Productivity Improvement of Assembly Workstation in a Small Scale Industry

Mr.Subodh Patil
Assistant Professor, Mechanical Engineering Department, Imperial College of Engineering and Research, Pune

---***---

Abstract: Line balancing (LB) is useful tool to make production line stretchy enough to absorb external and internal indiscretion. LB is the problem of assigning operation to workstation along an assembly line in such a way that assignment is optimal in some sense. This paper mainly focuses on improving overall efficiency of single model assembly line by reducing the non-value added activities, cycle time and distribution of work load at each work station by line balancing. The methodology adopted includes calculation of cycle time of process, identifying the non –value-added activities, calculating total work load on station and distribution of work load on each workstation by line balancing, in order to improve the efficiency of line.

Key Words: ***Key words***: **Assembly line balancing (ALB), Ergonomic Assessment REBA, Elimination of 7 wastes**

1. INTRODUCTION

Traditionally, line improvement focuses on balancing the various workstations and ensuring that each workstation meets the target demand. However in order to effect improvement of individual workstation, reduction in the work content through ergonomics intervention can prove to be very useful in the primary context of enhancing employee productivity and morale. The success of achieving the goal of production is influenced significantly by improving assembly line. An assembly line consists of workstations that produce a product as it moves successively from one workstation to the next along the line, which this line could be straight, u-line or parallel until completed. To balance an assembly line, some methods have been originally introduced to increase productivity and line efficiency. These objectives are achieved by reducing the amount of required manufacturing time to produce a finished product, by reduction in number of workstations or both of them. There is a growing concern to improve productivity, safety in assembly line. Some of the common problems of the small scale and unorganized sector industries are improper workplace design, mismatch between workers abilities and job demands, adverse environment, poor human–machine system design, poor working postures and inappropriate management programs.

2. SCOPE OF WORK

Spacer line is used for assembly of Silencer. Four models of Silencer are produced as per the order. These are - K1 cat, K1 non cat, K2 cat and K2 non cat. Table 1 shows the demand per month, manpower deployed and no. of workstation presently deployed on the line.

Table 1: Spacer Line status (Before Improvement)

Variant	K1 cat	K1 non cat	K2 cat	K2 non cat
Production/Month	62400	62400	62400	62400
Manpower	12	12	12	12
No. of Workstation	12	12	12	12

The demand for all products is almost equal .To carry out improvement, K2 CAT product was chosen for pilot study. Since, the operators at various workstations for all products are almost similar, improvement at K2 CAT can be horizontally deployed to the other three products.

3. Methodology

The following methodology was adopted for effecting productivity improvement on spacer line.

1. Cycle time study.
2. Assessing current state of the line.
3. Identifying opportunities for improvement.
4. Effective improvement in assembly line. 4.1) Postural analysis –REBA.
   4.2) Clubbing of workstations.

3.1 Cycle Time Study

To determine the production capability of each individual station, detailed cycle time study at each workstation was carried out .Cycle time study was done for 15 repetitive cycles. Then, activities were categorized in VA/NVA activities. NVA activities were focused to reduce or eliminate them in order to improve productivity at various workstations.

3.2 Assessing Current State of the Line

A detailed study of workstations was carried out using time study and problems were identified at each workstation. Line efficiency was calculated. At initial level, line efficiency percentage for the line (Spacer K2 cat) was 45%.Number of operators employed on the line were 12. Table 2 shows Initial state of the line and man machine relation.

Table 2: Initial State of Spacer Line

Summary (Model-K2 CAT)(All Values in Seconds)						
W/S No.	W/K Name	VA	NVA	CYCLE TIME	MACHINE	MANUAL
1	BUSH INSERTING STAGE	3	4.1	7.1		?
2	6 MM DRILL OF PIUG BUSH AND PIPE	3.12	2	5.12	?	?
3	MANUAL PLUG WELDING	3.48	2.2	5.68	?	?
4	SIZZING OPERATION	6.34	2.24	8.6	?	?
5	SPACER WELDING SPM	8.56	2.54	11.1	?	?
6	DRILL M/C 3 MM DRAIN HOLE	2.58	2	4.58	?	?
7	SPACER LEAKAGE TESTING	7	3	10	?	?
8	DRILL M/C 10MM	5.6	7.64	13.24	?	?
9	23MM DRILL M/C	11.14	7.62	18.76	?	?
10	BURR REMOVING STAGE	3.2	4	7.2		?
11	GAUGE	2.22	4	6.22		?
12	FINAL INSPECTION	2	2.4	4.4		?

