International Journal of Mechanical and Industrial Engineering

Volume 1 | Issue 1 Article 10

July 2011

Productivity enhancement by reducing adjustment time and setup change

M.S. Desai
Government engineering college Aurangabad. Aurangabad (M.S.) India., mukeshsdesai@gmail.com

R.M. Warkhedkar
Government engineering college Aurangabad. Aurangabad (M.S.) India., raviwarkhedkar@yahoo.com

Recommended Citation

Desai, M.S. and Warkhedkar, R.M. (2011) "Productivity enhancement by reducing adjustment time and setup change," *International Journal of Mechanical and Industrial Engineering*: Vol. 1 : Iss. 1 , Article 10.
DOI: 10.47893/IJMIE.2011.1009
Available at: https://www.interscience.in/ijmie/vol1/iss1/10

Productivity enhancement by reducing adjustment time and setup change

[1]M.S.Desai, [2]R.M.Warkhedkar
[1,2]Mechanical engineering department.
Government engineering college Aurangabad.
Aurangabad (M.S.) India.
E- Mail: mukeshsdesai@gmail.com, raviwarkhedkar@yahoo.com

***Abstract:** The paper presents a study of set-up time reduction in a small factory involved in the machining of precision components in small batches with large variety for the automobile industry. The factory has made some set-up reductions mainly using work study related methods and in one manufacturing cell by the use of the Single Minute Exchange of Die (SMED) methodology. Until recently the set-up times were not measured and worse still were considered as productive hours. As a consequence, there was a lack of awareness and motivation amongst operational personnel to reduce set-up times and knowledge of SMED was limited to a small group of individuals. This, along with the lack of investment in mechanisms to aid set-up time reductions and prevent errors, has restricted the use of this type of methods and technology. However, there is evidence that the demands made by the factory's major customer will lead to increased efforts to put into place these types of changes.*

***Keywords:** (SMED) Single minute exchange of die. Changeover. Internal and external setups TPM (Total Productive Maintenance).*

I. INTRODUCTION

The SMED system is a theory and set of techniques that make it possible to perform equipment setup and changeover operations in under 10 min. SMED improves setup process and provide a setup time reduction up to 90% with moderate investments. Setup operation is the preparation or after adjustment that is performed once before and once after each lot is processed [1]. Shingo divides the setup operation into two parts: Internal setup and external setup. Internal setup is that setup operation, that can be done only when the machine is shut down (attaching or removing the dies). External setup is that setup operation that can be done when the machine is still running. These operations can be performed either before or after the machine is shut down. For example getting the equipment ready for the setup operation before the machine is shut down. In Figure 1, setup operation periods are showed. The setup period is constituted by internal setup and external setup. During the internal setup there is no production. In

the run-up period re-adjustments and trial productions are taking place. This period

terminates when full output capacity is reached. SMED system includes three main steps. These steps are as follows:

Step1)

Separating internal and external setup

At this step an important question must be asked for each setup activity. "Do I have to shut the machine down to perform this activity?" The answer helps us in distinguishing between internal and external setup. This step can reduce the setup time by as much as 30 to 50 percent. The three techniques that SMED uses at this step are: Check lists, function checks, and improved transport of dies and other parts.

Step 2)

Converting internal setup to external setup

In order to achieve the single digit setup time objective SMED introduces this step. At this step internal setup activities tried to be converted to external activities. So the total time that the machine is shut down will be reduced. Advance preparation of operating conditions, function standardization, and use of intermediary jigs are the techniques to support the second step.

Step 3)

Streamlining all aspects of the setup operation

At this step "specific principles" are applied to shorten the setup times. Implementing parallel operations, using functional clamps, eliminating adjustment and mechanization techniques are used to further setup time reduction.[14]

All these steps are figured in fig.1.

II. FACTORY BACKGROUND

The factory at the focus of the study employs some 400 employees with a sales turnover in 2010 of 150 cords and comprises three divisions: Hot forging, cold forging and Machining department. The factory had established a manufacturing cell for the manufacture two and three wheeler gears, and had started to use SMED in this cell. Some degree of success has been attained in reducing setup time and errors through a combination of work study and SMED methodologies. For example, a typical set-up used to take up to one hour, and as part of the study the opportunity was taken to undertake a method study of a set-up in the cell which resulted in a time of some 15 minutes. However, the Factory is still looking to further reduce set-up change over time to a single digit through a more rigorous application of Shingo's SMED methodology (Shingo, 1985a). [1]

A number of these machines are over 15 years old and some were operating with broken or missing parts, contributing to longer set-up times and increased frequency of errors. It was clear that little effort was given to reducing set-up times and in Shingo's [1] terms they are in the preliminary stage of set-up reduction in which internal and external set-up have not been effectively distinguished.

