INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 3)
Available online at: www.ijariit.com

Production loss management using line balancing and cycle time reduction

Anil Bagare
anilbagare@hotmail.com
National Institute of Engineering, Mysore, Karnataka

Dr. G. L. Shekar
gl_shekar@yahoo.co.in
National Institute of Engineering, Mysore, Karnataka

Dr. M. Mohan Ram
mohanram_nie@yahoo.co.in
National Institute of Engineering, Mysore, Karnataka

ABSTRACT

Profit is life-line of any business. Profit can be increased by minimizing the losses in production and continuous improvement in quality. Losses will have a negative impact on the productivity and quality of the products produced by any organization. If cycle time is used as one the tool to measure each workstation's productivity, then reducing the cycle time at the workstation will minimize the time loss in production thereby increasing the productivity. The workstation which takes the longest cycle time will be the critical process or bottleneck process. Also, line balancing is used as one of the effective tools for reducing the cycle time. So, the productivity can be increased only if the critical process is 'debottlenecked.' The line efficiency also improves. This paper is aimed at identifying bottleneck workstations with the longest cycle time activities and reducing the losses in production at each workstation in an assembly line of automobile drive head.

Keywords*- Production Loss, Cycle Time, Line Balancing, Assembly Line and Station*

1. INTRODUCTION

Production is a process through which a firm transforms inputs into outputs. A production is considered a technically efficient method if the production process can produce maximum output from the given combination of input. Overproduction, waiting, unnecessary motion, excessive inventory, defects, delays, idle time, unnecessary stoppages, etc., are considered as production losses.

Production loss management is one of the basic approaches for all the production improvement activities. Losses in production can be detrimental to the profitability of any organization and production loss if not identified quickly and controlled properly may cause shut-down of any facility. It is therefore important to manage the losses in production which would otherwise increase the production cost.

If the loss is minimized even by a small amount, the productivity can be improved by a greater amount and the company can make a considerable profit.

1.1 Cycle Time:

Cycle time, defined as the total time from the beginning of any process to the end of the process, is used in differentiating total duration of a process from its runtime. The cycle time is usually measured with a stopwatch. Cycle time is normally larger than the service time.

$$\text{Cycle Time} = \text{Service Time} + \text{Idle time}$$

Also, Cycle Time,

$$C = \text{Useful production time per day (T) /Output per day (Q)}$$

1.2 Measurement of Cycle Time:

The cycle time for each workstation can be measured by picking apart until it has been located at the next workstation. The cycle time can be measured and recorded based on work sequences determined during observation. To enhance the reliability of the data obtained, a video camera can be used in recording.

1.3. Takt Time:

Takt time is defined as the maximum amount of time in which a product needs to be produced in order to satisfy customer demand. It is the speed with which the product needs to be produced in order to satisfy the demand of the customer. Takt time is defined as,

$$\text{Takt time} = \frac{T}{D}$$

Where T = Net available time for production
D= Customer's daily demand

1.4 Line Balancing:

In an assembly line, if the workers are not utilized effectively, then it results in less efficiency. If the cycle time of one workstation is high then it will affect the production rate of the whole product. If the line balancing is done in the assembly line, it will result in smooth functioning of the plant without bottleneck. Line balancing is done to obtain the maximum output at the desired time.

1.5 Standardized Work Combination Chart:

It is a combination table that shows manual work time, machine processing time and walks time for each operation in a production sequence. This chart or table is very helpful in identifying the waste of waiting and overburden and confirms standard work-in-process and shows workflow on a graph and depicts walking, waiting, machine time and operator cycle time. This is the basis for continuous improvement through Kaizen.

1.6. The layout of Drive Head Assembly Line:

Figure-1 shows the layout of a single model assembly line where the workers work on the same product. Differential case assembly is assembled in Bay-1 and pinion cage assembly is assembled in Bay-2. These two subassemblies will converge into a Drive Head Assembly Line where there are 8 stations (S1-S8) revolving in an elliptical manner and mounted on an indexing conveyor. The two subassemblies will now be finally assembled into a differential carrier.

