International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Effectiveness of the Single Minute Exchange of Die (SMED) Technique for the Productivity Improvement

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Abstract.

The Single Minute Exchange of Die (SMED), a process-based innovation originally published in the mid-1980s, involves the separation and conversion of internal setup operations into external ones. Traditionally some of the manufacturing company facing the problem loss of available time due to spent time for the changeover processes. Changeover process time meaning changing the programming or operation sequences on the machine based on process requirement during the change from one to another one model especially for the mixing parts. SMED technique is a systematic approach that enables to reducedramatically the “set-up time” or “changeover time”. Normally in the SMED technique, it was segregated between internal and external set-up. External set-up means any processing time was done up front which is before machine stop and internal time is any tasks was performed during machinein operating, which is considering changeover time. The impact to organization that it was increasing the productivity, capacity and at the same time increased the revenue. This paper focuses on the improving the productivity on the CNC machine process through implementing SMED technique and eliminating waste in the case study company.

Keywords: Single Minute Exchange of Die, Internal Setup, External Setup, Changeover Time

1. Introduction

In the present world scenario, the flexibility and responsiveness to customer demands are the imperative task. For example, in the expander machine of rim manufacturing unit, additional time is needed for exchange of setup. These in turns stop the activities of other processes for about 90 minutes, which probably breaks the production of rim in this unit. As this setup exchange is inevitable, the only solution is to reduce the time consumption. At this point, the process of Single Minute Exchange of Die (SMED) comes into play. A SMED goal is a quick changeover of setup. It is a suitable method not only for improving manufacturing process but also for the equipment design development. Customers are expected to get the reliable products in a short time. To accomplish this, it is needed to eliminate and improve productivity and quality. It is a customer driven requirement who demands a product and service diversity, high reliability, quality and meeting customer satisfaction.An example application of SMED is in formula one (F1) racing during change the tires. When an auto racer stops in the pits for fuel, tires, water, and whatever else they need, they do not stop racing. In the pits, they are racing the clock because to stop means they are giving up their place to the competitors who are still on the track. Typically they are in and out of the pit in approximately 10 to 15 seconds. At the racing speeds of 200 miles per hour, an extra second in the pits represent over 200 foots on the racetrack. The margins of victory in many races are often in inches.How does that race cars get in and out of the pit so quickly? While it may not be obvious or easy, the concepts and methods used are fairly simple. First, the specific pit stop process is formally defined. Everybody on the pit crew knows his job and everybody focuses and steps up to achieve the overall objective of short pit times.

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They have all parts and materials pre-staged before the pit stop begins. They have eliminated the use of tools where possible (i.e.; tear away windshields) and use the proper tool where they cannot be eliminated. Standardization of tools is done as much as possible. This same concept was applied in any manufacturing plant for changeover. These concepts and methods are called SMED, Quick Changeover, Setup Time Reduction, and or Turnaround Time Reduction. SMED, Single-Minute Exchange of Die, is a set of techniques for performing setup operations in below ten minutes (in a number of minutes expressed in a single digit.) The SMED method was formally practiced and originally written about by Mr. Shingo in the 1950's. The concept has revolutionized Japanese manufacturing since that time. The concepts and techniques became available around 1974 in West Germany and Switzerland and in 1976 in other parts of Europe and United States. However, not until the 1980s did the SMED technique began to gain acceptance with companies outside Japan.A production plant and its processes were in place 24 hours a day, 7 days a week, year round. In an ideal world, it would be nice if manufacturing plant could utilize those assets 24 x 7 year round as well. However, 24 x 7 year rounds are not feasible. Even if the plant produces only one product and never has to changeover, even if no unplanned downtime occurs, even if the plant is able to produce yields of raw material to product of 100%, planned downtime is necessary to provide the kind of repair, maintenance, installation that creates a state of repair in which unplanned downtime and poor yields do not occur.However, the ideal world does not exist for most operational plants, multiple products are often produced in the same process and therefore downtime is needed to change from one product to another. Some pieces of equipment within a process need to be cleaned or have planned but frequent maintenance need to be done to them. Unplanned downtime does occur. Yield, well some plants are lucky to have 80% yields. Inefficiency is the norm more than the exception to the rule. SMED can help the managements avoid unnecessary buildup of inventory due to the desire to have process efficiency by providing the process capability to change over, clean, or maintain the process in a quick non obtrusive, and efficient fashion.

The objective of this paper is to improve the productivity by using SMED technique and waste elimination and achieving 95% of the productivity in CNC process. Based on the study, the result shows lower productivity due to high changeover time during changing model which affected the productivity for the CNC process in the case studycompany. The scope and limitation are usingSMED methodology, PDCAapproach to meet the objectives and focusing on CNC machining process, which consider as changeover time.Traditionally firms regarded setup times as one of the most expensive costs they had to face and opted for both the minimization of the number setups carried out and for very large production lots [1]. This method contributed to an excessive inventory because they produced more than they needed to satisfy customer's needs [3]. Nowadays, the general understanding is that mass production has become obsolete as production costs have increased and efficiency has decreased steadily [1]. Today firms are forced to compete, simultaneously, in terms of price, product quality, product differentiation, and delivery time. To improve production processes, it is necessary to analyze the value added by each activity and eliminate all those that do not add value to the product [4], which makes the SMED methodology extraordinarily important.

