Reduction of Setup Time on Gear Case during Machining Using SMED Technique

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ABSTRACT: As we are acquainted with the fact that the major motive of any industry is the fulfilment of customer's requirements and increase its own production; so in order to achieve this, Setup time reduction plays a crucial role. This project is focused upon the reduction of setup time of Gear case on machining; under the leading Geared motors & reducers producing Company.
Here, Dr. Shingo's Single Minute Exchange of Die (SMED) has been used for obtaining an affirmative reduction in setup time by conversion of internal factors to external factors and streamlining them properly. SMED is a systematically framed and well drafted methodology which sanctions reduction of setup time from hours to less than 10 minutes. Once setup time is reduced, it will increase the productivity of gear cases and harmonize the cost and timing for the final product. Inventory will decrease thereof. Compiling the essential points of this research work, it aids in overall reduction of setup time and changeover time of up to 52.85%.

Keywords: *Setup time, SMED, Internal setup, External setup*

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1. INTRODUCTION

In order to reduce the overall cost of the product, one should reduce the cycle time of the product and secondly, reduce the setup time of the product. "Setup time" can be defined as amount of time taken to change from the last part of a production lot to the first good part of the next production lot. Therefore, setup time reduction is an important feature of the continuous improvement program of any manufacturing/service organization [1].

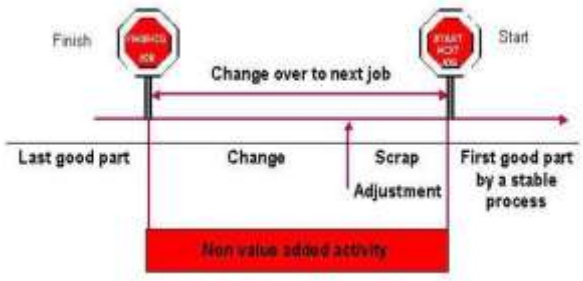

Fig-1: Changeover Process

Single Minute Exchange of Die (SMED) introduced by Shingo is a theory and set of techniques that make it possible to perform equipment setup operations in fewer than 10 min [2]. In SMED method, all activities of setup operations can be divided into two categories: Internal activities which can be performed while the machine is offline and therefore must be minimized because they decelerate the production; and External activities that are performed while the machine is running [3].

2. LITERATURE REVIEW

Mohammed Ali Almomani [3] et al uses conventional SMED and Multiple Criteria Decision Making techniques to reduce setup time. The case study was conducted in PVC extruder die exchange operations. With the use of this methods machines utilization and productivity is increased. After implementing the above mention techniques, they were able to reduce the time to 34 min from previous measurement of 130 min; saving almost 96 min.

M. Kemal Karasu [2] et al has conducted case study at injection molding industry where along with SMED, Taguchi design of experiment is incorporated with it to achieve the quality product with fewer trials. Before implementing the tools, 93 min were taken for changeover after implementing SMED it takes 61 min; but trial error production and resetting of injection parameters was taking around 40 min, so Taguchi method is used further. Using Taguchi method the number of trials which were 26 is reduced to 18 which means 30% improvement and saving approximately 15 min.

Smith [4] et al carried out research on setup time reduction in tablet manufacturing company. The utilization of machines was 38 percent; where two main reasons for non-utilization were setup time and unmanned time. The setup time was 27.9 percent of overall time. In that time, 45% time was ineffective time which was accounted for mainly by waiting time when the key resources such as setters, fitters and tooling were not available. In the first meeting on Principles of SMED, particularly the discussion on internal

and external activities was completed. The second meeting concentrated on problems encountered by the setters; and third meeting involved splitting the problems into small sub groups to explore possible solutions. The setup time declined from 27.9 to 7 percent of overall time & operating time devoted to 38 to 57 percent.

Charles F. Keberdle [5] explained importance of setup time reduction. The paper examines the definition, uses, benefits and techniques of reducing setup time in a very brief form. This paper explains how to gain valuable manufacturing capacity in a very short time; applying creativity and common sense before investing capital.

