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Improvement of Productivity in TIG Welding Plant by Equipment Design in Orbit

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Abstract. Measurements and improvements are very indispensable task at all levels of management. Here some samples are, at operator level: Measuring operating parameters to ensure OEE (Overall Equipment Effectiveness) and measuring Q components performance to ensure quality, at supervisory level: measuring operator's performance to ensure labour utility at managerial level: production and productivity measurements and at top level capital and capacity utilization. An often accepted statement is "Improvement is impossible without measurement". Measurements often referred as observation. The case study was conducted at Government Boiler factory in India. The scientific approach followed for indentifying non value added activities. Personalised new equipment designed and installed to achieve productivity improvement of 85% for a day. The new equipment can serve 360o around its axis hence it simplified loading and unloading procedures as well as reduce their times and ensured effective space and time.

1. Introduction

The efficiency of production not only depends on sophistication of core machine but also the various supporting equipments, facilities, services and employee's efforts which are located in a plant [1]. The authors focused on plant layout and material handling to achieve up to 85.31% production efficiency and 46% in reduction of transportation lengths. They used simulation software and string diagrams as tool for the same. Shewale et al [2] made attempt to increase the productivity by plant layout optimization through systematic layout planning (SLP). The operation process chart, flow of material and activity relationship chart were employed in their study and achieved shortened material flow length from 663.63 m to 351m. Mayank et al [3] studied about overall productivity improvement in casting and fastening Industry and incorporated changes in plant layout and achieved 5 to 6 minutes per mould. ArashGhodrati and NorzimaZulkifli [4] and Dinesh et al [5] used 5s technique to improve the productivity by reorganized the work place. Mayank et al [6] concentrated on overall productivity improvement in casting industry by applying work and motion study for reducing non-productive time and applying ergonomics for various working position and ensured effective utilization of plant area after incorporated necessary changes in plant and process layouts. Mallikarjun Koripadu and Venkata



Subbiah [7] used day-in-life-DILO (day in a life of...) along with Lean Principles for improving productivity in service organization. DILO is a kind of Time and Motion study technique used for identifying the waste by separating value-add, value-enable and non-value-add activities as per the process analysis. Anand Gurusurthy and Rambabu Kodali [8], Niall Piercy and Nick Rich [9], Alberto and Marco [10] and Manoj Dora et al [11], Krishna Kumari et al [12] and Dayanand Yadav [13] and many research articles published in productivity improvement by use of lean and six sigma principles in industries. This work is unique by achieving productivity by redesigned ancillary equipment.

2. Problem definition

Welding plays a major role in boiler manufacturing. Most of the products such as boiler drum, super heater, pre heater and economizer are manufactured with the help of welding. There are several welding processes available to make the permanent joints, Orbital TIG is one of the welding process used for making permanent joints (refer Figure 1). Orbital TIG is an expensive machine in which the defect rate of the weld is only one percent. The plant belongs to govt sector which produces super heater tubes for steam boilers. As it is government sector and its products' quality and services (even after sales) its p in India there is huge demand for their boilers in and around the nation. Hence the productivity improvement is demanded before launching expansion plan. This work is part of it. The approach started systematically with Work study, which is a basic scientific procedure to identify the possibilities of improving the production rate or in the words of lean identifying the waste. The work study conducted and the time consumed by for each and every process is recorded by 6 trails and average of them is considered for analysis. The work study helped to identify certain unnecessary operations which lead to poor production rate. Those unnecessary times were eliminated by designing alternate ancillary equipment namely Hoist. The conventional hoist is simply supported type; the implemented new one is cantilever beam type rotary hoist which can rotate 360 degree about its axis.



Figure 1. Orbital TIG welding

3. Identifying the waste

The process of identifying the waste was made by means of work-study. Orbital TIG (O-TIG) welding process is focused for this study. The objective is to record all the relevant factors in O-TIG welding process such as loading time, work preparation time, clamping time, welding time, and unloading time are recorded by conducting the stop watch time study which is one of the work measurement techniques.

4. Work measurement

The loading measurement details were tabulated in table 1. The unloading related measurements are given in table 2. Time and method of edge preparation was recorded and tabulated in table 3. Work piece setting time was recorded and noted in table 4. Self explanatory flow chart (refer figure 1)

prepared as per standard format which consolidate above measurement. The details of welding process were studied and recorded systematically and shown such measurement in table 5.