The differential carrier is washed in a washing machine first to remove the dust and oil and dried. The differential carrier then enters the workstation S1 which is the beginning point of-of Drive Head Assembly. The pinion cage assembly from Bay-2 moves to workstation S2 through a conveyor which is put into the differential carrier. The differential case assembly from Bay-2 goes into the differential carrier at workstation S4. The assembled component leaves the Drive Head Assembly after the task is completed at Workstation S8. The talk time available is 130 seconds at each workstation and after 130 seconds the workstation will start moving automatically to the next indexed position.

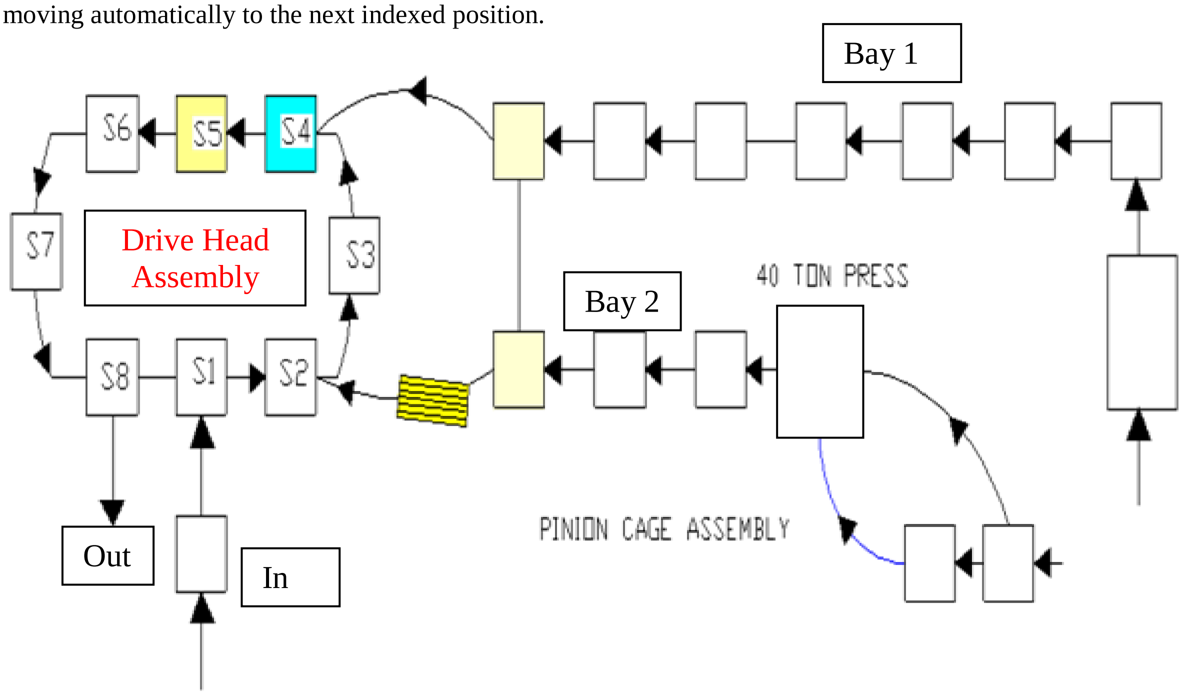


Fig. 1: The layout of Drive Head Assembly Line

2. LITERATURE REVIEW

Hiten Patel and Sanjay C. Shah (2014) present deep understanding on how the cycle time and work-in-process influence yield and throughput in a manufacturing industry.
The results demonstrate that if the cycle is reduced by 50% and work-in-process inventory is twice, the output increases by 50-70% [1].

Kanagaraj A, Vivek C, Vigneshraj CT and Rajesh Kannan K (2016) describe in their paper how to identify the bottleneck and reduce the cycle time to improve the productivity in a front door frame assembly line. The results demonstrate that the number of parts produced after cycle time reduction is 330 as against to 270 before cycle time improvement [2].