Table 3: Summary of Spacer line

Throughput time	102
Maximum activity cycle time	18.76
Therotical no. of operators	7
Takt Time for present Demand	16.75
Line efficiency	45%

Figure 1 shows graphical representation of the cycle time of workstations along with TAKT time. Workstation 9 having total cycle time more than TAKT time was bottleneck station and was considered for the improvement on priority.

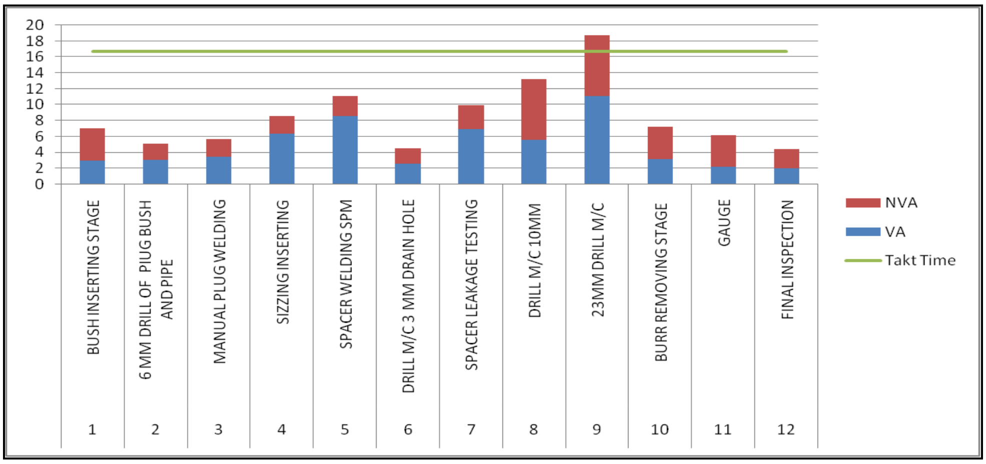


Figure 1: Cycle Time Graph along with TAKT time

3.3 Identifying Opportunities for Improvements

Taking improvement of individual workstation involves identification and elimination of 7wastes i.e. TIMWOOD. Out of these motion category can be addressed through ergonomics intervention. In the paper postural analysis of operator at each individual workstation had been done using REBA.

3.4 Effective Improvement in Line

3.4.1 Postural Analysis:

The postural analysis of the workers while performing different activities which would lead to sub-assembly of silencer was done and each posture was analyzed for improvement purpose. The neck, trunk, and leg postures were first examined. Depending on the measurements taken, the postures were assigned a numerical value. Working postures were evaluated directly by visual observation as well as indirectly by using a photography and video of the different activities performed by the workers to identify the different categories of work postures prone to injury such as bending, twisting, tilting the head forward. A scoring system was used to generate an action list which indicates the level of intervention required to reduce back strain due to physical loading on the operator. Figure 2 shows a complete list of measurements and REBA score for operator.

