INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume 4, Issue 2)

Available online at: www.ijariit.com

Balancing of the production line in a manufacturing industry to improve productivity

Shailendra Vishwakarma
shailendrabits10@gmail.com
Bansal Institute of Science and Technology, Kokta, Madhya Pradesh

Surjeet Singh Baghel
surjeetsinghbaghel@gmail.com
Bansal Institute of Science and Technology, Kokta, Madhya Pradesh

ABSTRACT

This work mainly focuses on the application of line balancing to minimize idle time of work station in the production line. The methodology adopted includes calculation of cycle time of the process, identifying the non –value-added activities, calculation of total work load on station and distribution of work load on each workstation by line balancing, in order to improve the efficiency of line. A production line of a bearing retainer component manufactured by Porwal Auto Components Pvt Ltd, Pithampur, Dhar (M.P) is considered for this research work and time study is performed in order to determine the standard time for each process. Then, rank positional weighted method (RPW) is evaluated with the help of standardized data to solve the assembly line problem and defines the line efficiency which provides a better productivity in the existing flow line by reducing the idle time.

Keywords: *Line balancing (LB), Non-value-added activities (NVA), Assembly line balancing (ALB).*

1. INTRODUCTION

Assembly line defines that manufacturing technique in which a product is carried with the aid of some form of mechanized conveyor among stations at which the diverse operations important to its assembly are finished. It is used to gather quickly large numbers of a uniform product. At first, Assembly line was evolved for a fee efficient mass manufacturing of standardized merchandise, designed to take advantage of an excessive specialization of labor and the related mastering effects [3]. On every other hand while we used assembly line balancing (ALB) this makes efficient flow-line systems available for low extent assembly-to-order production and allows contemporary manufacturing strategies like mass customization. This, in turn, ensures that the via planning and implementation of assembly systems will continue to be of high sensible relevance within the future and additionally assembly line balancing trouble involves an assignment of diverse responsibilities to the workstations, whilst optimizing one or greater goals without violating regulations imposed on the line. In practice, it is frequently proper to easy out the workload assignments and assign related responsibilities to the same workstation if feasible [4].

2. LITERATURE REVIEW

Joyal George Mathew and Biju Augustine. P (2017) minimized workloads and people at the assembly line at the same time as assembly a required output. The production charge is relying on how nicely the line is working. A new layout will be proposed to make the assembly line acquire its required manufacturing rate. The work includes evaluation of present production line for identifying the resources of waste in differentiating price brought time and non-cost brought time. Line balancing was achieved to minimize the idle time and enhance cycle efficiency via reducing the range of work stations.

Mahmud Parvez et al (2017) focused on improving the overall efficiency of the single model assembly line by means of lowering the bottleneck activities, cycle time and distribution of work load at every work station by means of line balancing; using line balancing strategies specifically work sharing technique. The method adopted includes calculation of cycle time of procedure, identifying bottleneck activities, calculating overall work load on station and distribution of work load the use of code block (C++) software on each computer also remodeling the format by means of line balancing, if you want to enhance the efficiency of line and increase overall productivity.

Pratik Anil Kumar Dudhedia et al (2017) founded productivity immediately effects on cost and growth of an organization so, productivity development is very vital for any employer to acquire an organizational goal. In industries all through production, many issues occur like the breakdown of the production line, slow rate of manufacturing, improper managing of material, intellectual fatigue of employees, and many others. So, reduce or elimination of all above issues increase the manufacturing cost as well as an increase in income. By way of identifying the problems they may be resolve via time look at, method observe and work study

W. Grzechca (2016) approached for the layout of the assembly line for modular merchandise is proposed. Assembly line layout of the subassembly line for basic operations can be viewed as a single model product assembly line balancing problem and be solved by way of existing line balancing strategies. The subassembly line for the variation operations is designed as a flow line structure and is sequenced with Johnson's algorithm for 2 machines case and heuristic methods for M machines case. A very last end result of responsibilities assigning to the complex manufacturing structure is given and a first-class of final solutions are mentioned.