Amith J Prakash and Aneesh K S (2015) in their paper proposed time standards along with operational analysis that can be used to reduce cycle time in the tiller assembly line. Standard time along with operational analysis and line balancing was done in the engine section which resulted in the improved productivity [3]

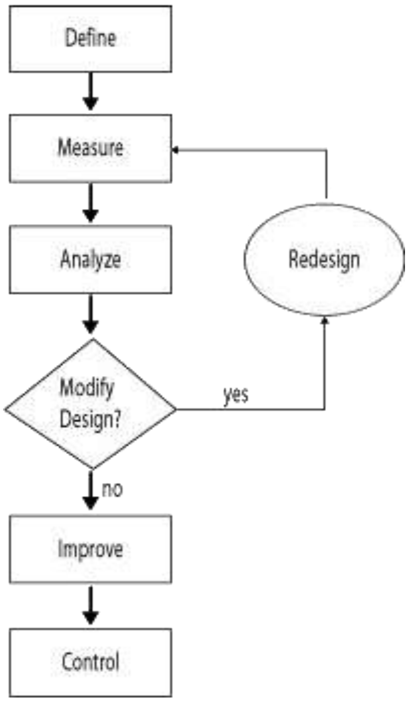
Md. Niaz Morshed & Kazi Saifujjaman Palash (2013) focus on improving the overall efficiency of the single model assembly line by reducing non-value added activities, cycle time and distribution of workload on each workstation in the garment industry. Results show that output has been increased to 1190 pieces a day compared to 1100 pieces before line balancing [4].

Ahmad Naufal Adnan, Nurul Ain Arbaai and Azianti Ismail (2016) state that by adopting line balancing method the losses can be greatly reduced besides improving the production rate and quality of the company's production in the automotive jack assembly production line. Results demonstrate that the company has increased the efficiency of production to 77% with the reduced number of manpower from 4 to 3 for assembly of a jack [5].

3. METHODOLOGY

Lean Six Sigma is used to reduce the cycle time: This method uses five stages which are abbreviated as DMAIC. The five stages are:

- Define:	Define the problem
- Measure:	Quantify the problem
- Analyse:	Identify the cause of the problem
- Improve:	Improve and verify the solution
- Control:	Maintain the solution



In the define phase, the problem is identified and broken into parts. The major problem identified in the Drive Head Assembly Line was of the line balancing problem. In some stations, the cycle time was more compared to others since they were overburdened. This had led to decreasing productivity and daily targets were not achieved.

In the measured phase, step-by-step data collection was done. The cycle time of each of the 8 stations was noted using a stopwatch. Also, the sequence of operation and number of operations at each workstation is noted and charted out as discussed in Table-2. There were stoppages and delays in the Drive Head Assembly Line for which a table is prepared that measures the duration of stoppage, the reason for the stoppage and the station which is consuming more time. The data is collected for one complete shift for a week. A table is prepared for the data collected whose sample is shown in Table-1.

The data was analyzed thoroughly to know the reasons for high cycle time and also the reasons for stoppages and delays and the station which is overburdened. A standardized work combination chart was prepared as shown in Chart-4.2 to analyze the data collected and to identify the station whose cycle time is more. This chart also helps in identifying the wastes and idle time at each workstation.

In the improvement and control phase, the idea and design are implemented. In the assembly, line balancing is done so that work gets distributed uniformly and controlled output is achieved. Redesigning is done wherever changes were required.

4. RESULTS AND DISCUSSION

After the problem is identified and literature reviewed, objectives and methodology were drawn to resolve the problem. This section discusses in detail the various charts and tables used for data collection and analysis.

4.1 Variation of Cycle Time before Improvement:

On observing the data collected it is found that there is no equal distribution of work and the line is not balanced. Chart-4.1 shows cycle time variation between the workstations. It is seen that the cycle time of Station-4 and Station-5 is high and is referred to as bottleneck stations. In bottleneck stations S4 and S5 the cycle time is almost near to the takt time of 130 seconds and exceeds the takt time if a new operator or unskilled operator operates the station or if there is a slight delay in any of the operations.

