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PRODUCTIVITY IMPROVEMENT THROUGH SETUP TIME REDUCTION IN AUTOMOBILE COMPONENT MANUFACTURING COMPANY – A CASE STUDY

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Abstract

In today's competitive world, catering to the varied needs of customers warrants frequent and quick setups. Quick setups drive smaller lot sizes, lower production costs, improve productivity in terms of increased output, increased utilization of machine and labor hours, make additional capacity available (often at bottleneck resources), reduce scrap and rework, and increase flexibility. This paper presents a simplified approach to reduce setup time on forging machine (being bottleneck in the process) in a bolt manufacturing company. The initial step was gathering information about the present setup times and its proportion to the total productive time. Subsequently SMED philosophy was adopted to investigate the setup operations. It primarily consisted of analyzing the external and internal setup activities in terms of their need (i.e. preparation, replacement or adjustment), time taken and the way these could be reduced, simplified or eliminated. The improvements effected were of three categories viz., mechanical, procedural and organizational. The paper concludes by comparing the present and proposed (implemented) methods of setup procedures.

INTRODUCTION

Any machine producing multiple products is a good candidate for setup time reduction. Mr. Shigeo Shingo \... Shigeo Shingo,(1986)…\, the pioneer of setup time reduction, first applied the SMED philosophy in 1950 on press machines by reducing the setup time from 4 hours to 3 minutes. This exercise was horizontally deployed across variety of equipment in Toyota Motor Co. Shingo's major thrust was on dividing the setup activities into internal setups (machine needs to be stopped) and external setups (machine is working) and ensuring that all external activities are done before the machine is stopped. Thus, all processes that are completed during the setup (internally) should be completed beforehand (externally). He also used a variety of mechanical techniques like simplification of fittings and tightening, use of quick attachment devices, functional clamps, etc. Gest et al carried Shingo's work further by proposing new mechanical improvements in the form of improvements to clamping, one-touch fasteners, half-turn fasteners, T-slots, hydraulic and vacuum clamping, etc. Shingo's work was further supplemented by Chaneski who emphasized on standardizing the setup procedures for sustaining setup reduction process. Culley et al explore the issue of the sustainability of a reduced setups and highlight the importance of making staff accountable for setup times as part of their job description. B. Kayas et al propose a comprehensive procedure for reducing setup time on injection molding process. It summarizes current practices and aims to focus on cost effective mechanical, organizational and procedural changes which will provide a simplified approach that can be implemented on forging machine. This paper attempts to adopt a variety of approaches like SMED, Time Study, and Work Simplification & Standardization to reduce setup time on forging machine

IDENTIFICATION OF BOTTLENECK & ASCERTAINING THE NEEDS FOR SETUP REDUCTION

Out of the total product range of the company, bolts comprise (70%) and the remaining being shared by studs (20%) and other components viz., nuts, connecting rods and washers (10%)

A generalized process of manufacturing bolts is shown below: (number in bracket indicate the number of machines available for that particular process)

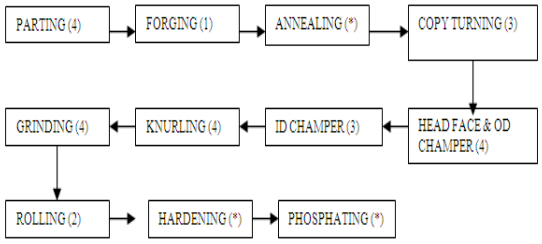

Fig 1: Manufacturing of Bolts

Note: The sequence can be generalized with few modifications for any type of bolts. Number in the bracket i.e. (x) indicates the number of machines available for particular operation. (*) Indicates that the operation is outsourced

The forging operation is the major bottleneck in the whole process due to the following reasons

- The company has only one forging press
- Accumulation of inventory before the forging press
- Errors/defects in forging affect succeeding operations
- Cost and quality considerations do not permit the company to outsource forging operation

DATA COLLECTION AND ANALYSIS (DOWNTIME AND SETUP TIME RECORDS)

The following information about bolt production was compiled from the past 3 year records:

1. Average Annual Production: 780,000	780000	
2. Product Variety of Bolts Manufactured = 240	240	
3. No. of setups = 310	310	
4. Average Setup Time (hours)	2	
5. Total Time Available for Production / year (hours)	6230	100.00%
6. Setup Time / Year (hours) (9.95%)	620	9.95%
7. Productive Time / Year (hours) (90.05%)	5610	90.05%
8. Time for Manufacturing One Bolt (sec)	12	
9. Production Loss Due to Setup (units)	186000	

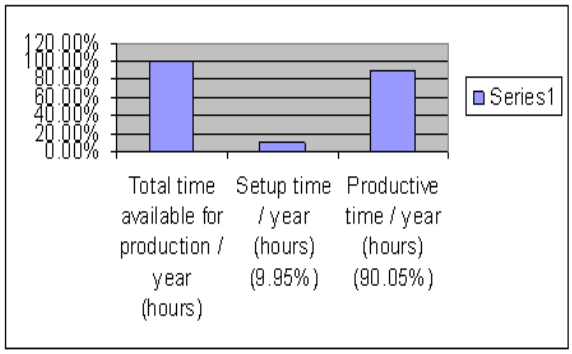

Fig 2: Proportion of Productive Time & Setup Time

CLASSIFICATION & ANALYSIS OF SETUP ACTIVITIES

Detailed list of activities performed during setup and their respective times are given in the table 1. (Note: Two workers are involved in performing the setup activity.)