Katkuri Srikanth and Basawaraj. S. Hasu (2016) targeted on enhancing the ordinary performance of single version assembly line by using decreasing the cycle time and distribution of labor load at each work station through line balancing. The method followed consists of calculation of cycle time of the process, calculating total work load on station and distribution of labor load on every computer by using line balancing, in order to improve the performance of the line. This associated line is studied by time look at strategies. The time is taken via stopwatch. The guide calculation also covered in particular in line balancing algorithm. In his work, a problem of line balancing for engine manufacturing has been discussed the use of ranked role weighted approach.

3. PROBLEM STATEMENT

For our examine cause we select Porwal automobile additives Pvt Ltd, Pithampur, Dhar (M.P.). Initial evaluation of "Bearing Retainer" products production on housing production line become achieved. The demand for those elements is round 1200 housings in keeping with the month. Current output is in the variety of 950-1100 housings in keeping with the month. For that reason, there's want to increase the productiveness of housing product with the aid of enhancing the overall performance of housing production line. This includes increasing potential of machine assets, reducing work in process inventory and utilization of resources. The organization has given this problem for productivity improvement of housing product. It's far proposed to use line balancing approach to contemporary trouble by way of focusing on bottlenecks in the production line and enhance the productivity of the housing product by using looking after potential constraint resource.
After statement and analyzing production branch the manufacturing cost of bearing retainer is reducing yearly and now not able to meet the required demand.
The following are the main problems observed due to which production rate of bearing retainer is reduced.
1) Idle times occurring in the assembly line is not controlled
2) The existing time standards are too old and inaccurate in present practices
3) The cycle time is not reduced in the assembly line
Problem Statement - "Excessive cycle time and uncontrolled idle time increases waste of time and reduce the productivity of a firm".

4. OBJECTIVES OF WORK

The aims and objectives of the present study are as follows:-

- To reduce production cost and improve productivity
- To determine the number of the feasible workstation.
- To identify the location of the bottleneck and eliminate them.
- To determine machinery and equipment according to assembly mechanism.
- To equally distribute the workloads among workmen to the assembly line.
- To optimize the production functions through the construction of mix form of automation assembly and manual assembly.
- To minimize the total amount of idle time and equivalently minimizing the number of operators to do a given amount of work at a given assembly line speed.

5. TOTAL AVAILABLE CAPACITY OF EACH RESOURCE IN THE PRODUCTION LINE

Identification of constraint is a most vital step of the line balancing. The constraint identification procedure indicates that there are two maximum important steps figuring out the constraint. Analysis of capability and evaluation of WIP amassed in front of a useful resource.

According to time look at statistics evaluation, common of total to be had potential of every aid in the manufacturing line has decided that's shown in table 1. evaluation of available potential of each resource via thinking about cycle time as well as loading and unloading time required for every task on each resource in production line were proven.

Table 1 Total available capacity of each resource in the existing production line

Machine Name	Workstation	Element	Cycle Time (min)	Idle Time (min)
CNC 1	1	1	5	3
CNC 1		2	3	1.5
CNC 2	2	3	4	2
VMC 1	3	4	3	2

VMC 1		5	6	4
VMC 2	4	6	5	2.5
VMC 2		7	2	1
LTM 1	5	8	6	3
LTM 1		9	1	1
LCM 1	6	10	4	2.5
LCM 1		11	4	3
RCM 1	7	12	7	3.5
Total task time			**50**	**29**

