International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 04, April-2015

Improving the Efficiency of Steam Turbine Rotor Manufacturing

Sharanakumar[1]
M.Tech student, Department of IEM
M S Ramaiah Institute of Technology
Bangalore, India

Dr. Chethan Kumar C S[2], S. Appaiah[3]
Professor[2, 3], Department of IEM
M S Ramaiah Institute of Technology
Bangalore, India

Abstract*—The project was carried out at a reputed steam turbine rotor manufacturing unit, Bangalore. The product considered is steam turbine rotor used for generating power in sugar plant, it is a job order production. Previously, when this rotor was manufactured, the company was not able to supply the product to the customer at the promised time. The customer was not satisfied with this and demanded that the rotor be supplied in time. The cause for this was that the time required to manufacture this particular rotor was 7207 minutes which is quite high. The objective of this project is to reduce the cycle time of the steam turbine rotor manufacturing. The operations involved in steam turbine rotor manufacturing were noted and data was collected for each operation. The operations were classified into value added and non-value added activities and critical examination was applied to non-value added activities that took place on the CNC machine. The non-value added activities that were identified were approach checking, checking dimension values, inspection and chip cleaning. By the application of critical examination, the non-value added activity time was reduced from 1669 minutes to an estimated time of 635 minutes. Single Minute Exchange of Dies technique was applied for the three set up operations. The activities involved in the set up operations were divided into internal and external activities, reducing external and internal activities and then streamlining the internal activities. By doing so the set up operation time was reduced from 2280 minutes to an estimated time of 2140 minutes. By the application of critical examination and single minute exchange of dies technique, the cycle time to manufacture the steam turbine rotor is reduced from 7207 minutes to 6033 minutes. The estimated savings because of the cycle time reduction is found to be Rs. 1, 17,400/-.

***Keywords*— Cycle Time, Value Added Activities, Non Value Added Activities, SMED, Internal Activities, External Activities, Setup time.**

I. INTRODUCTION

Method study is the technique of systematic recording and critical examination of existing and proposed ways of doing work and developing an easier and economical method [7] [8]. Method study is essentially used for finding better ways of doing work. It is a technique for cost reduction [9]. The philosophy of method study is that 'there is always a better way of doing a job' and the tools of method study are designed to systematically arrive at this better way of doing a job [12]. This procedure involves seven basic steps as follows [10]:

1. Select the work to be studied.
2. Record all facts about the method by direct observation.
3. Examine the above facts critically.
4. Develop the most efficient and economic method.
5. Define the new method.
6. Install the new method
7. Maintain the new method by regular checking

Single Minute Exchange of Die (SMED) is one of the many lean production methods for reducing waste in a manufacturing process [3]. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product [1]. This rapid changeover is key to reducing production lot sizes and thereby improving flow [11]. The phrase "single minute" does not mean that all changeovers and startups should take only *one* minute, but that they should take less than 10 minutes (in other words, "single-digit minute")[2]. Closely associated is a yet more difficult concept, One-Touch Exchange of Die, (OTED), which says changeovers can and should take less than 100 seconds.

II. OBJECTIVES

Productivity improvement by reducing the cycle time for Rotor manufacturing.

III. METHODOLOGY

- Selection of study to be carried out i.e., manufacturing of turbine rotor
- First the entire processes during manufacturing of turbine rotor are recorded.
- Identified Value added activities and Non Value added activities.
- Total time taken for these above activities is recorded.
- Critical Examination is done on Non value Added activities using Questioning technique
- To reduce the setup time SMED technique is applied
- Setup operations are recorded and analyzed.
- Operations are divided into smaller elements and time taken for each element is noted.
- Identify the internal and external element
- Convert from internal steps into external steps
- Reduce time consumed by the internal steps
- Streamline the new process.

IV. EXISTING METHOD

After recording the timings of all the operations the following observations were done.

Table 1: Components of Total time

Setup time in min	*Machining time in min*	*Non-value added time in min*	*Total time in min*
2280	3258	1669	7207

The non-value added activities time had the following components: approach checking, checking dimension values, inspection and chip cleaning.

Table 2: Components of Total time

Approach checking time In min	Inspection time In min	Checking Dimension values In min	Chip cleaning time In min
378	213	408	670

Present method time:

Setup time = 2280 min
Total Actual cutting time in min = 3258 min
Total non value added time in min = 1669 min
Total time = 7207 min
Total time in hrs = 120 hr 6 min

V. PROPOSED METHOD

A. Critical Examination by Questioning Technique

Develop – For checking program dimensions values

Before running the program, the operator has to check the dimension values with the data sheet. To avoid this, check list has been developed. By doing so we can eliminate or reduce this time. Before keying the programs to the machine, programmer has to cross check the dimension values in the program. Then inspector in the programming department has to recheck the program and it has to be approved by the programming department. Later it has to be sent to the production department for the process.

1. Purpose – What should be done?
   Provide the check list to reduce checking dimension values time.
2. Place – Where should it be done?
   It should be done at the programming department
3. Sequence – When should it be done?
   Soon after preparing the programs and before keying it into the machine
4. Person – Who should do it?
   Programming dept should do it.
5. Means – How should it be done?
   It should be done using process sheet.