III. METHODOLOGY

The researcher observed three complete set-ups, in addition to the one in the manufacturing cell, and several partial set-ups. The set-ups have been evaluated to examine the type of improvements which can be made using the SMED methodology. The observations were undertaken using manual means employing a standardized recording and analysis sheet. The factory had not used video techniques to record set-ups and a decision was taken not to employ this method as it was considered this would prevent operators from co-operating in the study. The methods employed by the researcher were those used by the Cummins Engine factory as described by Lee (1986); the details of one of these set-ups are given in Figure 1 The first step in the implementation of SMED is to separate internal (activities which can only be carried out when the machine is stopped) and external (activities which can be carried out when the machine is operating) setup activities.

It can be seen that steps 2 and 3 in Figure 1 are external activities whilst the others are internal. These external activities should be done during the current operation, such as tools and fixtures located for the next job whilst simultaneously returning the tools and fixtures which are used on the current operation, avoiding excessive transportation of tools and fixtures. On a similar theme, paperwork for the next job should also be prepared during the current operation. As indicated in Figure 1 there were also unnecessary internal activities which increased the set-up; these activities can either be eliminated or converted into external activities. Similar conclusions were drawn from analysis of the other two set-ups. [2]

Once the internal and external activities are identified and separated a checklist can be made of all the parts and steps which should be carried out externally during the current and preceding operations. The checklist of the set-up procedure which has been developed for the CNC shaping machine is given in Table 1, saving an estimated 30-35 minutes. Based on the set-ups observed, there are numerous other activities that need to be eliminated, which are contributing to longer set-up times. For example, as changeover time was not regarded as a lost production opportunity there was a very relaxed approach by operational personnel to the changeover operation. Operators were also keeping tools and fixtures in their personal lockers so that they would be close to hand when needed. It was also observed that the grinding of cutting tool tips was not carried out on time. In addition, the computer program was not updated and this could potentially lead to an incorrect set-up and therefore delays. Another problem was that the machines used metric measurements whereas the schedules used imperial figures; this meant that operators had to convert the imperial figures into metric, thus increasing the set-up procedure. It is estimated that by tackling these types of problems an extra 10-15 minutes would be saved on the total set-up times.

The second stage in Shingo's SMED methodology is to convert internal to external set-up activities.

- The height of the machine tables could be fixed and the distance to the cutting tip set at the appropriate level.
- The dimensions of the various components and jig could be determined and contact jigs, compensating for height, could be mounted and set on the table so that the Cutting surface would be at the appropriate level.

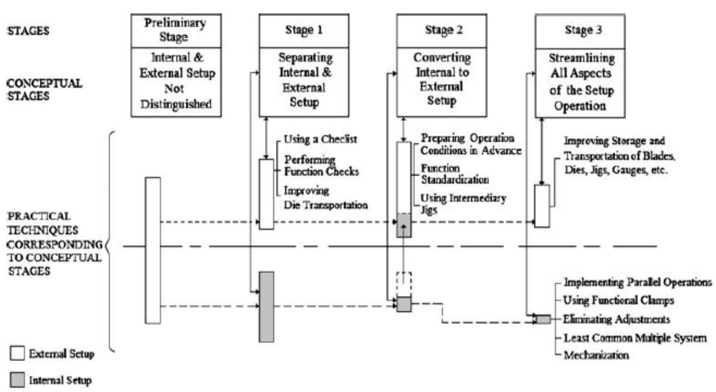

Fig1. SMED Conceptual Stage and practical Techniques.

A. Setup time of shaping machine for the part no 2 01 3 150

Name of Machine: BA 4156; LORENZ GEAR

Name of Fixture: RE 332

Sr. No	Activities	Time (Sec) On 21.12.09	Time (Sec) On 03.01.10	Time (Sec) On 17.01.10	Internal Activity	External Activity	Modification	Remark	Time After 21.03.10 (Sec)	Time After 28.03.10 (Sec)	Time After 11.04.10 (Sec)
1	To prepare trolley for setup	120	120	120		External			0	0	0
2	Take a Allan key	10	10	10	Internal				02	02	02