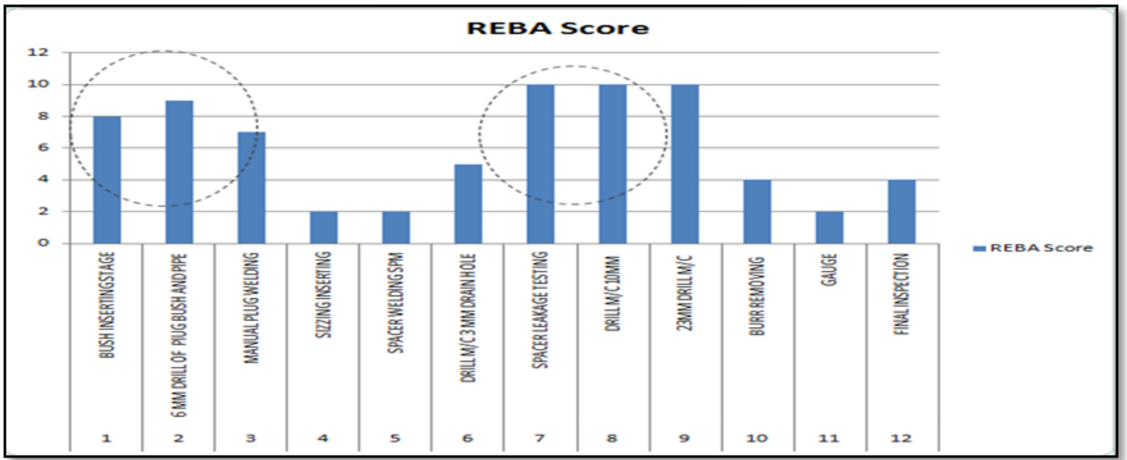


Figure 2: REBA Score for Operator (Initial State)

Observations:

Operator at workstation 1 had to insert bush in to pipe. Since pipes were stacked on the floor and bushes on a low level platform, operator had to bend excessively causing back strain. Figure 3 shows pipes stacked on floor in part (a) and bush stacked on the workstation in part (b). From these postures it can be inferred that the due to excessive bending there was a lot of stress on the back and arms of the worker which is substantiated by the REBA score of '8' which indicates high risk and a need of immediate ergonomic intervention. Figure 4 shows REBA assessment worksheet for operators.

Part (a)

Part (b)

Figure 3: Pipe and Bush Inserting Workstation

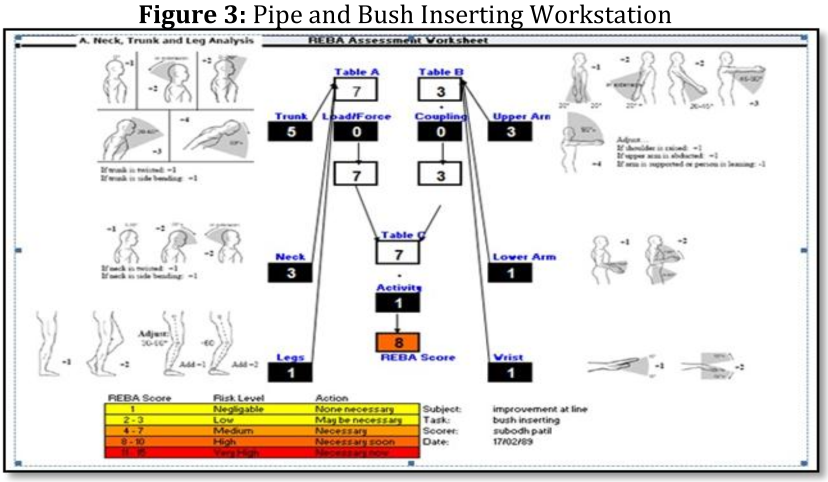


Figure 4: REBA Assessment Worksheet for operator (Before Improvement)

From the video, the study has done on assessment of REBA scores and got the score as 8.To avoids excessive bending and twisting of operator, a rack was provided for storing the silencer spacers. There were also improper provisions for bushes at workstation no.1.A plated bin was welded to workstation no.1 (having 2000 bushes storage capacity).This enabled operator to easily pick the bushes for inserting in pipes. REBA score was reduced to 2.