Table 2: List Setup Activities & associated Task Times

SR. NO	ACTIVITY	Average Time (min)
1	Bring bottom die holder to the top position	0.14
2	Search for spanner	0.87
3	Loosen 4 bolts of top die holder	2.40
4	Press lever to bring top die holder down with bottom	0.40
5	Lift top die holder and place it at a position near plates	0.65
6	Lift top die holder or roll it and adjust it upside down on half plate	0.45
7	Search for hammer	0.30
8	Remove top sleeve by hammering on top of rod	0.17
9	Put die holder aside by rolling it	0.80
10	Adjust the sleeve with die or punch on half plate	1.42
11	Remove die and punch with small plate	0.24
12	Keep hammer aside	0.27
13	Get required top die or punch from die rack or cupboard	14.2
14	Unscrew nuts of bottom die holder (4 nuts) with spanner 30, (12 half rotations)	2.23
15	Remove rectangular plate and keep it aside	1.80
16	Lift and remove the bottom die holder	0.39
17	Adjust holder on half plates	0.47
18	Remove sleeve with the help of hammer	1.93
19	Separate rod, holder from sleeve and adjust sleeve on half plates	0.85
20	Take smaller d-sleeve and place it on other sleeve	3.23
21	Remove bottom die by hammering 8-14 strokes	3.74
22	Get bottom die from stand and check diameter and depth	4.54
23	Search for allen key (4mm size) to unscrew bolts of heating m/c	1.23
24	Remove allen bolts with 40 half rotations (2nos)	0.29
25	Remove v-block	1.49

REDUCE / SIMPLIFY / ELIMINATE INTERNAL & EXTERNAL SETUP ACTIVITIES

The analysis of data and information gathered led to significant improvements to be carried out in three categories, namely; Mechanical, Procedural and Organizational in order to implement Setup Reductions. Mechanical improvements covered several engineering changes that will streamline the physical processes involved in completing a setup. Procedural improvements aimed to investigate the efficiency of the procedures used to carry out a setup whereas Organizational improvements were towards how resources have to be organized and allocated to the setup process \... B. Kayas (2007) …\. The above improvements were adopted to reduce the total setup time. Refer table 2 for the improvements effected in all three categories.

ORGANIZE EXTERNAL ACTIVITIES BEFORE MACHINE STOPS:

The following measures ensured that all external setup activities were done externally (before the machine stops) in order to eliminate the waiting and searching time during setup:

1. Preparation of Week-Wise Schedule for Setups: The PPC department will display schedule of setups one week in advance to enable the setup workers perform the external setup activities before the machine stops .
2. Preparation of Setup Checklist: The setup checklist serves as full-proof mechanism and ensues that everything is ready before the machine stops.
3. Prepare Setup Cart & Tool Kit (Setup Cart to move dies – old and new, from and to storage. Tool kit to hold basic setup tools like spanners (8 sizes), nuts, allen keys (6 sizes), dial gauges, washers, hammers,

etc. at the workplace itself.): This will eliminate the searching time ensuring prompt availability of all necessary tools for setup activities.

4. Proper Systems for Codification, Storage & Selection of Dies: The following measures were adopted:

a. Codification & Storage of Dies: Considerable time is saved in searching dies (from a set of 450-500) by proper codification & labeling of dies using the following convention:

Classification Basis	Code for Subclass	(Example: Bottom die of notched bolt with a/f as 13 and depth of die as 32 is represented as: BN1332)
a. Die Type	Top die - T Bottom die – B	
c. Across Flat	Dimension (Value)	
d. Depth	Dimension (Value)	

Table 3: Codification of Dies

A chart listing all dies, their codes and location of dies is placed at the die storage area. This eliminates the searching time.

b. Prepare Die Selection Chart: A die selection chart will facilitate the selection of appropriate die based on the bolt type.

c. Prepare Die Utilization Chart for Die Life Estimation: Expected life of dies varies according to production volume. An excel based (macros enabled) die utilization chart will be updated immediately after the removal of die from machine. The expected remaining life of the die can be estimated (based on past experience) from the usage history of die. This procedure will facilitate procurement of new dies within the lead times to prevent stoppage of machines and/or overproduction of other bolts on account of non-availability of die. Additional advantage of this procedure will be cost estimation and cost allocation.

Standardize Setup Procedures

The next logical step is to integrate the above measures and standardized the setup procedures to ensure that there are no deviations from the set procedures.