3	Rotate the fixture	30	30	30	Internal			Repeated activity	20	20	18
4	Remove the tie rod	25	20	22	Internal		By automatic Spanner		05	05	05
5	Remove the burrs with the help of Allan key	65	60	70	Internal		By compressed Air (Air Gun)	Repeated activity	05	05	06
6	Remove the fixtures bolts	40	35	38	Internal		By automatic Spanner		15	15	17
7	**Remove the previous fixture**	200	206	209	Internal		By automatic Spanner		45	47	47
8	Remove the burrs from fixture	35	30	28	Internal		By compressed Air (Air run)		05	07	07
9	Remove the insert rod of fixture	20	25	30	Internal		By automatic Spanner		10	10	13
10	Clean the hole or Remove the burrs from base plate	68	50	56	Internal		By compressed Air (Air Gun)		10	12	09
11	Take new fixture	10	10	10		External			05	05	05
12	Rotate the base plate	20	20	20	Internal				15	16	15
13	To clean the new fixture by compressed air	20	20	20		External	By compressed Air (Air Gun)		00	00	00
14	Clean the base plate	40	40	40	Internal		By compressed Air (Air Gun)		10	11	12
15	To take dial indicator with magnetic stand	10	10	10		External		Repeated activity	10	10	08
16	To fixed & adjust the collector	65	60	58	Internal		By compressed Air (Air Gun)		30	32	29
17	To fixed the new fixture	85	75	74	Internal		By compressed Air (Air Gun)		60	62	61
18	**To fixed the bolts of fixture**	278	240	253	Internal		By compressed Air (Air Gun)		30	32	33
19	To rotate, tight & adjust the fixture	120	100	110	Internal		By compressed Air (Air Gun)		30	29	27
20	To fixed the stand of dial indicator	10	10	10	Internal				12	10	11
21	To check the run-out of tie rod	100	100	100	Internal			Repeated activity	50	49	48

22	To rotate, tight & adjust the fixtures bolts w.r.to run out	245	240	243	Internal		By compressed Air (Air Gun)		20	22	23
23	To remove the dial indicator	20	20	20	Internal				20	20	20
24	To fix the bottom bolts of fixture	20	25	27	Internal		By automatic Spanner		10	10	12
25	**To fixed and adjust the height of tie rod**	800	940	955	Internal		**Design the fixed/ dedicated tie rod**	**Very Critic al Activit y**	40	43	44
26	To fix the job & fix the cap	45	50	50	Internal				25	24	25
27	To set the machine parameter	150	100	120	Internal			Extern al activit y	00	00	00
	Total time (sec)	**2651**	**2636**	**2743**					**484**	**488**	**497**
	Total time (Min)	**45**	**44**	**46**					**8.06**	**8.09**	**8.28**

Table1: Worksheet analysis showing the original and improved setup time of Machine BA 4156; Lorenz gear

B. Check list

1. A setup trolley consist of
   - A set of Allen keys
   - New cutter
   - New fixture with Tie rod & cap
   - Allen nuts
   - A dial indicator with magnetic stand
   - Job to be set on machine
   - Cotton
   - Automatic Spanners
   - Tool box / kits
   - GO No- Go Gauge (Go 20.885 & No Go 20.936)
2. To set machine parameter (Part program)
3. To Check Air gun / air supply of machine
4. Stop watch
5. Digital camera
6. Check list
7. Observation sheet

The factory would need to invest in fixtures which can attach or un-attach objects more quickly and effectively than the conventional methods. This need has been recognized from the study carried out and it is now just a matter of funding. The distinction between setting and adjusting is not fully appreciated in the factory. The goal should be to design measures based on settings. Many of those interviewed are under the impression that adjustments are a necessary evil and there was no desire to reduce them or be smarter at carrying them out. From the interviews it was clear that operators pride themselves on how frequently, cleverly and quickly they can make adjustments, thus demonstrating appropriate levels of expertise. This is indeed a skill an important one but sight must not be lost of the improvements which can make the adjustments unnecessary. The many adjustments observed were due to inaccurate centering and dimensioning, conducted earlier in the set-up procedure. For example, one operator had to use a dial test indicator to assess the alignment of a turret because the turret was damaged. In another case, an operator was observed wedging a component by measuring and cutting thin pieces of paper to make the component lie flat on the jig plate; this was due to the base plate not being uniformly flat. The machine tools tended to be standard and therefore have an infinite number of adjustable positioning methods requiring operators to measure for new positions and then manufacture a ``first-off'' with the attendant scrap and rework risks; dead stops/dowels, in which the load movement positions automatically, would eliminate these types of adjustments.

The following are the type of errors observed during the study which indicate the potential for further mistake proofing:

- Errors due to absentmindedness and those made without knowing how they have happened (e.g. operators using the wrong equipment or tools).
- Errors due to a lack of concentration (e.g. operators overlooking the need to properly tighten clamps, screws, and tools, etc.).