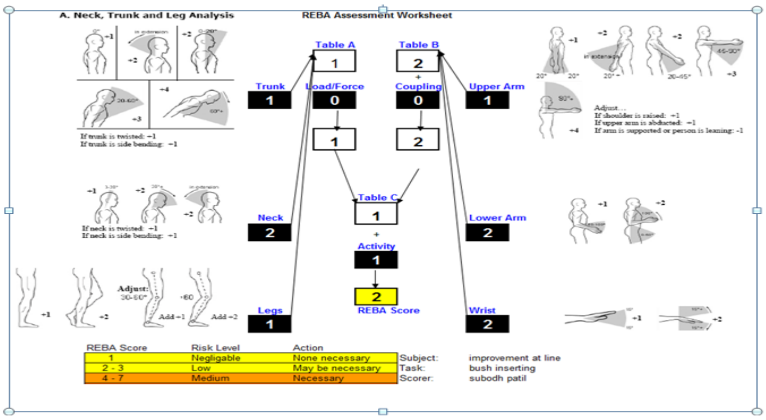
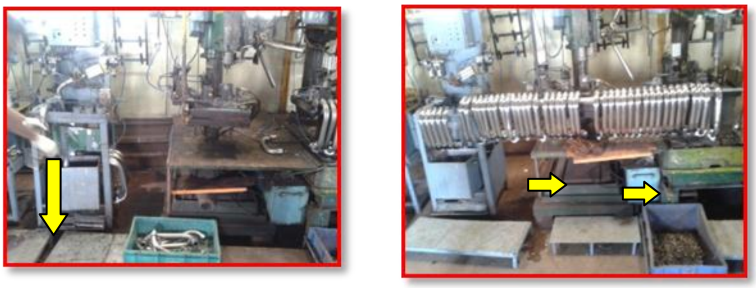


Figure 5: REBA Assessment Worksheet (After Improvement)

Part (a) Part (b)

Figure 6: Workstation No.1 Rack and Bush Inserting Table

Figure 6(a) and 6(b) shows Racks for storing Silencer spacers and Plated bushes boxes respectively.



Before (a) After (b)

Figure 7: Workstation No.9 drilling machine

Operator at workstation no.9 had to bend on the floor to pick a pipe for drilling. Since pipes were stacked on floor, operator had to bend excessively causing back strain. To avoid this excessive bending, long pipe was welded horizontally from workstation no.7 to workstation no.9 and bin was removed from workstation as shown in figure 7 separately in part (a) and part (b).

Total time of workstation no. 9 was reduced to 13.14 sec, which is below the takt time. All the pipes are now closer to operator and parts being forward for next operations from left to right as shown in figure 7 part (b). Horizontal long pipe helped to avoid the unnecessary bending, twisting movements. REBA score is reduced to 2.Thus, after studying and analyzing initial state, bottlenecks were identified on the assembly line.

Table 5: Summary of workstation no.9

Work station	Before	After
	Cycle Time in Seconds	Cycle Time in Seconds
23 mm Drill Machine	18.76	13.14

3.4.2 Clubbing of Workstations

3.4.2 .1Clubbing of Workstations no.1 and no.2:

At workstation no.2 drilling operation was carried out on the bush and pipe with 6mm drill. The total time at combined w/s was 10.12 sec, which was well below the takt time and NVA time had been removed. Clubbing of workstations 1 and 2 eliminated one operator. Figure 8(a) shows two workstations with two operators and 8(b) shows combined stage of two workstations with one operator.


Before (A)


After (B)

Figure 8: Bush Inserting and Drilling Workstation

3.4.2.2Clubbing of Workstations no.6 (Drilling) & no.7 (Leakage Testing):

Operator at Workstation no. 6 has to do drilling of pipes and at workstation no.7 leakage testing. REBA score of workstation no.7 was 10.

Man –Machine Process Chart:

Man–machine chart where activities of more than subject (worker or equipment) are each recorded on a common time scale to show their inter-relationship activity chart is made and determine number of machine handled by one operator. Figure 9 shows man-machine chart of two workstation with one operator.