S. Patel [6] et al identified and examined the critical success factors relating to the social & scientific issues involved with the implementation of the SMED and mistake proofing together with associate problems and barriers. Four manufacturing companies were observed which uses traditional work study type methods instead of Shingo's single minute exchange of die and Poka-yoke. So, they implemented SMED and Poka-yoke to avoid accidents/mistakes and reduce setup time. The mistake proofing devices used by the four companies can be classified as control and warning methods. The main Control methods used are jigs, pegs or guide pins, Reset/interlock devices, gauges and beam sensors. All the four companies use fixtures, Pre-set tooling and automatic toll changer mechanism to reduce set-up time and mistake. The company reduces the time mainly by using teamwork, standardization methods, work study, new machinery/ technology, empowerment, fixtures/fittings, pre-set tooling and automatic tool changers. But after implementing mistake proofing and SMED the elimination of set-up errors and improved quality, decreased set-up times and increased safety.

SMED technique is a very reliable, abridged technical approach which can be used by any type of industry In case of companies using traditional methods, use of SMED & implementation of mistake proofing can eliminate set-up errors and improves quality; decreases set-up times and can increase the safety. Taguchi design of experiment is incorporated into SMED methodology to achieve the quality product with fewer trials. SMED can be used to increase capacity, operational availability to reduce manufacturing cost and increase flexibility to meet the customer demand; along with greater variety of products and greater volume. As time is precious, SMED brings a number of boons along with its implementation.

3. CASE STUDY

The SMED (Single Minute Exchange of Dies) is implemented on four HMC machines namely HMC-5, 6, 8 and 9. The number of setup per month is around 10 per machine which means around 40 setups. The setup time is much more; as the costs of machines are very high, which cannot afford non-value added time. Per machine one operator is allotted. The whole process is converted in five parts which are as follows:

1. Tool holding
2. Work holding
3. WPC
4. Inspection and
5. Machining

To reduce the overall time of setup these five parts must be studied properly and proper steps should be taken to reduce it.

Step -1 Observe the current set up process.

Firstly, we have made a sheet to record the data of the setup time. In which along with activity, its sub activity is also mentioned. Through that the Pareto chart has been constructed, and have highlighted the activity which takes the unnecessary time. Later, we started to take videos so that we can observe each process thoroughly. Various data have been recorded. The pattern of data is shown in table 1.

Setup Activity Chart M2/3 Foot to M07 Foot

Sr. No.	Activity	Detail Activity	Time Taken Before (in min.)	Cumulative	Time Taken After (in min.)	Cumulative	Action taken
1	Tool holding	Tool Assign (f/f)	3	3			
2	Tool holding	Tool loading in magazine	4	7			
3	Tool holding	Tool length measure	13	20			
4	WPC Check	Programme correction	9	29			
5	Machining	Machining	2	31			
6	Work holding	Boring fixture l & ul	13	44			
7	Work holding	Fixture truing	4	48			

8	Work holding	Gear case clamp	20	68			
9	Tool holding	Insert check	11	79			
10	Tool holding	Tool Assign (s/s)	12	91			
11	Tool holding	Tool loading in magazine	15	106			
12	Tool holding	Waiting for tool	19	125			
13	Tool holding	Tool length measure	26	151			
14	WPC Check	Z-check	3	154			
15	Tool holding	Rough bore set	11	165			
16	Tool holding	Finish bore set	26	191			
17	Machining	Machining	3	194			
18	Inspection	Program correction after correction	29	223			
	Total		223				

Table-1: Data Sheet

With properly converting the activity in this five parts and segregating the activity the Pareto chart for the five activities has been made as shown below.