For approach checking

This can be avoided by providing the checklist for the programming department. The programmer can cross check the program after developing the program. The same should be approved by the programming department. This reduces the operator's time to check the program.

1. Purpose – What should be done?
   Provide the check list to reduce approach checking.
2. Place – Where should it be done?
   It should be done by the programming department
3. Sequence – When should it be done?
   After preparing the programs by the programmer
4. Person – Who should do it?
   Programming department should do it.

Check list for Checking Dimension values and Tool approach checking during programming

The checklist was prepared after discussion with the production engineer, supervisor, programmer and programming department head. This checklist has to be filled by the programmer after developing the program and get the program and the checklist checked and approved by the concerned authority.

Project: Steam turbine rotor

Frame: 012

Drawing no: 002

Table 3: Checklist

Sl. No.	*Tool Description*	*Tool path description*	*Approach checking*	*Checking Dimension Values*	*Checked by*
1					
2					
3					
…					
166					

Inspection time reduction Straight groove and coupling flange holes

Inspection at the straight groove and coupling flange holes using slip gauges takes more time. To avoid this, inspection has to be done by using plug gauges. This would takes less time.

Time reduction for Chip cleaning

Chip cleaning activity is doing by manually and it is time consuming. To avoid this problem chip breaker has to be provided. By providing chip breaker, chip-cleaning time can be reduced.

Estimated time savings after the application of Questioning Technique

Table 4: Estimated cycle time for proposed method

Setup time in min	Actual cutting time in min	Non-value added time in min	Total time in min
2280	3258	635	6173

Table 5: Non-value added time (Estimated) in proposed method

Approach time In min	*Inspection time In min*	*Checking D-values In min*	*Chip cleaning time In min*
Nil	104	Nil	531

B. Single Minute Exchange of Dies technique

The setup time in manufacturing of steam turbine rotor was more; to reduce this set up time we had applied Single Minute Exchange of Dies technique.

Setup time reduction by SMED Technique

Table No 6: Streamline the Internal and External activities

Sl. No.	*Setup Operations*	*Internal Activity time in min*	*External Activity time in min*	*Remarks*
1	cleaning of machine	90	⊗	
2	Removal of old jaws and fixing new jaws by manually	⊗	35	External (Parallel to cleaning)
3	weight support steady rest position have to be found out so that the weight of the component uniformly distributed from the chuck till tail stock as per the position which has arrived from the following	⊗	40	External (Parallel to cleaning)
4	check the jaws to be opened to enter the component Also check the Z-axis support length where the component rested which machining	⊗	5	External (Parallel to cleaning)
5	winding the rotor with belt	⊗	10	External (Parallel to cleaning)
6	Hook the rotor to the crane & check the belt is in balancing for lifting	20	⊗	
7	Load the component in the machine & close the jaws softly so that the component is approximately in the center of the machine	60	⊗	
8	Remove the belt from rotor	10	⊗	
9	Engage the tail stock center. Ensure Z-axis butting	5	⊗	
10	Engage the weight support on steady rest 1& 2	10	⊗	
11	Check & correct the run out of component near by check. Tighten the hard jaws fully	125	⊗	
12	Once again check run out of the component on same diameter within same limit	30	⊗	

Contd..

Sl. No.	*Setup Operations*	*Internal Activity time in min*	*External Activity time in min*	*Remarks*
13	Dis-engage both the weight support & engage of weight support in middle of component	15	⊗	
14	Machine the steady band areas. Select the depth of cut, cutting speed & feed rate	20	⊗	
15	Move the steadies in right positions & close them	15	⊗	
16	Machine 4 disc which are required to align component in this without chattering marks a) first disc nearby chuck b) Second & third diameter nearby steady rest c) Fourth one nearby tail stock	40	⊗	
17	Adjust the steady rest by dial gauge in X-Y axis	45	⊗	
18	The tail stock end side disc can be aligned in X-axis by using a dial & adjustment screw provided on tailstock	35	⊗	
19	Work offset taken for probing	70	⊗	
20	Probe program altered outer diameter runned for X-Y alignment	65	⊗	
21	X-Y alignment probing	85	⊗	
22	Measure the same by measuring program and adjust the steady rest until to control the parameter	120	⊗	
23	Ensure the parameter readings once again that tolerance is within the limit(10-20 microns)	45	⊗	
24	check the raw part allowance related with the rough turning program	70	⊗	
25	After rough machining gross check the alignment of component by measuring program	40	⊗	
26	Disengage the both weight support and engage of weight support in the required position	40	⊗	
27	Remove the tail stock	5	⊗	
28	Probe program called and run	55	⊗	
29	X&Y Alignment done within 0.002micron	80	⊗	
30	Linear distance cross checked for disc 2-12	65	⊗	
31	Run out checked after alignment completion within 0.015micron	110	⊗	
32	Winding the rotor with belt	10	⊗	
33	Hook the rotor to the crane & check the belt is in balancing for lifting	20	⊗	
34	Disengage the steady rest Open the jaws and lift the rotor	5	⊗	
35	Open the jaws and lift the rotor	40	⊗	
36	Place the rotor on the rotor stand(without removing the belt with crane support)	10	⊗	External (Parallel to jaws removing)
37	Hard jaws removed and soft jaws mounted	⊗	35	External (Parallel to positioning steady rest)
38	Cleaning	⊗	15	External (Parallel to placing rotor)
39	weight support steady rest position have to be found out so that the weight of the component uniformly distributed from the chuck till tail stock as per the position which has arrived from the following	40	⊗	
40	Check the jaws to be opened to enter the component Also check the Z-axis support length where the component rested which machining	⊗	5	External (Parallel to loading the component)

Contd...