- Errors due to unsuitable instructions or work standards. More than one operator commented that they found it difficult to adhere to rules and standards (e.g. a measurement may be left to an operator's discretion ± the imperial/metric issue mentioned earlier is a case in point).
- Errors which occur due to equipment running differently than expected
  (e.g. machines malfunctioning without arming).
- Errors arising from operators misjudging a situation.

These types of mistakes happen for many reasons, but can be prevented if root cause analysis is undertaken to identify when and why they happen, and then steps are taken to prevent them happening again by the use of mistake proofing methods. The use of checklists and check tables will also reduce the likelihood of errors such as those described above.

The factory also experiences problems with internal services such as schedules and paperwork. For example: the tool shop failing to ensure the repairing or grinding tools on time and/or this activity is done incorrectly; incorrect paperwork and schedules are provided by production control; and computer program not periodically updated. If the failure in these tasks is due to forgetfulness then the fail-safe procedure is to notify, in advance of beginning the next job, the department(s) involved. In the case of the tool shop, the tools to be repaired or re-ground can be put in a bag with a tag or sticker which contains the details of the customer/operator and other information such as the required time, procedures, etc. These and other repairs can then be scheduled in priority order. In the case of paperwork, the supplier can double-check the paperwork and periodically monitor the movements of the components on the shop floor. This is to ensure that he/she knows the location of jobs and the correct allocation of paperwork.

The supplier could also communicate with the operator to confirm the paperwork is correct. Production control should also proofread the paperwork to identify and eliminate the errors before this is issued to the shop floor. Chase and Stewart (1994) recommended task and tangible poka yokes to mistake-proof services such as these. The management and control of materials is also critical to set-up reduction and the following problems were observed:

(1) Operators were unable to find tools, clamps, etc.
(2) Difficulties were encountered in retrieving jigs from their point of storage. For example:
- sometimes a forklift driver could not be found, which meant that a set-up could not proceed; and
- It was a time-consuming task getting the jig plates off the shelves and putting them away once the operation had been completed.

(3) Tools, jigs, etc. were not put away in the correct place.

(4) Operators felt that there was a lack of desk and storage space on which to put tools, clamps, etc.

(5) Jig plates were misplaced on shelves and as a consequence they were not easy to locate when required.

(6) Raw materials not arriving on time.

(7) Finished components or work-in-progress taking up valuable space.

These types of problems result in longer set-up times and greater opportunity for errors and mistakes.

C. Discussions

During the interviews the General Manager, production manager and other middle managers indicated that they wanted to reduce set-up times and errors. The interviews undertaken with operators indicate that this interest has not filtered through to the shop floor. The Factory will not be able to achieve single-minute set-ups and zero defects unless awareness of the importance of this is raised. Management must:

- understand and believe in the link between ``doing things right at first time & always'' and the factory's business strategy;
- understand the practicalities of set-up time reduction and mistake proofing and be able to communicate the principles and techniques to all employees;
- participate in the problem-solving process to reduce set-ups and eliminate errors;
- formulate and maintain a clear idea of what set-up time reduction and

mistake proofing means for the organization. Management must also be prepared to allocate appropriate investments in SMED and mistake proofing devices. The factories are a small independent concern and as a consequence, finance for investment is always going to be problematic. For example, even in the manufacturing cell there was a lack of spare brackets and clamps which are used for transporting and clamping. If any of these items were to be lost then this could potentially halt a set-up. Subsequent reductions in setting-up time are dependent on the investment at work centre level. For example, a common activity in the SMED process is to institute a standard die-clamping system. However, this investment yields little immediate benefit, but it sets the stage for substantial set-up reductions when subsequent investments are made at product level.

There is a lack of planning, organization and structure in the identification and implementation of set-up time reduction and mistake proofing devices. Everything is done in an *ad hoc* manner with only parts of set-up time reduction and mistake proofing methods applied but in an almost random manner. The Factory needs to consider how set-up time reductions and mistake proofing fits into their manufacturing strategy. SMED and mistake proofing applications seem better suited to the cellular manufacturing approach rather than the more traditional functional/process layout. In a cellular system the details created on component families, in terms of shape, dimensions, tolerances, surface finish, holes, re-entrant angles, length to width or length to diameter ratios, etc. provide the ideal database on which to develop SMED and mistake proofing methodologies.

The factory has had in the past little guiding philosophy, core value and beliefs, etc. which manifested itself in terms of housekeeping problems and lack of team working and motivation, poor discipline and a tendency to accept the status quo and a tendency to fritter away valuable production time.

The problem of housekeeping and team working is particularly pertinent to set-up time reductions and the elimination of errors.

