job for cooling	Internal	**32**	Internal	**20**	Heater operator	Provision of tray for hot sample part movement, Provision of water bath near hot inspection area
62	Sample job cooling	Internal	**170**	Internal	**180**	Heater operator	-
63	Take the jobs for hot inspection	Internal	**29**	Internal	**0**	Heater operator	Provision of water bath near hot inspection area
64	Hot inspection	Internal	**482**	Internal	**240**	Hot inspector	-
65	Wait for OK temperature billet	Internal	**53**	Internal	**0**	Heater operator	Start IBH 2 min before adjustment finish
66	1st ok part Production	Internal	**80**	Internal	**40**	Operators	-
	Internal Element time in (sec)		**8597**		**5104**		
	External Element time in (sec)		**858**		**540**		
	Total time in (sec)		**8597**		**5104**		
	Total time in (Min)		**143**		**85**		

4.5.1 Preparation for Setup changeover before stoppage of press

It was observed that, searching for tools, clamps, springs, packings required during setup changeover takes more time. Also, the setup procedure stops due to unavailability of necessary tools. To avoid this, it is necessary that the setup related preparation activities should be performed as external activities and before production of previous batch ends. Responsibility of such activities is given to shift coordinator. To ensure these following measures are taken into account:

- Display of Weekly press-wise schedule of setups released by PPC enables press operators to perform the external setup activities before the production of previous part ends
- The checklist of tools and accessories required for setup is prepared to ensure that everything needed for setup change activity is available before the production of previous part ends
- The tools, clamps, packings required for setup change are arranged in trolley before the production of previous part ends. 5S and visual management principles have been followed to avoid time loss in searching.

4.5.2 Parallel activities

In existing setup changeover method, many times one of the workers was observed being idle due to poor work distribution among the workers. External activities which can be performed parallel with internal activities are identified. To carry out the internal and external activities parallelly, the work is distributed in such a way that, Internal activities such as fixing/removing bolts, clamps, dies, packing, setup adjustments, autonomous maintenance of press have been assigned to Worker 1 (forger), and External activities such as cleaning, movement of old/new die sets, sample jobs (for hot inspection) have been assigned to Worker 2 (airman).

4.5.3 Kaizens

Team involving members from production, QA, Design, maintenance department was formed for brainstorming. The press operators concerned with setup changeover were involved in discussion for the problems faced during setup changeover process. Why-Why Analysis is used as tool to find out root causes of each identified. Various ideas were generated through brainstorming to eliminate these problems and reduce activity time.

Fig.18 and 19 shows some of the kaizen ideas generated for reducing the die loading/ unloading time and tool searching time, respectively.

Kaizen Theme: To Reduce die handling time in Setup changeover	
Problem: More time is consumed in die loading/ unloading on bolster during setup change activity	
Why Why Analysis: W1: Die loading / unloading is done manually W2: No means for die loading / unloading **Root Cause:** No means for die loading	**Idea:** Provison of trolley **Countermeasure:** Trolley is provided for placing tools, clamps, packings.
Before	**After**
	
Horinzontal Deployment: Yes, On All Press.	**Benefits:** 1. Operator Fatigue reduced 2. Safe operation

Fig -1: Kaizen for die loading/Unloading

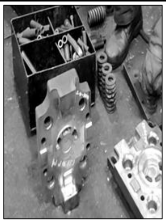
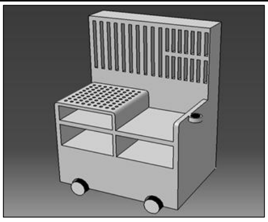
Kaizen Theme: To Reduce searching time in Setup changeover	
Problem: More time is consumed in searching tools, packings, clamps during setup change activity	
Why Why Analysis: W1: Tools, packings, clamps are placed on ground during setup change W2: No specific place allocated for tools, packings, clamps required **Root Cause:** No Specific place allocated for tools	**Idea:** Provison of trolley **Countermeasure:** Trolley is provided for placing tools, clamps, packings.
Before	**After**
 	
Horinzontal Deployment: Yes, On All Press.	**Benefits:** 1. Operator Fatigue reduced

Fig -2: Kaizen for quick retrieval of tools, accessories, etc.

4.6 Process standardization and training

First step for deployment of the proposed technique is to prepare standardized work sequence sheet. Based on the Proposed Setup changeover Procedure, standard work sequence sheet is prepared as shown below. The standard work sequence sheet helps to avoid deviation from sequence in which the activities to carried out. Also, it clarifies the roles and responsibility of the press workers in setup changeover process.

For sustenance of the proposed setup changeover procedure, on job training is given to all the concerned persons i.e. shift coordinator, heater operator, forger, airman, etc.

5. RESULTS AND CONCLUSION

With Implementation SMED, setup changeover time is reduced by 41%. Table shows activity-wise reduction in time.

Sr. No.	Activity	Before SMED	After SMED	% Reduction
1	Die Unloading	15.8	6.9	56%
2	Die Loading	27.8	11.9	57%
3	Die Heating	23.2	15.0	35%
4	Die Adjustments	76.5	51.3	33%
	Total Time (Min)	**143.3**	**85.1**	**41%**
	Total Time (Hrs.)	**2.4**	**1.4**	**41%**

Implementation of SMED can save 58 minutes per setup change which improves the availability of the press by 244 Hrs. per year. The production capacity of the press can be improved by 34230 jobs/ year.

The setup changeover time can be reduced further. Currently, die heating is performed as internal element. It can be converted into external element by making external provision of heating platform or furnace for die heating. Else, it can be reduced by changing heating method from LPG gas heating to Infrared heating or induction heating. Also, the die adjustments required after die loading can be reduced by making improvements in design of die set, bolster.

Application SMED has helped not only in improving the availability, OEE and Productivity, but also it has benefited in reducing the lead time, WIP reduction, improving work safety and employee morale.

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