Activity	Time (in min)
Tool holding	140
Work holding	37
Inspection	29
WPC Check	12
Machining	5

Table-2: Setup Activity Table

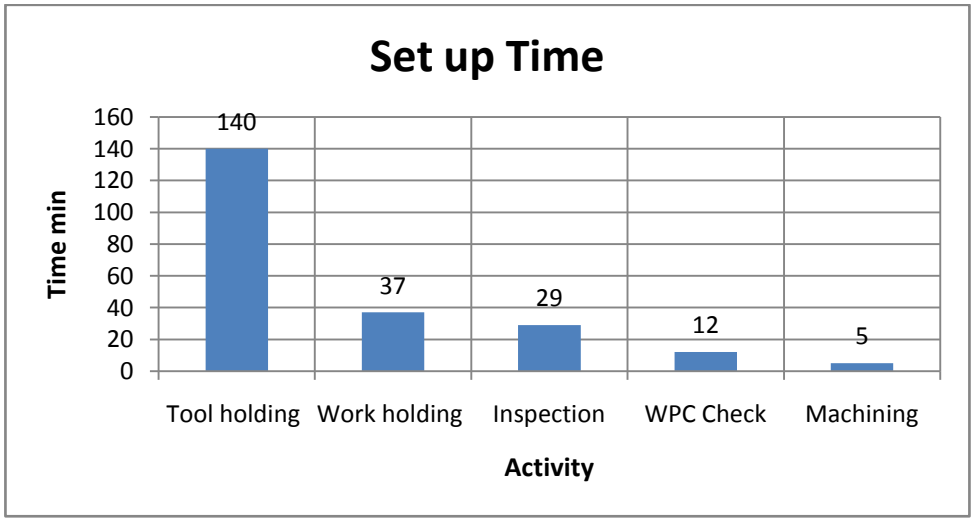

Fig-2: Setup Activity Graph

From the above graph, it is clear that the tool holding activity holds the maximum time out of the five activities. So, we started first with the tool holding activity and then work holding and so on decreasing order of time.

Step -2 Classifying activities into internal and external activities and separating external activities from it.

As per data collected during the setup, all the activities were of internal type but some activities were there which we can convert easily with the help of supervisor or other operator;

but at that time one operator was assigned per machine so, all activities which were recorded were of internal type. The other activities like unloading of previous gear case foot side and its fixture were remaining sometimes but later on with sufficient training it was made external.

Step – 3 Convert internal activities in to external activities.

In table 1 the digits with yellow color have been worked upon. Firstly the work has been done on loading and unloading of the second side fixture. If the same operator, who is doing the setup, will also do loading and unloading of the second side fixture, then it will consume the time. On an average 10-12 minutes have been wasted on it. In order to improve this, another operator has been placed for loading and unloading of the second side fixture and hence, the activity of changing the second side fixture has been converted into external activity.

For loading of the second side gear case it usually takes 20 minutes while if we first load foot only it takes 5 minutes. So, to reduce the time first the second gear case of foot will be started. At the time of loading the second side machine will be on. On an average 15 minutes can be saved.

One of the main aspects to reduce time during setup is tool preparation. If the tools are well prepared before the setup then setup can be finished in less time. But here during setup at least 5 tools were left to prepare. In preparing those 5 tools around 21 minutes were wasted in tool making during setup. So to reduce time tool making must be made external activity. For that tables have been made where all tools will be kept before starting the setup. Along with that one separate operator has been appointed whose job is to make tools only at proper time. Training has been given to him for making accurate tools on time to convert the tool making an external factor.

Along with that around 8 minutes are wasted for changing the insert, training is given for that purpose to make this activity an external one.

After the gear case was completed, the machine was stopped for inspection, so that the correction can be done before the next gear case starts, so that the successive work piece will be perfect. But if the operator is trained properly to inspect the foot facing then the foot can be inspected in 10-12 minutes with all the dimensions. After that the other foot is started; later the unloading of second side gear case is done and then the supervisor will inspect the whole gear case. So inspection time which was taking around 28 minutes has been reduced to 12 minutes.

The other main factor because of which the setup time is more, is the time taken to record the tool length because if the tool length is not taken properly accidents can take place. Firstly the length was taken inside the machine, during which the machine remains in off condition which doesn't add any value to the product. In four machines HMC-5 has BT-50 taper spindle block, HMC-6 has BT-40 spindle and HMC-8 & 9 has BT-40+ spindle. With the help of the design, spindle block has been made because of which the tool length activity has been made an external activity. The images of the BT-50 and BT-40 are shown in the figure 3 and 4 respectively. There is only 3mm difference in BT-40 and BT-40+ taper block, so after taking length in the BT-40 taper block, 3mm is added in it so the length for the BT-40+ is ready. With this spindle block the tool length activity has been made an external factor. Now, on an average 18 tools is there whose length has to be taken and on an average 2.2 minutes is consumed for taking one tool length, so around 40 minutes has been reduced here.