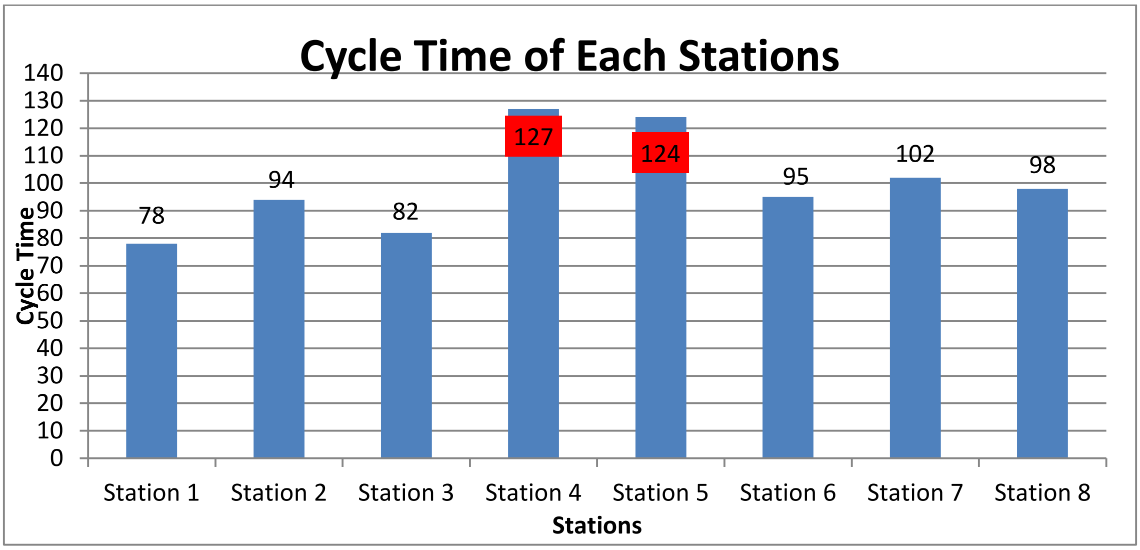


Chart 4.1: Variation of Cycle Time Before Improvement

4.2 Stoppages and Delays in Drive Head Assembly Line (Sample Data):

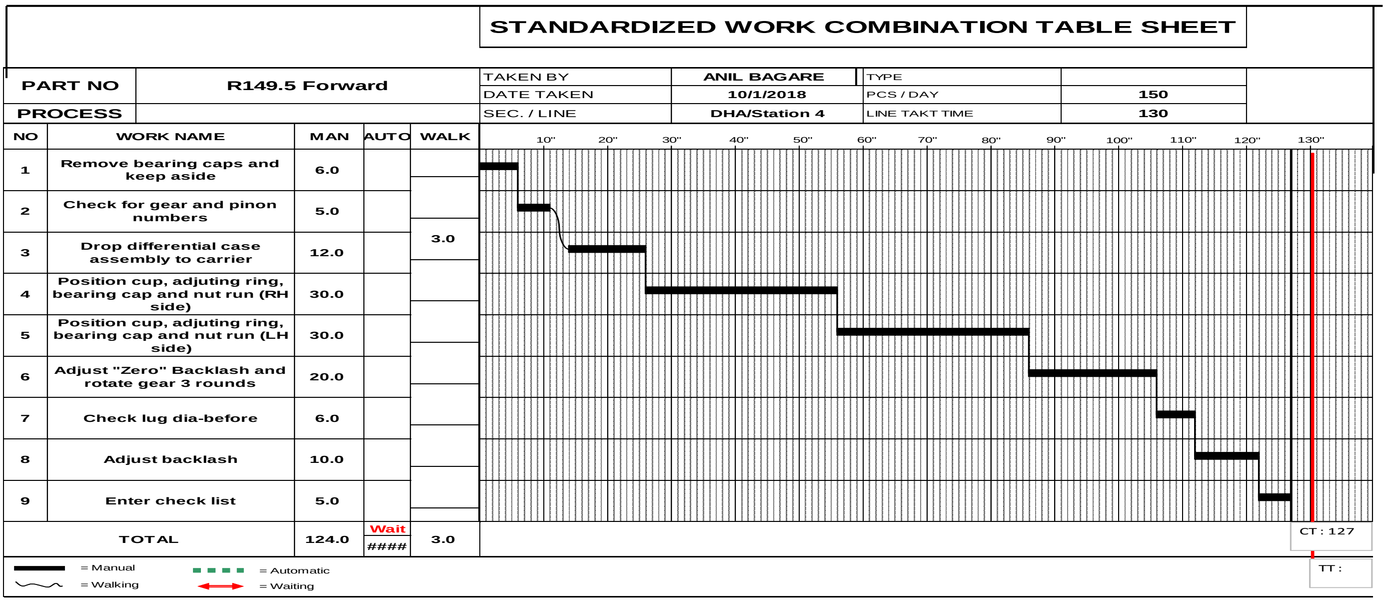
The stoppages and delays in Drive Head Assembly Line were observed for one complete shift for a week whose details are shown below in the Table-3.1. It is observed that stoppage is more in Station-4 and Station-5 compared to others. The reason for the stoppage is also noted down for further analysis.