Sr No	Average Time	Activity Classification			Type (External / Internal		Improvement Terms				Changes in Proposed Setup Procedure	
		Preparation	Replacement	Adjustment	External	Internal	Eliminate Activity	Organize Externally	Reduce Setup Time	Reduce / Eliminate Adjustment	Change in Activities	Internal Time
1	0.14	*				*					No Change	0.14
2	0.87	*			*		*				Eliminated	0
3	2.40	*				*			*		Mechanical Improvement – M.I. (Spare set of Top Die Holder)	1.35
4	0.40	*				*						
5	0.65	*				*			*			
6	0.45	*				*			*			
7	0.30	*			*		*				Eliminated	0
8	0.17		*			*					Mechanical Improvement – M.I. Spare set of Top Die Holder	2.10
9	0.80		*			*			*			
10	1.42		*			*				*		
11	0.24	*				*						
12	0.27		*			*			*			
13	14.2	*			*			*			Perform Externally	0
14	2.23	*				*			*		Mechanical Improvement – M.I. Spare set of Bottom Die Holder	5.25
15	1.80	*				*						
16	0.39	*				*						
17	0.47		*			*						
18	1.93		*			*						
19	0.85	*	*			*			*			
20	3.23		*	*	*			*			Performe Externally	0
21	3.74		*			*					No Change	3.74
22	4.54	*			*			*			Perform Externally	0
23	1.23	*			*		*				Eliminated	0
24	0.29		*			*			*)	*	M.I. – Spare set of V-Block	0.66
25	1.49	*	*			*						
26	13.0	*	*		*			*			Perform Externally	0
27	4.6		*			*					M.I. – Spare set of V-Block	2.50
28	5.34		*			*						
29	0.63	*				*		*			Perform Externally	0
30	0.21	*				*					No Change	0.21
31	2.09			*		*				*	No Change	2.09
32	2.23	*	*			*					No Change	2.23
33	1.25	*				*					M.I. – Use Bolts (35-40RC)	1.25
34	6.22	*				*						
35	0.12	*		*		*			*		No Change	0.12
36	0.10	*	*			*					No Change	0.10
37	0.62	*	*			*					No Change	0.62
38	3.54	*		*		*			*		M.I. - Spare set of Bottom Die Holder	1.54
39	1.54			*		*						
40	1.94			*		*			*		No Change	1.94
41	2.22	*		*		*					No Change	2.22
42	4.23	*				*			*		M.I. – Modified Stopper Used	1.26
43	0.43			*	*				*			
44	4.43			*	*				*			
45	4.50			*	*						No Change	4.50
46	4.50	*			*						No Change	4.50
47	3.10	*			*				*		No Change	3.10
48	0.45	*			*		*				Eliminated	0
49	0.75	*			*						No Change	0.75
50	4.35	*			*			*			Perform Externally	0
51	6.25	*		*	*			*			Perform Externally	0

Table 4: Identification & Separation of Internal & External Setup Activities

Mechanical Improvements

Sr. No.	*Problems*	*Improvements*
1	Die holder bolts of forging press: Bolts bulged on threads due to continuous hammering action and being subjected to hot conditions bulged on threads.	Replace all four bolts with new bolts having hardness of 35-40 RC (instead of 16RC) to sustain compressive load.
2	Excessive adjustment time for stopper: The following activities are performed: - Adjust shank length of job - Forge trial job & adjust the position of stopper - Repeat the process until acceptable jobs are obtained - Check the job dimensions after every hour to check if setting has disturbed Other problems faced: • Damaged internal threads of stopper. • Damaged threads of gauge. • Lock pin is unable to withstand hammering action of stopper. • Frequent setting of stopper required after few hours of operation.	Modify stopper design & follow the following procedure: With the outer stopper adjusting the shank length of blank, rotate the locknut in opposite direction so that they are inter-locked. This keeps the setting intact. - Easy to lock arrangement provided - No equipments required - Eliminate frequent checking of the setting - Less chances of wear out - Time saved in adjustments - Number of trial jobs reduced by 65% - Quality of jobs in terms of shank length has increased substantially
3	High replacement and adjustment time of V-block: Considerable time is taken to fit the V Block on heating machine (due to small size bolts and space constraints)	Provide spare set of V-block to do the setup procedure externally
4	High replacement and adjustment time of upper and bottom dies: Considerable time is taken for die setups	Provide spare set of top and bottom die-holder to do the setup procedure externally

Table 5: Mechanical Improvements

DESIGN FOR IMPLEMENTATION

The most crucial part of any setup reduction program is implementation and sustenance of the standard setup procedures recommended. Work standardization, clear definition and allocation of responsibilities of the setup team and formulation of standard operating procedures for setup will ensure its successful implementation. Training of people will be essential to ensure success of the setup reduction program.

8.0 CONCLUSIONS

Total cost of implementing suggestions: INR 16010

Productivity Measures	Before Improvement	After Improvement	% Change
Setup Time / Setup	120 min	43 min	Reduction in setup time: 77 min (64%)
Availability of Machine (Considering 310 setups)			Increase Availability: 398 hrs
Production of Bolts (Considering Existing Product Mix)	16,96,200	18,15,350	Increase in Output: 119350 (7 %)

There is still enough scope for further reduction in setup time with help of large improvements requiring investment in the form of automation although the methodology created is implemented, sustaining the change and continual improvements will ensure

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