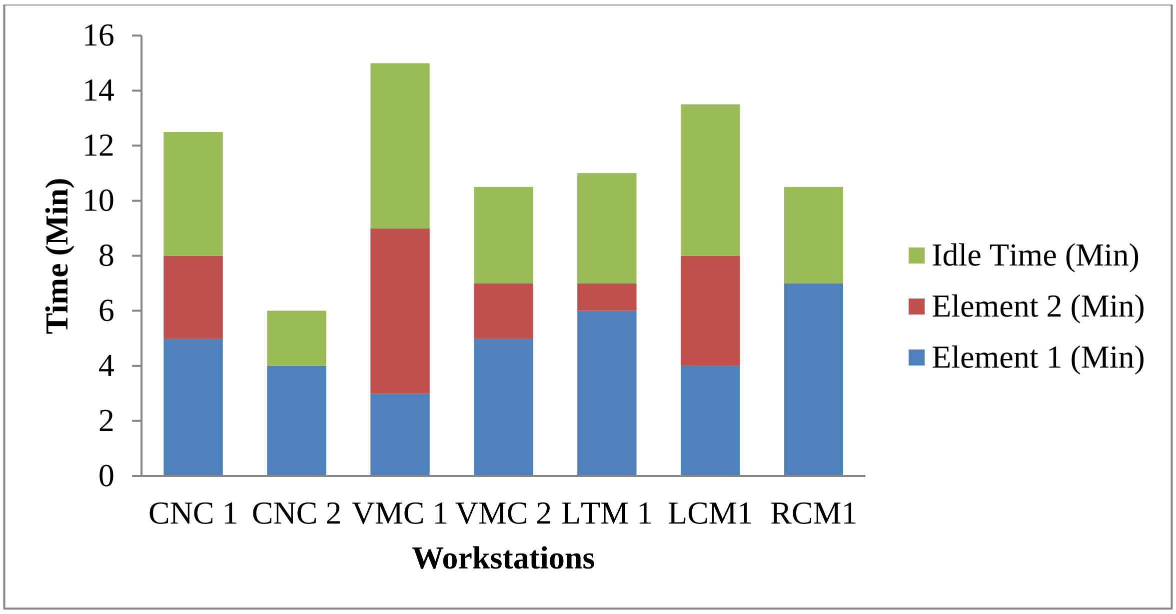

Fig. 1: Cycle Time Consumed on Each Workstation

Based on table 1, total cycle time consumed on each workstations bar chart has been drawn as shown in fig. 1.

6. PRECEDENCE DIAGRAM

A precedence Diagramming technique (PDM), that is every now and then additionally referred to as the Activity on Node (AON) Diagramming approach, is a graphical representation method, which indicates the inter-dependencies among various assignment activities. At the beginning, the precedence elements became identified and for this reason, the precedence diagram becomes constructed.

Table 2: Work Element time and Precedence at Present Assembly Line

Element	Duration (Min)	Precedence Relation
1	5	-
2	3	1
3	4	2
4	3	1
5	6	4
6	5	3,5
7	2	6
8	6	7
9	1	6
10	4	6
11	4	10
12	7	8,9,11