Table 6: Summary of workstation

Workstation	Before		Workstation	After	
	Cycle Time (sec)	No. of Worker		Cycle Time (sec)	No. of Worker
Bush Inserting Stage	7.1	1	Bush Inserting Stage +6mm Drill of Bush and Pipe	10.12	1
6mm Drill of Bush and Pipe	5.12	1			

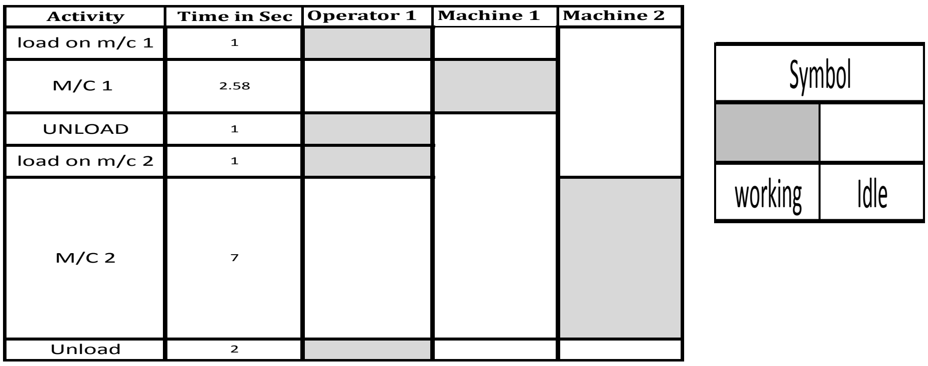


Figure 9: Man – Machine Chart of One Operator and Two Machines

Table 7: Summary of Workstation

Subject	cycle time	time worked per cycle	percentage utilization
Operator	14.58	5	34.29
Machine 1	14.58	2.58	17.70
Machine 2	14.58	7	48.01

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 4 | Apr 2019 www.irjet.net p-ISSN: 2395-0072

Figure 10(a) shows Drilling and Leakage testing workstations with two operators and 10(b) shows combined stage of two workstations with one operator.

Before (A) After (B)

Figure 10: Clubbing of Workstation

The total time at combined workstation is 14.58 sec, which is well below the Takt time. Clubbing of workstations 6 and 7 had eliminated one operator and unnecessary bending was avoided.

Table 8: Summary of Workstation

Workstation	Before		Workstation	After	
	cycle time (sec)	No. of worker		cycle time(sec)	no of worker
3mm drill of pipe	4.58	1	3mm drill of pipe + leakage testing	14.58	1
leakage testing	10	1			

3.4.2.3. Clubbing of workstations No. (10, 11 and 12) Burr Removing, Gauge Inspection and Final Inspection:

Operations at workstations no.10, 11 and 12 consist of manual work. The total time at combined workstation is 14.42 seconds, which is well below the takt time .Clubbing of workstations no. 10, 11 and 12 has eliminated two operators. Figure 11(a) shows workstation 10, 11 and 12 separately and 11(b) shows combined stage of workstations with only one operator.

Before (a) After (b)

Figure 11: Clubbing of Workstation

Table 9: De-bottleneck workstation (with 1 operator)

Workstation	Before		Workstation	After	
	cycle time (sec)	No. of worker		cycle time(sec)	no of worker
Bur removing	7.2	1	Burr removing + gauge inspection + final inspection	14.42	1
Gauge	6.22	1			
Final inspection	4.4	1			

Results:

Figure 12 shows graphical representation of the cycle time of workstations along with TAKT time. Bottleneck workstation was worked out and cycle time of the bottleneck workstation was reduced below TAKT time.