Table 1. Conventional Loading Time

Description	Time Taken (Minute) *						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Move from hanger to extreme end	4.46	4.4	4.32	4.43	4.45	3.89	4.33
Waiting for hoist	18.5	20.5	17.5	20	15.5	19	18.5
Transport empty	1.07	1.09	1.05	1.11	1.08	1.14	1.09
Grasping	0.55	0.58	0.57	0.55	1	0.56	0.57
Transport load	1.53	10.55	1.5	1.56	1.65	1.56	1.56
Release load	0.26	0.27	0.28	0.3	0.26	0.28	0.28
Allowances							1.32
Total loading time							27.65

Table 2. Conventional Unloading Time

Description	Time Taken (Minute) *						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Transport empty	1.07	1.09	1.05	1.11	1.08	1.14	1.09
Grasping	0.58	0.55	0.57	0.55	0.6	0.56	0.57
Transport load	1.25	1.31	1.12	1.21	1.1	1.2	1.2
Release load	0.26	0.27	0.29	0.3	0.26	0.28	0.28
Total unloading time							3.14

Table 3. Edge Preparation Time

Description	Time Taken (Minute) *						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Fixing the machine	1.8	1.1	1.4	1.2	1.7	1.3	1.4
Operation	2.15	1.55	2.09	2.13	1.49	1.56	2.25
Removing the machine	1.4	0.8	1.1	1	0.8	0.9	1
Total time taken							4.65

Table 4. Work Piece Setting Time

Description	Time Taken (Minute) *						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Work piece setting time	7.85	7.95	8	7.9	7.9	7.92	7.92

Table 5.Time for O-TIG Welding Process

Description	Time Taken (Minute) *						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Machine setting time	6.3	6.4	7	11.7	8.5	7.2	7.8
Arc time	11.8	12.5	15.4	12.4	12.07	13.4	12.93
Machine removal time	4	5	4.2	6.6	4.5	5.5	5
Allowances							1.44
Total welding time							30.17

5. Cantilever beam type rotary hanger

The existing hanger is simply supported beam type, which can handle only single row of pipes in the layout. For increasing productivity the new type hanger systematically designed, fabricated and tested well. This new hanger is cantilever type can rotate around 3060 and simple in construction which is illustrated in figure 2. In the existing lay out (ref. figure 3) of pipes are single row and a stand provided to place them but in the newly suggested layout (shown in figure 4), the pipes can arrange two rows (both side of the proposed type hanger) by using its advantage of rotary type (It can works for 360o). So that time taken for (loading) moving the work piece to the work centre is reduced (76.67%) from 15 minutes to 3.5 minutes as well as the time taken for (unloading) moving the work piece for Temporary storage was reduced (80.77%) from 13 minutes to 2.5 minutes.

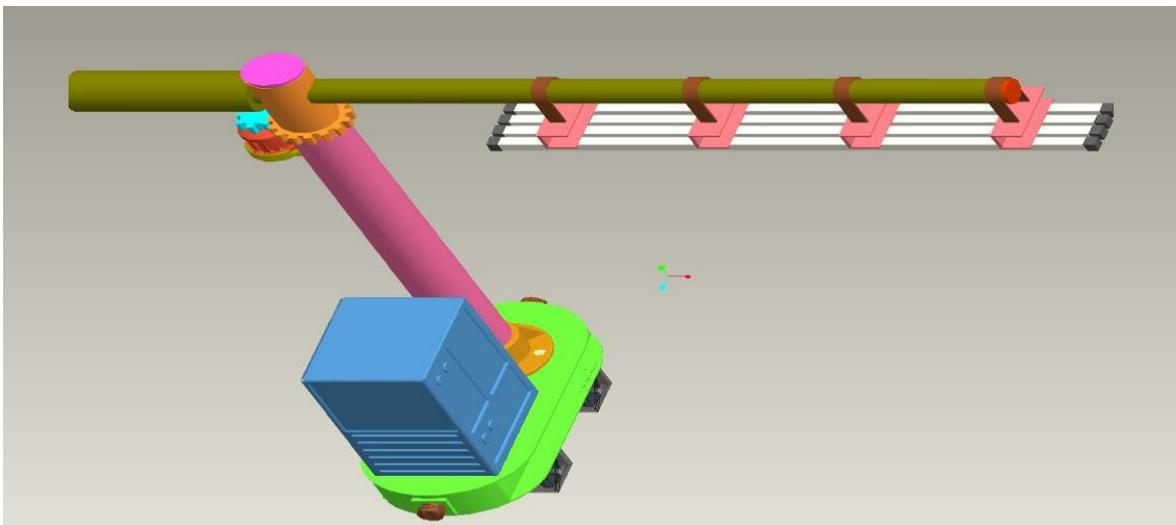
**Figure 2.** Cantilever Beam Type Rotary Hanger