Fig-3: BT-50 Taper Block

Fig-4: BT-40 Taper Block

Further, the boring bar gauge has been made to reduce the time of setting the rough boring bar during the setup. On an average 8 minutes were taken to set the rough boring bar. After the use of this gauge, the activity has been converted into an external activity. The figure 5 is showing how the boring bar is made with the help of gauge, so that there is no need to fix it during the setup.

Fig-5: Rough Boring Bar Gauge

Work is carried out further for reducing the finish bore set during setup which consumes more time. For this the use of reamer has been started on HMC- 8 & 9. With the use of this the finish bore setting time on the machines is eliminated. The use of this reamer is limited right now because the larger size reamer vibrates more and can cause bore oversize defect. The reamer should be used because it has good accuracy and it can compensate the cost well. With the use of reamer, around 25 minutes are reduced; which is the time taken up normally for the setting of finish bore.

By either eliminating or reducing the time some activities which were taking more time has been converted into external activity from internal activity. Table 3 shows the data sheet comparison between both the data's i.e. before and after the implementation of SMED.

Setup Activity Chart M2/3 Foot to M07 Foot							
Sr. No.	Activity	Detail Activity	Time Taken Before (in min.)	Cumulative	Time Taken After (in min.)	Cumulative	Action taken
1	Tool holding	Tool Assign (f/f)	3	3	3	3	
2	Tool holding	Tool loading in magazine	4	7	4	7	
3	Tool holding	Tool length measure	13	20	0	7	Spindle block is made to take length externally
4	WPC Check	Programme correction	9	29	4	11	
5	Machining	Machining	2	31	3	14	
6	Work holding	Boring fixture l & ul	13	44	0	14	When first side setup start than other operator load & unload second side fixture
7	Work holding	Fixture truing	4	48	0	14	Eliminate
8	Work holding	Gear case clamp	20	68	5	19	Reduce
9	Tool holding	Insert check	11	79	0	19	Eliminate
10	Tool holding	Tool Assign (s/s)	12	91	13	32	
11	Tool holding	Tool loading in magazine	15	106	14	46	
12	Tool holding	Waiting for tool	19	125	0	46	Prepare advance tooling
13	Tool holding	Tool length measure	26	151	0	46	Spindle block is made to take length externally
14	WPC Check	Z-check	3	154	3	49	
15	Tool holding	Rough bore set	11	165	0	49	Gauge has been