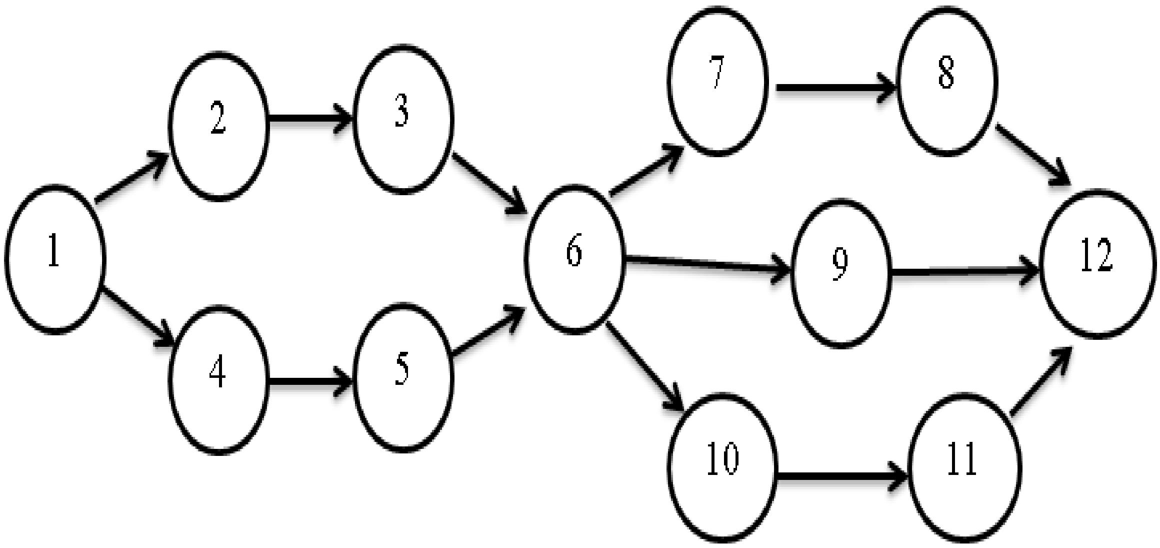

Fig. 2: Precedence Diagram

The RPW is calculated by summing Tek and the other times for elements that follow Tek in the arrow chain of the precedence diagram Table 3.

Table 3 RPW Calculation

Element	RPW	Total Rank Positional Weight
1	5 + 3 + 4 + 3 + 6 + 5 + 2 + 6 + 1 + 4 + 4 + 7	50
2	3 + 4 + 5 + 2 + 6 + 1 + 4 + 4 + 7	36
3	4 + 5 + 2 + 6 + 1 + 4 + 4 + 7	33
4	3 + 6 + 5 + 2 + 6 + 1 + 4 + 4 + 7	38
5	6 + 5 + 2 + 6 + 1 + 4 + 4 + 7	35
6	5 + 2 + 6 + 1 + 4 + 4 + 7	29
7	2 + 6 + 7	15
8	6 + 7	13
9	1 + 7	8
10	4 + 4 + 7	15
11	4 +7	11
12	7	7
Total	50	

Table 4 RPW in Descending Order

Element	RPW	Duration	Precedence
1	50	5	-
4	38	3	1
2	36	3	1
5	35	6	4
3	33	4	2
6	29	5	3,5
7	15	2	6
10	15	4	6
8	13	6	7
11	11	4	10
9	8	1	6
12	7	7	8,9,11
Total		50	

Assign the ones to work elements first which have no priority relationship. In step with the Positional Weight Rule, the element with greatest positional weight is allotted first. You begin to allocate work elements of their descending order of Ranked Positional Weight. Work elements may be allocated to a workstation until the cycle time is violated.
Rearrange the values of time using the previous steps, work elements are listed according to RPW value in Table 5.

Table 5: Work Element Assigned to Station for RPW

Workstation	Element	Cycle time (Min)	Cycle time at workstation	Idle Time (min)
1	1	5	8	4
	4	3		
2	2	3	7	3
	5	4		
3	3	4	9	2
	6	5		
4	7	2	6	4
	10	4		
5	8	6	10 (Max)	1
	11	4		
6	9	1	8	4
	12	7		
Total task time			50	18

The actual number of workstations is 7 after implementation it is going up to 6.

7. RESULTS AND DISCUSSIONS

Using the existing production line data we can investigate performance analysis of existing layout.

7.1 CYCLE TIME

From table 5.4, cycle time C = 10 min in keeping with unit every work station ought to have a cycle time of 10 or less than 10 minutes. So on each work station process have to be in this kind of way that summation of time required to process the elements ought to be equal or much less than cycle time 10 mins.