Figure 3. Conventional layout of pipes to be welded Pipe



Figure 4. New layouts of pipes to be welded

Table 6. New status of Loading

Description	Time Taken (Minute)*						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Transport empty	1.07	1.09	1.05	1.11	1.08	1.14	1.09
Grasping	5.55	5.89	5.78	5.56	5.78	5.65	5.7
Transport load	0.77	0.78	0.75	0.77	0.83	0.78	0.78
Release load	0.26	0.27	0.28	0.3	0.26	0.28	0.28
Allowances							0.39
Total loading time							8.24

Table 7. New status of Unloading

Description	Time Taken (Minute)*						Average
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	
Transport empty	1.07	1.09	1.05	1.11	1.08	1.14	1.09
Grasping	0.58	0.55	0.57	0.55	0.6	0.56	0.57
Transport load	0.45	0.5	0.43	0.41	0.42	0.5	0.45
Release load	0.29	0.27	0.28	0.31	0.26	0.28	0.28
Total Unloading time							2.51

Hence the new equipment reduced the time for loading from 27.65 minutes to 8.24 minutes per joint 70.199% (shown in table 6) similarly in case of unloading the time the new equipment and method reduced 20.064% of unloading time per joint (shown in table 7). A boiler tube requires 4 joints. Performance of new hoist during loading is reduced to 8.24 minutes (ref. Figure 5) and also the performance of new hoist during unloading is reduced to 2.51 minutes (ref Figure 6)