Table 1: Stoppages and Delays (Sample Data)

Date	Model	Time	Station	Duration of stoppage	Reason for stoppage
10/01/2018	**R149.5 Forward**	11:24 a.m.	4	2.45 min	Component not arrived from subassembly (Crown wheel assembly)
		11:28 a.m.	4	35 sec	The component does not arrive from subassembly station 4
		11:31 a.m.	4	4 min	Component no arrived from subassembly station 5
		11: 41 a.m.	8	45 sec	Work not completed
		11:46 a.m.	4	25 sec	Work not completed
		11:55 a.m.	8	1 min	Work not completed
		11:59 a.m.	8	30 sec	Work not completed

4.3 Standardised Work Combination Chart:

The data collected were plotted and analyzed using standardized work combination chart which is very helpful in identifying the wastes and idle time. The manual work is indicated by a straight line and walking by a curved line in the table. A sample standardized work combination chart is shown in Chart-3.2. After extensively analyzing the data collected, it was found that the Station-2 and Station-4 are overburdened and the line is not balanced.



STANDARDIZED WORK COMBINATION TABLE SHEET

PART NO	R149.5 Forward	TAKEN BY	ANIL BAGARE	TYPE	
		DATE TAKEN	10/1/2018	PCS / DAY	150
PROCESS		SEC. / LINE	DHA/Station 4	LINE TAKT TIME	130

NO	WORK NAME	MAN	AUTO	WALK
1	Remove bearing caps and keep aside	6.0		
2	Check for gear and pinon numbers	5.0		3.0
3	Drop differential case assembly to carrier	12.0		
4	Position cup, adjuting ring, bearing cap and nut run (RH side)	30.0		
5	Position cup, adjuting ring, bearing cap and nut run (LH side)	30.0		
6	Adjust "Zero" Backlash and rotate gear 3 rounds	20.0		
7	Check lug dia-before	6.0		
8	Adjust backlash	10.0		
9	Enter check list	5.0		
TOTAL		124.0	Wait ####	3.0

Chart 4.2: Standardized Work Combination Chart

4.4 Suggested Line Balance Activities at Drive Head Assembly Line:

The suggested work element and work sequence to balance the line is shown in the Table 4.2 below.

Table 4.2: Observed and Suggested Line Balance Activities at Drive Head Assembly Line