Sl. No.	***Setup Operations***	***Internal Activity time in min***	***External Activity time in min***	***Remarks***
41	Load the component in the machine and close the jaws softly, so that the component is approximately in the center.	60	⊗	
42	Remove the belt from the rotor	10	⊗	
43	Engage the tail stock center. Ensure Z-axis is butting	5	⊗	
44	Engage the weight support on steady rest 1&2	10	⊗	
45	Check and correct the run out of the component nearby chuck. Tightened the hard jaws fully	120	⊗	
46	Once again check run out of component on same diameter within the same limit	30	⊗	
47	Steady holding on thrust collar outer diameter re-centering done	80	⊗	
48	Work offset taken for probing	70	⊗	
49	Probe program altered outer diameter run for X-Y axis alignment	65	⊗	
50	X-Y alignment probing	85	⊗	
51	Work offset taken and cross checked by measuring linear dimension	70	⊗	
52	C-axis done zero	65	⊗	
TOTAL		2195	185	

VI. Results and Conclusions

Critical examination was done for non-value added activities and the non-value added activities time was reduced from 1669 min to 635 min.

SMED Technique was applied to set up operations and set up time was reduced from 2280 min to 2140 min. Following table gives time taken for non-value added activities and set up operations for both present and proposed methods. Hence the cycle time was reduced from 7207 min to 6033 min.

A. Results obtained

Savings (estimated) after applying critical examination and single minute exchange of dies (SMED) technique.
Cycle time (present method) = 7207 min
Cycle time (proposed method) = 6033
Total saved time in min =1174

B. Estimated savings (in terms of cost) to the company

Loss to the company if machining operation is stopped per hour = Rs 6000
Loss per min if machining operation is stopped = Rs 100
Total saved time in min (Estimated) = 1174
Net savings per Rotor (Estimated) = 1174*100
Net savings per Rotor (Estimated) = Rs. 117400

Most of the suggestions given for reducing the cycle time of this steam turbine rotor hold good for many of other types of rotor also. Hence, these suggestions can be implemented for other rotors and cycle time and cost can be reduced to a great extent.

Table No 7: Results

Operations		Present Method (time in min)	Proposed Method (time in min)	Savings (time in min)
Non value added Activity	Approach Checking	378	Nil	378
	Inspection	213	104	109
	Checking dimension values	408	Nil	408
	Chip cleaning	670	531	139
Set up operations		2280	2140	140
Total		3949	2775	1174

References

(1) Holweg, M., (2006). The genealogy of lean production.Journal of Operations Management, 25, 420–437.
(2) Johansen, P., McGuire, K. J. (1986). A lesson in SMED with Shigeo Shingo. Industrial Engineering, 18, 26-33.
(3) Liker, J.K. (2004). The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer. McGraw-Hill, New York.
(4) Mcintosh, R., Culley, S., Mileham, T., Owen, G. (2000).A critical evaluation of Shingo's "SMED" (Single Minute Exchange of Die) methodology. International Journal of production Research, 38(11), 2377-2395.
(5) Shingo, S. (1985). A Revolution in Manufacturing: the SMED System. Productivity Press, Cambridge, MA.
(6) Process Planning and cost Estimation, 2nd Edition By R. Kesavan, C. Elanchezhian
(7) Badiru, A. (Ed.) (2005). Handbook of Industrial and systems engineering. CRC Press. ISBN 0849327199
(8) Blanchard, B. and Fabrycky, W. (2005). Systems Engineering and Analysis (4th Edition). Prentice-Hall. ISBN 0131869779
(9) Salvendy, G. (Ed.) (2001). Handbook of industrial engineering: Technology and operations management. Wiley-Interscience. ISBN 0471330574
(10) Turner, W. et al. (1992). Introduction to industrial and systems engineering (Third edition). Prentice Hall. ISBN 0134817893.
(11) Dr.C.S. Chethan Kumar and Dr.NVR Naidu (2014)."Implementation of SMED Procedures To Reduce The Setup -Time Of FSF Machine"- AMMMT-2013 International Conference on Advanced Materials, Manufacturing, Management and Thermal Sciences. During 3 rd-4th May, 2013, Tumkur.
(12) Dr.C.S. Chethan Kumar and Dr.NVR Naidu (2014). International Conference on Modeling Optimization and Computing during 10th -11 th April, 2014, NI University, Tamil Nadu.