2. Literature Review

SMED, also known as Quick changeover of tools, was developed by Shingo [5], who characterized it as a scientific approach for the reduction of setup times, and which can be applied in any industrial unit and by any machine. SMED was defined as the minimum amount of time necessary to change the type of production activity considering the moment in which the last piece of a previous lot was produced the first piece produced by the subsequent lot (Shingo, 1985). Before the development of the SMED methodology, the best way to minimize the cost of idle machines during setup operations was to produce large lots, in order to obtain the lowest possible percentage of idle time per unit produced. According to Min and Pheng [6], the ideal amount of each production lot was obtained when the inventory costs equaled the costs of idle equipment during the changeover of tools.Toyota came across this problem because the inventory costs for their vehicles were extremely high. Before this problem, the best way to reduce the amount of production loss was to reduce the setup times [5]. Thus, if production changes could be done in less time, the ideal amount of production could be smaller, which, consequently, would decrease the costs involved. The question around the optimum amount of the production lot remains as it is necessary to calculate the minimum amount for each production lot. The production of large lots also has inherent capital costs with the amount invested in inventory. If we add to this inventory cost the capital opportunity cost, it is no longer profitable to produce large lots. In the Single Minutes exchange Of Die there are four stages involved to make a setup reductions which are Preliminary stages, Separate internal and external setup, Convert internal to external setup and Streamlining all aspect of setup. In Single Minutes exchange Of Die (SMED), two important operations are involved. They are the internal and external setups:

- Internal time : can be only carried out when the machine or process has stopped
- External time : could be while the machine or process is still in operating

The SMED concepts was applied accordingly to certain pre-determined conventional process, Plan-Do-Check-Act (PDCA) cycle is a checklist of four stages which must be gone through, to get from 'problem-faced' to 'problem-solved'.

3. Data Collection and Improvement Activity

This paper is the summary resultof the research project which is was conducted at case study company, and the research werestarted with the process familiarization. The case study company was supplied the child parts for the automotive, medical and oil and gas sectors. At this stage, the all steps of the processes involved need to be understood and identify the actual problem at the CNC department especially the low productivity. The SMED technique wasappliedto solve the problem of the high changeover time or conversion time. Analysis of the problem has beenconductedand the root cause wasidentified. Three important tools that wereused in collecting data are stop watch, cam recorder and camera. Once the problem has been identified, the next steps are proposing the countermeasure of the appeared problem and improve the actual process. To improve the actual process, the SMED technique wasapplied to reduce the machine changeover. All the data were analyzed and the improvement activity was carried out to improve the current machine changeover time. Verification was done using mathematical equations to check and shows the impact of productivity and capacity based on the improvement activity. The actual data have been collected and shows in Table 1. Based on the actual condition, the results showed the machine need 4.15 hours for the changeover time before producing the next product. The frequency of the changeover is 2 times per week equivalent to 8.3 hours per week. That means the company losses 8.3 hours per week to produce the part due to change over time. Three steps were used to reduce the machine changeover time. The first is by separating the external activities and the internal activities. Table 2 shows the cheek sheet internal versus the external time. Based on the results, the procedures of all set-up tools or operation were segregated into internal activities and external activities. After the segregated all activities into internal and external activities have been done, the time has taken for each activity was calculated. The external activities show that 1 hour 11 minutes can be reduced if all the activities that in this group were prepared before the next product batch were started. The second step is by using working instruction. The working instructions were used to eliminate the error. The data show that the wrong installation of the holder injector causes the 48 minutes was used to install back the holder injector in the right position. Working instruction or check sheet was applied to eliminate this error because the machine setter should check the holder injector and ensure that the position of the holder injector is in the right position based on the picture in the working instruction. The last step is proposed to dedicate drawer tool cabinet with caster. The main problem is when the setup was done, the machine setter always going back to the tool room to take the tools that should be used. This situation happens because the machine setter need to bring all the tools to the machine and usually they always forget to bring certain important tools that should be used when the set up were done. To solve this problem, the drawer tool cabinet with caster was used to eliminate the waste of the motion. This drawer was designed to facilitate the machine setter to bring all the tools needed when the set up was done as per Figure 1.