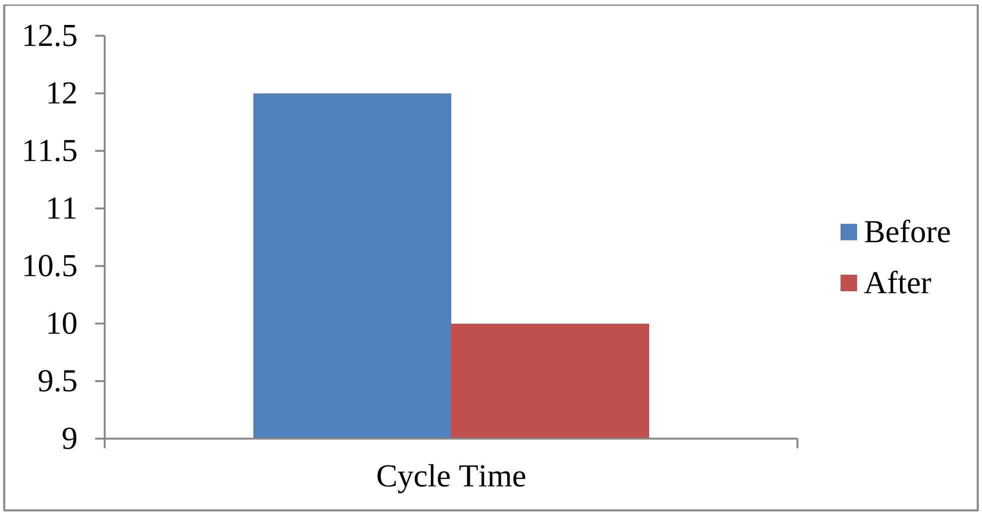

Fig. 3: Cycle time before and after line balancing

7.2 IDLE TIME

From the cycle time of numerous operations, the corresponding idle times are calculated and listed below. It is crucial to emphasize that the records below changed into recorded earlier than balancing the manufacturing line.
From table 5.3, **Idle time = 18 min**

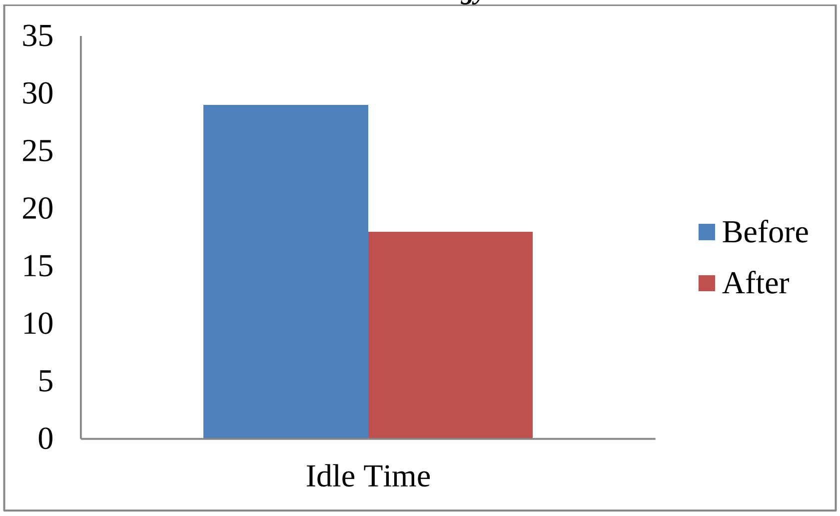

Fig. 4: the Idle time before and after line balancing

From above fig, it is clear that idle time is reduced from 29 min to 18 min after implementing RPW.

7.3 MINIMUM NO. OF WORKSTATION REQUIRED

The actual number of workstations is 7, however, the ideal number of workstations is 5. It approaches that preferably we will work with theoretical minimum workstations as five but we're unable to convert into 5 workstations due to some constraints. It is going up to 6.
So, **N= 6**