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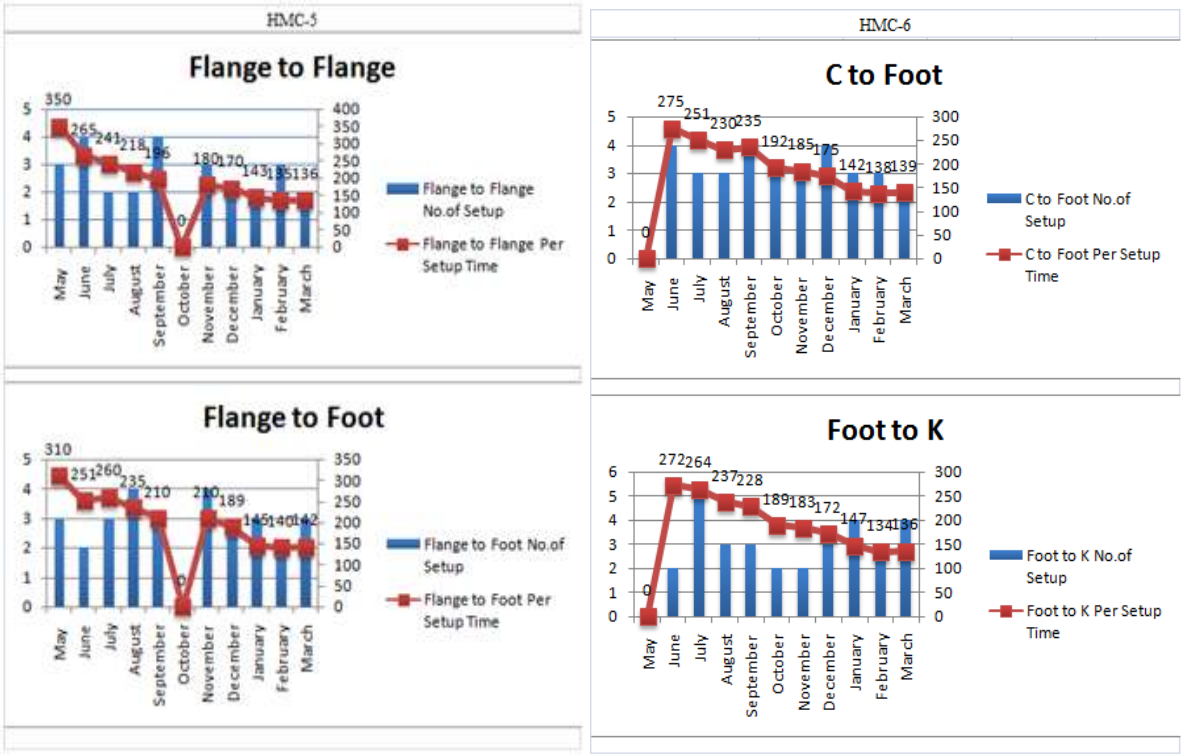
							made according to requirement
16	Tool holding	Finish bore set	26	191	0	49	Use of reamer has been started
17	Machining	Machining	3	194	3	52	
18	Inspection	Program correction after correction	29	223	12	64	During inspection the foot facing should be on since it is inspected by operator
	Total		223		64		

Table-3: Data Sheet after Implementation

4. RESULTS

After implementation of SMED methodology to HMC machines, the data collected need to be analysed in order to scrutinize the effectiveness of changes made through SMED for the reduction of setup time. Monthly data has been collected for time utilized for Setup on four HMC machines. For analysing data perfectly and with thorough ease, Pareto chart analysis method is used for individual settings.



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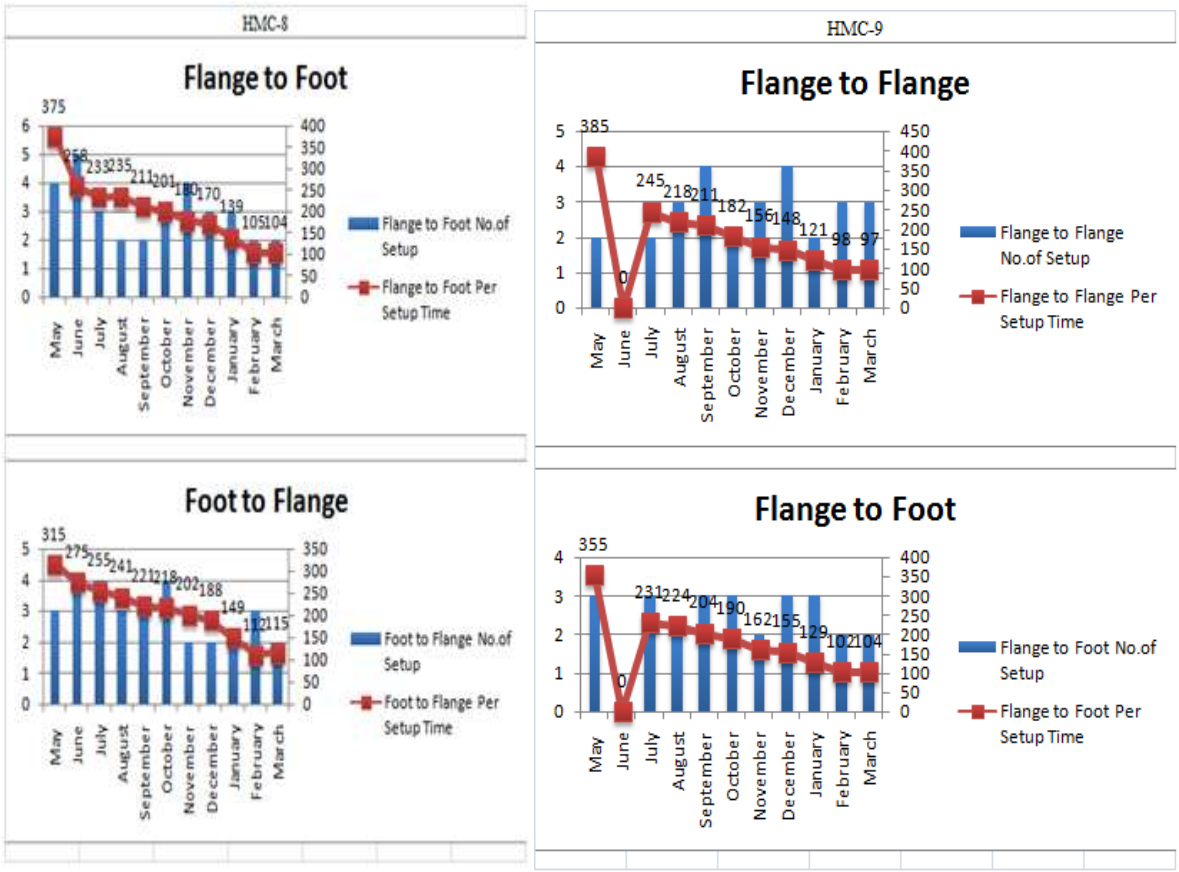