The poor housekeeping has resulted in the following problems:

- Operators and engineers are unable to quickly find equipment such as tools, fixtures, clamps, etc.
- Unused and scrapped jigs and fixtures are discarded in places which make them a safety hazard.
- Equipment breakdown is accepted as inevitable.

With respect to team working it was frequently observed that operators in the machined controlled cycle of component manufacturing, which involved 30 minutes of cutting time, did nothing to help their colleagues in setting up an adjacent machine. There are currently no incentives/reward/appreciation systems in place for pursing set-up time reductions and mistake proofing. This, coupled with a lack of a team working ethic, means that the Factory is not fully utilizing the talents of their workforce. The Factory has an adequate training and education Programme, recognized by recent Investors in People award. In the last financial year each person, on average, received the equivalent of six days of training; however this training has not covered SMED and mistake proofing methodologies.

IV. CONCLUSIONS

SMED principles. However, for small batch manufacturers the issues that led to the change in focus for long run producers have not been present to the same degree. In the case of the Factory at the focus of this study, the changeover and set-up times were never measured or, worse still, measured and considered as productive hours. As a consequence there was no awareness and motivation to reduce set-up times as it was considered that this type of action would reduce the productive efficiency of the plant. A further consideration with respect to set-ups is the potential for error in the setting process. Hence, not only is it imperative to focus on reducing the amount of productive time that is lost when a machine is being set, but also to eliminate errors, with the application of poka yoke principles to the setting equipment and procedures.

The main barriers to the implementation of set-up time reductions and mistake proofing were identified to be:

- A lack of financial resources to support the set-up time reduction and mistake proofing devices;
- A resistance to change from middle managers and operators;
- A lack of a strategy to apply SMED and mistake proofing;
- A lack of knowledge and training on these methodologies.

V. ACKNOWLEDGEMENT

The Authors would like to acknowledge the contribution of Mr. Jami Rao (VEPL-V)

VI . REFERENCES

1) ***Shingo, Singo, "A Revolution in Manufacturing": the SMED System, Productivity Press, Cambridge, MA. Shingo, S. (1985b), Zero Quality Control: Source Inspection and the Poka Yoke System, Productivity Press, Cambridge, MA.***

2) ***S.Patel, P.Shaw and B.G.Dale, "Set-up time reduction and mistake proofing methods: A study of application in a small factory" Business Process Management Journal, vol No. 1,2001,pp.65-75.***

3) ***B.Kayis, S Kara, "Set-up Reduction (SUR) in Injection Molding Process- A Study in packing Industry",4th International Conference and Exhibition on Design and Productivity of Machine and Dies / Moulds, Cesme, Turkey, 21-23/6/2007***

4) ***Ali Allahverdi & H.M. Soroush, "The significance of reducing setup times/setup costs" European Journal of Operational Research 187 (2008) 978–984***

5) ***Subhashish Samaddar, Craig A. Hill, "Controlling adverse effect on work in process inventory while reducing machine setup time", European Journal of Operational Research 180 (2007) 249–261***

6) ***Jeffrey E. Schaller b. Jatinder N.D. Gupta," Single machine scheduling with family setups to***

8) ***Kuo-Lung Hou, " An EPQ model with setup cost and process quality as functions of capital expenditure", Applied Mathematical Modeling 31 (2007) 10–17***

9) ***Michele Ciavotta , Paolo Detti , Carlo Meloni , Marco Pranzo, "A bi-objective coordination setup problem in a two-stage production system", European Journal of Operational Research 189 (2008) 734–745***

10) ***Dirk Van Goubergen, Hendrik Van Landeghem, "A Quantitative Approach for Set-Up Reduction of Machine Lines", Production and Inventory Management Journal, 1990. 31(4): p. 55-59.***

11) ***Dirk Van Goubergen, Hendrik Van Landeghem, "An Integrated Methodology for More Effective Set-up Reduction" Production and Inventory Management Journal, 1994. 60 (2): p. 45-59***

12) ***Mehmet Cakmakci, "Process improvement: performance analysis of the setup time reduction-SMED in the automobile industry" Springer-Verlag London Limited 2008***

13) ***Dirk Van Goubergen, Hendrik Van Landeghem, "Reducing Set-up Times of Manufacturing Lines" International Conference on Flexible Automation and Intelligent Manufacturing 2002, Dresden, Germany***

14) ***Mehmet Cakmakci . Mahmut Kemal Karasu, "Set-up time reduction process and integrated predetermined time system MTM-UAS: A study of application in a large size factory of automobile industry" Springer-Verlag London Limited 2006***

15) ***Dirk Van Goubergen, Hendrik Van Landeghem, "An Integrated Methodology for More Effective Set-up Reduction", Proc. IIE Solutions 2000, Cleveland (OH)***