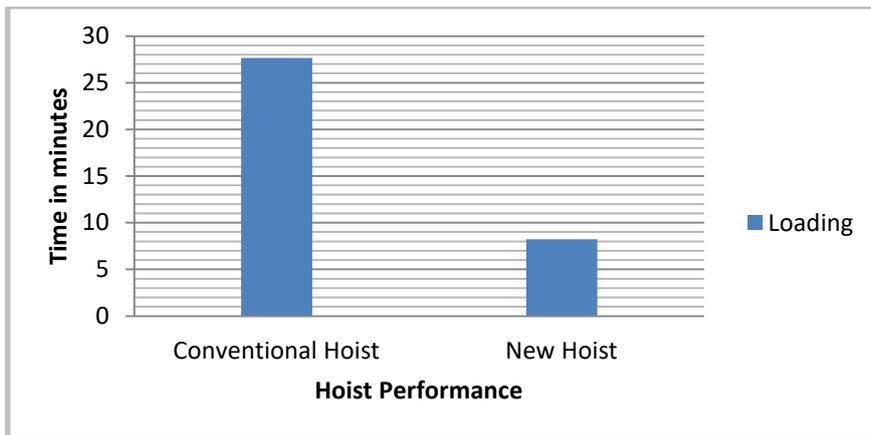


Figure 5. Performance of new hoist in loading

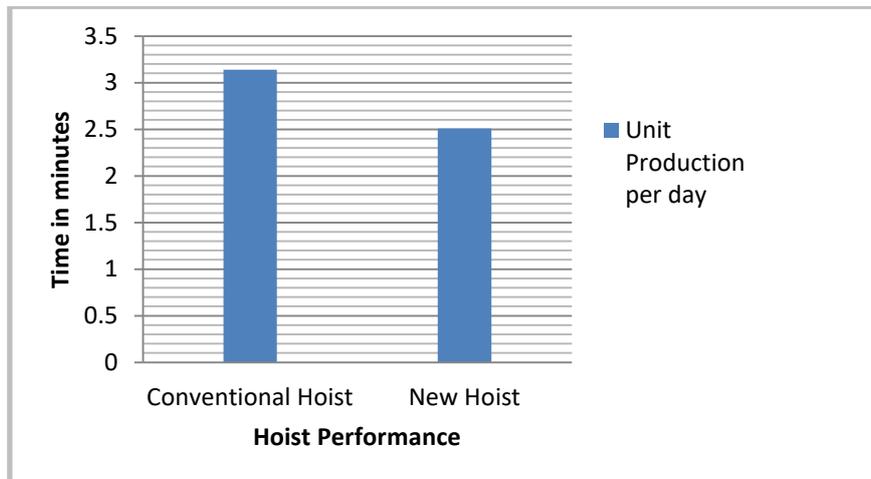


Figure 6. Performance of new hoist in unloading

6. Productivity improvement

6.1 Conventional Status

Working hour per shift is 480 minutes (8 hour shift), Time spent for organization matter such as Enter daily work consumed 7minutes, Official discussion 15minutes, Time spent for personal needs like Tea time (twice) 20minutes, Lunch hour 30minutes, Personal allowances 24minutes (5% of shift time), Fatigue allowances 24minutes (5% of shift time), hence total time consumed for non productive work is 120minutes. (shown in Table 8)

So Net Available working time per shift (T) = $480 - 120 = 360$ minutes

Total processing time per weld joint (tp) = $27.64 + 3.14 + 4.65 + 7.92 + 30.17 = 73.51$ minutes

Total no. of Boiler Tubes can be welded = $(T / tp) * \text{no. of joints per boiler tube piece}$

$$= (360 / 73.53) * 4 = 19.59 \approx 19 \text{ boiler tube piece per shift}$$

6.2 New status

In case of new equipment the loading and unloading time was reduced significantly (shown in Figure 7). Hence the Total processing time per weld joint (tp) = $8.24 + 2.51 + 4.65 + 7.92 + 30.17 = 53.49$ minutes

Total no. of Boiler Tubes can be welded = $(T / tp) * \text{no. of joints per boiler tube piece}$

$$= (360 / 53.49) * 4 = 26.92 \approx 26 \text{ boiler tube piece per shift}$$

Table 8. Improvement Status

S. No.	Description of Productivity Criteria	Conventional Status	New status	Difference	Productivity Improvement	Remarks
1	Productivity in loading & unloading Tasks (minutes)	30.79	10.75	20.04	65.09%	Loading & Unloading Time Reduced
2	Productivity per joint (minutes)	73.51	53.49	20.04	27.25%	Total time per joint reduced
3	Productivity per Boiler tube (minutes)	294.12	213.96	80.16	27.25%	Total time per boiler tube manufacturing reduced
4	Net Productivity per shift (Nos)	19	26	7	36.84%	No of boiler tube manufactured increased
5	Productivity per day (2 shift) (Nos)	38	52	14	85.71%	Production per day increased

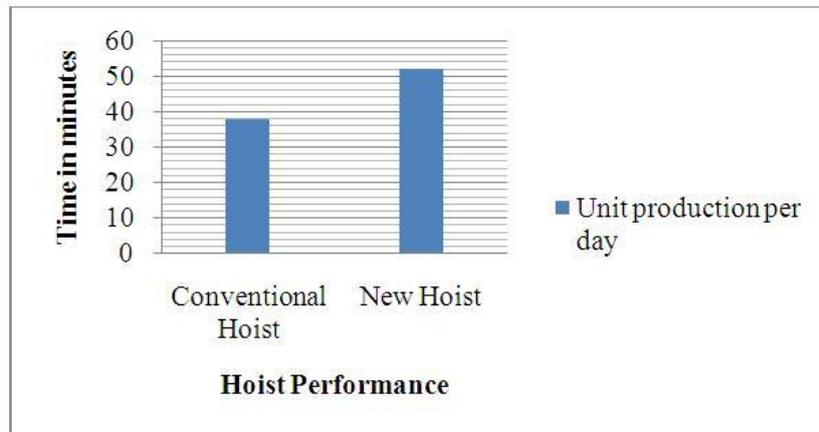


Figure 7. Improvement in day production

7. Conclusion

The O-TIG welding on pipes to produce super heater tubes for the boiler is discussed in this article. Based on the lean principle the conventional method was studied with work study principles and identified the waste. For eliminating the identified waste new hanger was suggested and implemented. The new method decreased the loading time 70% and unloading time by 20% thereby increases (85.71%) of number of super heater tubes production for a day (two shift per day) from 38 to 52 tubes per day. Hence the significant productivity was achieved in O-TIG welding plant.

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