Fig-6: Graph of Minutes Before & After Implementation

HMC	Before Time (in min)	After Time (in min)	Difference (in min)	Percentage Reduction
5	262	140	122	46.56%
6	268	139	129	48.13%
8	256	107	149	58.20%
9	246	102	144	58.53%

Table-4: Percentage Reduction of Setup Time on HMC

With the help of calculation the following results are clear:

1. **225 gear cases** have been increased on **HMC-5 per year**.
2. **608 gear cases** have been increased on **HMC-6 per year**.
3. **390 gear cases** have been increased on **HMC-8 per year**.
4. **617 gear cases** have been increased on **HMC-9 per year**.

5. CONCLUSION

In manufacturing process, most of the time is wasted due to long setup times. So keeping into mind this obstacle for success in production, research work is done in manufacturing company by using SMED technique. The overall conclusions obtained on analyzing the results of Case study are as follows:

- The overall reduction in Setup time is 52.85% including all four HMC machines.
- With the help of SMED technique, overall production of 1840 gear case per year has been increased by reduction of Setup time.
- Thus the productivity of gear case has been increased by 5.041%.

REFERENCES

[1] Ali Allahverdi, H.M. Soroush "The significance of reducing setup times/setup costs", European Journal of Operational Research, 7 November, 2006.

[2] M. Kemal Karasu, Mehmet Cakmakci, Merve B. Cakiroglu, ElifAyva, NeslihanDemirel-Ortabas "Improvement of changeover times via Taguchi empowered SMED/case study on injection molding production" , 2 October 2013.

[3] Mohammed Ali Almomani, Mohammed Aladeemy, AbdelhakimAbdelhadi& Ahmad Mumani, "A proposed approach for setup time reduction through integrating conventional SMED method with multiple criteria decision-making techniques", Computer and Industrial Engineering, 25 July 2013.

[4] Gilmore, M. and Smith, D.J., "Set-up reduction in pharmaceutical manufacturing: an action research study",

International Journal of Operations & Production Management, Vol.16 No. 3, pp. 4-14.

[5] Charles F. Keberdle, CPIM "Reducing Machine Setup & Changeover Times", 2008

[6] S. Patel, B.G. Dale and P. Shaw, "Set-up time reduction and mistake proofing methods: an examination in precision component manufacturing", Volume 13. Number 3. 2001