Global Journal of Researches in Engineering
Mechanical and Mechanics Engineering
Volume 12 Issue 5 Version 1.0 Year 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 Print ISSN:0975-5861

Productivity Enhancement by Reducing Setup Time - SMED: Case study in the Automobile factory

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Abstract - The Single Minute Exchange of Die (SMED) is one important lean tool to reduce waste and improve flexibility in manufacturing processes allowing lot size reduction and manufacturing flow improvements. SMED reduces the non-productive time by streamlining and standardizing the operations for exchange tools, using simple techniques and easy applications. However the process doesn't give the specific actions to implement which can result in overlooking improvements. To overcome this, common statistical and industrial engineering tools can be integrated in the SMED approach to improve SMED implementation results.

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GJRE-A Classification : FOR Code : 091399

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Abstract - The Single Minute Exchange of Die (SMED) is one important lean tool to reduce waste and improve flexibility in manufacturing processes allowing lot size reduction and manufacturing flow improvements. SMED reduces the non-productive time by streamlining and standardizing the operations for exchange tools, using simple techniques and easy applications. However the process doesn't give the specific actions to implement which can result in overlooking improvements. To overcome this, common statistical and industrial engineering tools can be integrated in the SMED approach to improve SMED implementation results.

In the present work, experiments were carried out to reduce the setup time and tool change time this are important factors which will take lot of time of the production in an automobile factory. The applicability of the proposed SMED approach was tested for shaping machines changeovers in the automotive industry. The implementation has enabled reduction in setup time, through company's internal resources reorganizations without the need for significant investment.

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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. 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:

a) 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.

b) 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.

c) 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.[1].

II. 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 first step in the implementation of SMED is to separate internal

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(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.

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. The horizontal and vertical dimensions of the contact jigs could be standardized by locating them against stops set into the table, enabling the operators to centre the component more easily. These improvements would not only make the set-ups easier for the machine operators but they will also reduce the set-up times by up to 15 minutes. To facilitate these improvements spacer jigs would have to be made. They are thinner than the main jig plates, making them easier to transport. Another option for the smaller components is to use intermediary jigs, which involve the use of two standardized jig plates of the appropriate size and shape. When the component attached to one of the plates is being processed, the next component can be centered and attached to the other jig. When the first component is finished, this second jig, together with the attached component, can be mounted on the machine. From the set-ups observed it was found that operators spend considerable time attaching and fastening jigs and components, and undertaking the necessary checks, and in some cases these fastenings were problematic.

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	Time After 28.03.10	Time After 11.04.10
1	To prepared trolley for setup	120	120	110		External			0	0	0
2	Take a Allan key	10	10	10	Internal				02	02	02
3	Rotate the fixture	30	30	34	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	66	Internal		By compressed Air (Air run)	Repeated activity	05	05	06
6	Remove the fixtures bolts	40	35	38	Internal		By automatic Spanner		15	15	17
7	**Remove**	200	206	209	Intern		By		45	47	47

	the previous fixture				al		automatic Spanner				
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	28	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 run)		10	12	09
11	Take new fixture	10	10	8		External			05	05	05
12	Rotate the base plate	20	20	22	Internal				15	16	15
13	To clean the new fixture by compressed air	20	20	18		External	By compressed Air (Air run)		00	00	00
14	Clean the base plate	40	40	37	Internal		By compressed Air (Air run)		10	11	12
15	To take dial indicator with magnetic stand	10	10	7		External		Repeated activity	10	10	08
16	To fixed & adjust the collector	65	60	58	Internal		By compressed Air (Air run)		30	32	29
17	To fixed the new fixture	85	75	74	Internal		By compressed Air (Air run)		60	62	61
18	**To fixed the bolts of fixture**	278	240	247	Internal		By compressed Air (Air run)		30	32	33
19	To rotate, tight & adjust the fixture	120	100	116	Internal		By compressed Air (Air run)		30	29	27
20	To fixed the stand of dial indicator	10	10	07	Internal				12	10	11

21	To check the run-out of tie rod	100	100	103	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 run)		20	22	23
23	To remove the dial indicator	20	20	18	Internal				10	10	09
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 Critical Activity**	40	43	44
26	To fix the job & fix the cap	45	50	52	Internal				25	24	25
27	To set the machine parameter	150	100	120	Internal			External activity	00	00	00
	Total time (sec)	**2651**	**2636**	**2733**					**474**	**478**	**486**
	Total time (Min)	**45**	**44**	**46**					**7.9**	**7.96**	**8.1**

Table 2.1 : Worksheet analysis showing the original and improved setup time of Machine BA 4156; Lorenz gear

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.

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.

III. Discussion on Findings

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.

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

In this study, SMED methodology is applied to prepare an optimal standard procedure for changeover operations on defined machine. Ergonomics and safety issues were also taken into consideration during setups. Since an ergonomic workplace makes operations easier for the operators, simple however crucial changes are suggested. Further studies in the facility may include 5S and Kaizen studies for internal setup. Alternative ways to shorten internal setups can be searched in detail. In order to eliminate adjustment steps, trial and errors should be minimized. Settings must be used for changeover operations instead of adjustments.

Therefore, a design of experiments study can be done to determine parameters of the machine. It should be kept in mind that successful implementation of new production methods requires sustainability and permanent solutions and the key of sustainability is the standardization of that optimal solution.

As a conclusion, it can be stated that SMED "single –minute exchange of die" in other words "Quick Changeover" is still a suitable method not only for manufacturing improvement but also for equipment/ die design development.

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