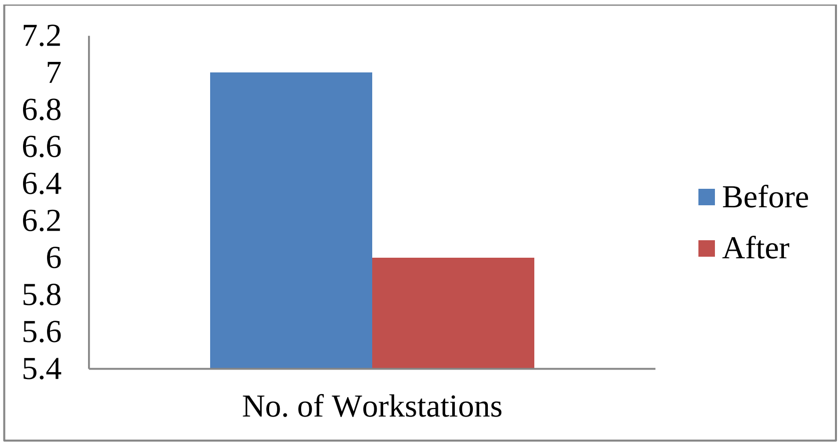

Fig. 5: No. of workstation before and after line balancing

7.4 BALANCE DELAY AND LINE EFFICIENCY

Balance delay defines as it is a measure of line efficiency which results from ideal time due to the imperfect allocation of work among station.
Following calculation, we have done to get line efficiency and balance delay. As reference taken reading from Table 5.3. Now, we are going to calculate line efficiency and it is given by formula as follow,

Line efficiency $= \frac{\text{Total Station Time}}{\text{Cmax X no.of station}} \text{ x } 100$

$= \frac{50}{6 \text{ X } 10} \text{ x } 100 =$ **83.33 %**

Also, we can calculate Balance delay as follows,

Balance delay = 100-83.33 = **16.67 %**

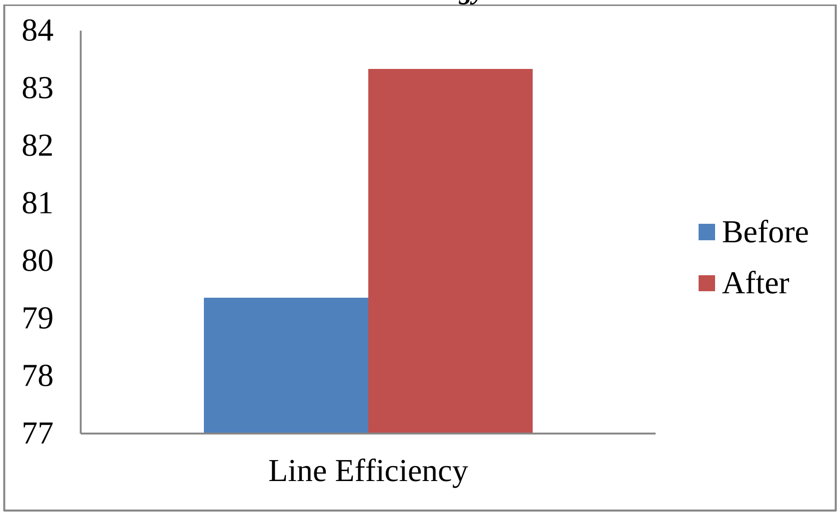

Fig. 6: Line Efficiency before and after line balancing

Fig. 6.4 shows that line efficiency is improved from **79.36** to **83.33 %** after implementing RPW.

7.5 SMOOTHNESS INDEX

(SI) describes relative smoothness for a given assembly line balance. Perfect balance is indicated by smoothness index 0. This index is calculated in the following manner:

$$SI = \sqrt{\sum_{i=1}^{K}(ST_{max} - ST_i)^2}$$

Where:
ST_{max} = maximum station time (in most cases cycle time),
STi = station time of station i.