Table 1: Current process of Change-over

Current Process & time				
Area/Department : CNC Department	Part Name : Core XM5	Machine : A20	Standard Set-Up Time : 5 Hour	
	Part No : 182-0033-01	Date : 30/03/2012	Time Start Setting : 10.00 A.M	
No	**Set Up Tool Required/Operation**	**Time**	**Int**	**Ext**
1	Find a memory card	5 minutes		
2	Find programming	3 minutes		
3	Transfer programming	14 minutes		
4	Change tool - Find collect - Change collect - Install tool - Change finger chuck	1 hour, 11 minutes		
5	Setting cut off	2 minutes		
6	Zero set for all tools	13 minutes		
7	Modified programming - Check using single block	8 minutes		
8	Test run - Measure dimension - Test until get a perfect dimensional	35 minutes		
9	Set back spindle - Using point drill - Test run	30 minutes		
10	Install boring tool - Test run - Measure dimension - Wrong installation of injector	1 hour, 3 minutes		
11	Last Dimensional Check (QC check) - Using Vernier Caliper - Using Micrometer - Using Dial Test Indicator - Using Profile Projector	5 minutes		
TOTAL TIME 4 HOUR 9 MINUTES				
FULLY RUN TIME TO PRODUCE PRODUCT : 3.00 P.M				
*REMARK : TOTAL TIME 4 HOUR 9 MINUTES (NOT INCLUDE REST TIME)				

Table 2: Change-over after improvement

Current Process & time				
Area/Department : CNC Department	Part Name : CoreXM5	Machine : A20	Standard Set-Up Time : 5 Hour	
	Part No : 182-0033-01	Date : 30/03/2012	Time Start Setting : 10.00 A.M	
No	**Set Up Tool Required/Operation**		**Internal**	**External**
1	Find a memory card			5 minutes
2	Find programming			3 minutes
3	Transfer programming			14 minutes
4	Change tool			
	- Find collect			1 minutes
	- Change collect		25 minutes	
	- Install tool		40 minutes	
	- Change finger chuck		5 minutes	
5	Setting cut off		2 minutes	
6	Zero set for all tools		13 minutes	
7	Modified programming - Check using single block		8 minutes	
8	Test run			
	- Measure dimension		5 minutes	
	- Test until get a perfect dimensional		30 minutes	
9	Set back spindle			
	- Using point drill		25 minutes	
	- Test run		5 minutes	
10	Install boring tool			
	- Test run		10 minutes	
	- Measure dimension		5 minutes	
	- Wrong installation of injector			48 minutes
11	Last Dimensional Check (QC check)			
	- Using Vernier Caliper		1 minutes	
	- Using Micrometer		1 minutes	
	- Using Dial Test Indicator		1 minutes	
	- Using Profile Projector		2 minutes	
TOTAL TIME			**2 hour 58 minutes**	**1 hour 11 minutes**
FULLY RUN TIME TO PRODUCE PRODUCT : 3.00 P.M				
*REMARK : TOTAL TIME 4 HOUR 9 MINUTES (NOT INCLUDE REST TIME)				

Figure 1: Drawer Tools Cabinet with Caster

4. Result and Discussion

The first step to reduce the changeover time of the machine is by separating the internal activities and external activities. The detail of this separating activity is shown by using the network model analysis and the working instruction was used to eliminate the error when the set up was done. For the improvement, the drawer tool cabinet was used to reduce the motions of the machine setter. All the improvement activities and improvement percentage are shows in the Table 3.Based on the result, the implementation ofthe working instruction or check sheet was improved 100% of the errors and using dedicated drawer tool cabinet it can improve 11.4% of productivity. In overall results, once the improvement has been implemented, the changeover time or conversion time was reduced28.5%. The project objectives have been achieved where the productivity was increased from 93% to 95.6% and changeover time wasreduced to 28.5%.

Table 3: Improvement Activities and Improvement

Improvement Activities	Current	Future	Improve	Improvement Percentage
Working Instruction (Eliminate Failure)	48	0	48	100%
Workstation (Drawer)	201	178	23	11.4%
Cycle Time	249	178	71	28.5%

5. Conclusion

In the manufacturing process, the changeover time means when the last item produce has been completed, the equipment and machinery are shut down, and cleaned and new tooling is added and changed. This gets the equipment ready for the produce on a new product with a different model. This changeover can involves a number of small to large adjustments, re-supply of raw materials, and system checks before the machines are starting up again. Even after the machines have been started and materials used, operators may need to continue their adjustments to produce an item that meets the desired requirements. The time spent during changeover costs the company money as there are no finished items being produced. The high machine changeover wasaffecting the productivity of the product produced. Based on this research project, the result shows that with the simple improvement it was reflecting the management in term of financial activities. The steps in SMED were used to make the improvement to ensure that the productivity can be increased and the time has taken for the machine changeover can be reduced. Some benefits were gains from the SMED project are increased customer service levels and profits. The most important from lean principles is waste elimination and from the SMED technique it was able to reduce lead times which are effectof faster delivery and improved cost of set-up are lower due to less time spent during changeover and less waste. In overall of research project, the result shows that the productivity was increased to 95.6%.

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