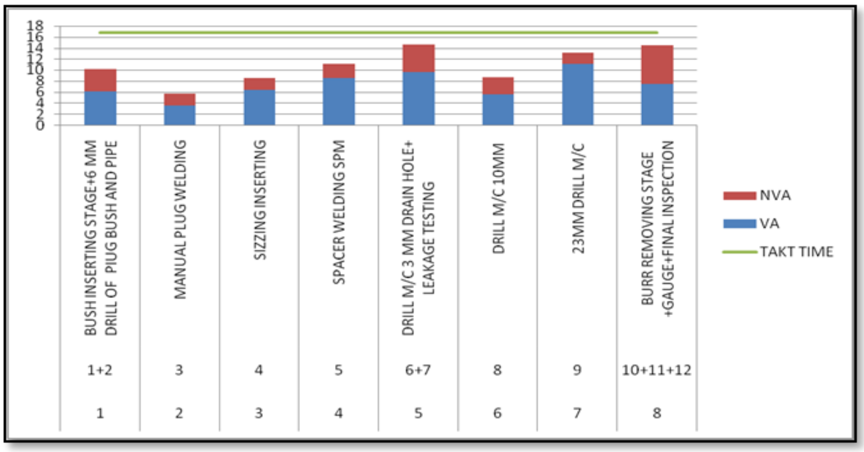


Figure 12: Cycle time graph along with Takt Time (after improvement with 8 operators)

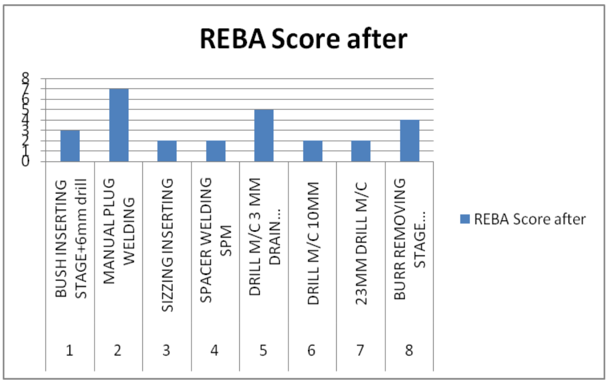


Figure 13: REBA Score (After Improvement)

Table 11: Summary of Spacer Line

Improvements	Before	After	Savings	% index
Manpower	12	8	4	33
Line efficiency	45.00	74.70	29.70	66
No. of Workstations	12	8	4	33.33
Total Cycle Time	102	89.64	12.36	12.12

4. CONCLUSION:

In this study, the problem regarding line efficiency and productivity in spacer assembly line was solved by removing the non-value added activities at spacer subassembly line workstations. In addition, the total number of operators had also reduced from 12 to 8. This amounted to an increase in line efficiency from 45% to 74.7%. There were also other improvements done. Ergonomic factors also impact on improving the line productivity. Unawareness about ergonomics were observed in spacer subassembly line in which work was undertaken. On the basis of analysis of results and scores obtained by REBA, it could be concluded that there was a lack of ergonomics planning in spacer subassembly line. After the necessary changes it has achieved a very low score of REBA which is acceptable. Clubbing of activities 1& 2, 6&7 and 10, 11 &12 helped to reduce the number of workers and also the working time.

5. REFERENCES:

[1] Raghunath G.KulkarniN.KulkarniV.N.Gaitonde,"Productivity Improvement in Assembly workstation of motor winding unit",Materlastoday Proceedings Volume5,Issue 11 ,Part 3 ,2018,Pages 23518-23525.

[2] Korhan Enez,Sibel Secil Nalbantoglue,"Comparison of ergonomic risk assessment output from OWAS and REBA in forestry timber Harvesting ",International Journal of Industrial Ergonomics, Volume 70,Mrach 2019,Pages 51-57.

[3] Srijit Krishnan, A. Sarang Dev, Rahul Suresh, A. Sumesh, K. Rameshkumar,"Bottlenech identification in a tyre manufacturing plant using simulation analysis and productivity improvement",Material today proceedings,Volume 5,Issue 11,Part 3,2018,Pages 24720-24730.

[4] Dewi Kurniawati,Henry Yuliando,"Productivity Improvement of small scale medium enterprises on Food Products:Case study at Yogyakarta Province,Indonesia",Agriculture and Agriculture Science Procedia,Volume 3,2015,Pages 189-194.

[5] Sanjeev kadin ,Randeep Singh,Ashok Kumar Malik,"INCREASE PRODUCTION IN SMALL INDUSTRY OF INDIA BY USING OF LEAN MANUFACTURING TECHNOLOGY", International Journal of Mechanical Engineering,Vol3,Issue4,April2015.