$$SI = \sqrt{\sum_{i=1}^{7}(2)^2 + (1)^2 + (1)^2 + (4)^2 + (0)^2 + (2)^2}$$

SI (Smoothness Index) = 5.099

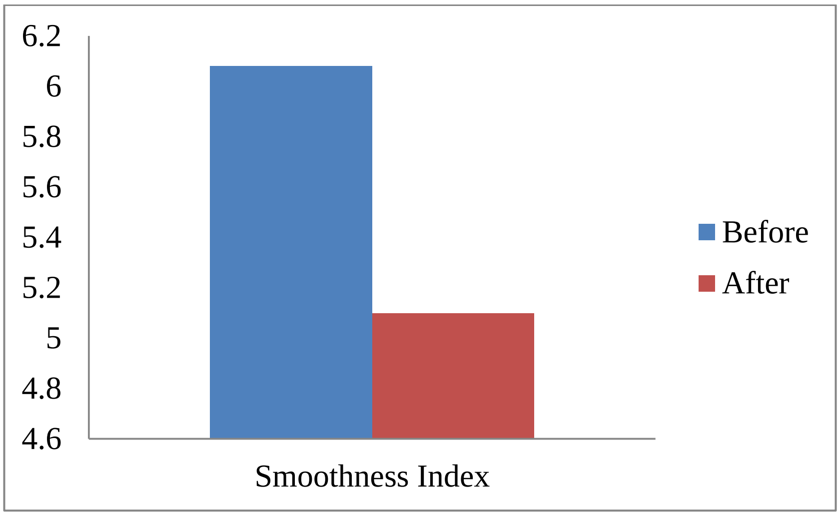

Fig. 7: Smoothness index before and after implementing RPW

Table 7: Comparison of results before and after line balancing using RPW

S.No	Parameter	Present assembly line	RPW method
1	Cycle time (min)	12	10
2	Idle time (min)	29	18
3	Line efficiency %	79.36	83.33
4	Smoothness index	6.08	5.099
5	Balance delay %	20.64	16.67
6	Production rate per day	35	40
7	No. of workstation	7	6

After the analysis of performance parameters such as on-time deliveries, the productivity measurement has carried out for selected housing component. Productivity has measured in terms of labor, machine, and material. The table 8, indicates analysis of labor productivity, machine productivity, and material productivity. After measurement of productivity, it is observed that labor productivity improved by 20 %, machine productivity improved by 14.06 %.

Table 8: Analysis of Productivity

Type of Productivity	**Before Line Balancing**	**After Line Balancing**	**Percentage of Improvement**
Labour Productivity	5	6	20 %
Machine Productivity	5.26	6	14.06 %

8. CONCLUSION

After implementation of line balancing, the analysis gives following results.

- As the calculated cycle time C = 10 min per unit every work station should have a cycle time of 10 or less than 10 minutes. So on each work station process should be in such a way that summation of time required to process the elements should be equal or less than cycle time 10 minutes. Hence cycle time is 12 min before and after it is 10 min.
- Idle time is reduced from 29 min to 18 min after implementing RPW.
- The actual number of workstations is 7 but the ideal number of workstations is 5. It means that ideally we can work with theoretical minimum workstations as 5 but we are unable to pack the individual work elements into 5 workstations due to their individual values. It is going up to 6.
- Line efficiency is improved from 79.36 to 83.33 % after implementing RPW.
- Smoothness index is proved from 6.08 to 5.099 after implementing line balancing
- After implementation of line balancing the labor productivity increased by 20 %, and machine productivity increased by 14.06 %
- The average amount of work in process inventory for selected housing product is reduced. Before implementation of line balancing, WIP was 245 bearing retainer and it is reduced up to 35 bearing retainer after implementation. This gives 85 % reduction in work in process inventory.
- The average amount of raw material inventory has considerably reduced; earlier it was 266 housings while it has come down to 63 housings. This gives 76.3 % reduction in raw material inventory.
- The average amount of on-time delivers before implementation was 82.4 %. This improves up to 96.4 % after implementation i.e. 16.9 % increment in on time deliveries after implementation of Line Balancing. This consequently resulted in improved throughput.

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