S. No	Work Station	Observed Work Element & Sequence	Suggested Work Element & Sequence
1	Station - 1	**Carrier Load Station** 1. Place empty tray onto the trolley, pick loaded tray & transfer to assembly stand. 2. Pick carrier from washing m/c & place on to the fixture. 3. Fasten 2 bolts between carrier & the fixture. 4. The operator moves back to washing m/c.	**Carrier Load Station** 1. Pick carrier from washing m/c & place on to the fixture. 2. Fasten 2 bolts between carrier & the fixture. 3. Apply Anabond on pinion cage mating face. 4. Insert locating studs (2) 5. Place shims on to the mating face. 6. Apply Anabond over shims 7. Position pinion cage assembly on to the carrier. 8. Insert bolts (8) to pinion cage assembly.
2	Station - 2	**Pinion cage load station:** 1. Apply Anabond on pinion cage mating face. 2. Insert locating studs (2) 3. Pick shims & pinion cage assembly in the air. 4. Place shims on to the mating face. 5. Apply Anabond over shims 6. Position pinion cage assembly on to the carrier. 7. Apply Anabond on all bolts. 8. Insert bolts (8) to pinion cage assembly. 9. Enter checklist.	**Pinion cage load station &** pinion cage **bolt torque station:** 1. Torque pinion cage bolts (8). 2. Apply white paint over the bolts. 3. Index the fixture 180 degrees.
3	Station - 3	**Pinion cage bolt torque station:** 1. Torque pinion cage bolts (8). 2. Apply white paint over the bolts. 3. Index the fixture 180 degrees. 4. De-torque bearing cap bolts. 5. Loosen bearing cap bolts using nut runner. 6. Enter checklist	1. De-torque bearing cap bolts. 2. Loosen bearing cap bolts using nut runner. 3. Remove bearing caps & keep aside (2). 4. Check for gear & pinion numbers & nameplate. 5. Drop differential case assembly to the carrier. 6. Position cup, adjusting ring, bearing cap & nut run (RH Side). 7. Enter checklist.
4	Station - 4	1. Remove bearing caps & keep aside (2). 2. Check for gear & pinion numbers & nameplate. 3. Drop differential case assembly to the carrier. 4. Position cup, adjusting ring, bearing cap & nut run (RH Side). 5. Position cup, adjusting ring, bearing cap & nut run (LH Side). 6. Adjust "ZERO" backlash & rotate gear 3 rounds. 7. Check lug dia and adjust backlash. 8. Enter checklist.	1. Adjust "ZERO" backlash & rotate gear 3 rounds. 2. Check lug dia – before. 3. Adjust backlash. 4. Enter checklist
5	Station - 5	1. Roll gear 2 rounds 2. Check for actual reading using dial gauge. 3. Adjust backlash & set to required reading. 4. Torque bearing cap bolts (4). 5. Apply white paint over the bolts. 6. Check for backlash reading using dial gauge (after torque). 7. Check for the pattern at 1 point 8. Enter checklist.	1. Roll gear 2 rounds 2. Check for actual reading using dial gauge. 3. Adjust backlash & set to required reading. 4. Torque bearing cap bolts (4). 5. Apply white paint over the bolts. 6. Enter checklist.
6	Station - 6	1. Pick & place dial stand on to fixture. 2. Check for backlash at 4 points 3. Check lug dia at 2 points. 4. If any variation, readjust backlash & lug dia. 5. Recheck for backlash at 2-4 points. 6. Recheck lug dia at 2 points 7. Enter checklist. 8. Check for a back face run out & contact pattern. 9. Enter checklist and stick pattern at 120 degrees apart.	1. Check for backlash reading using dial gauge (after torque). 2. Check for the pattern at 1 point 3. Check for backlash at 4 points 4. Check lug dia at 2 points. 5. Recheck lug dia at 2 points 6. Enter checklist. 7. Check for a back face run out & contact pattern. 8. Enter checklist and stick pattern at 120 degrees apart

7	Station - 7	1. Insert cotter pin 2. Apply white paint over the pin. 3. Index the fixture 180 degrees. 4. Enter checklist and fix thrust screw (1). 5. Torque thrust Screw. 6. Check for the gap.	1. Insert cotter pin 2. Apply white paint over the pin. 3. Index the fixture 180 degrees. 4. Enter checklist and fix thrust screw (1). 5. Torque thrust screw. 6. Check for the gap.
8	Station - 8	1. Fix nameplate. 2. Enter checklist. 3. Tag check sheet to drive head assembly. 4. Loosen & remove screws (2). 5. Unload drive head assembly to trolley conveyor index.	1. Fix nameplate. 2. Enter checklist. 3. Tag check sheet to drive head assy. 4. Loosen & remove screws (2). 5. Unload drive head assembly to trolley conveyor index.

4.5 Summary of Results:

The stations which were more burdened were released so that the work progresses smoothly without any delays and stoppages. Chart-4.3 shows cycle time at each workstation after new work element and sequence have been suggested. The cycle time of all the 8 stations is now equally poised.

The total productivity of the line will improve from 170 units per shift to around 200 units per shift after line balancing is done with the new suggested method. The increase in production is from 30 to 32 units per shift with 18% increase in production.

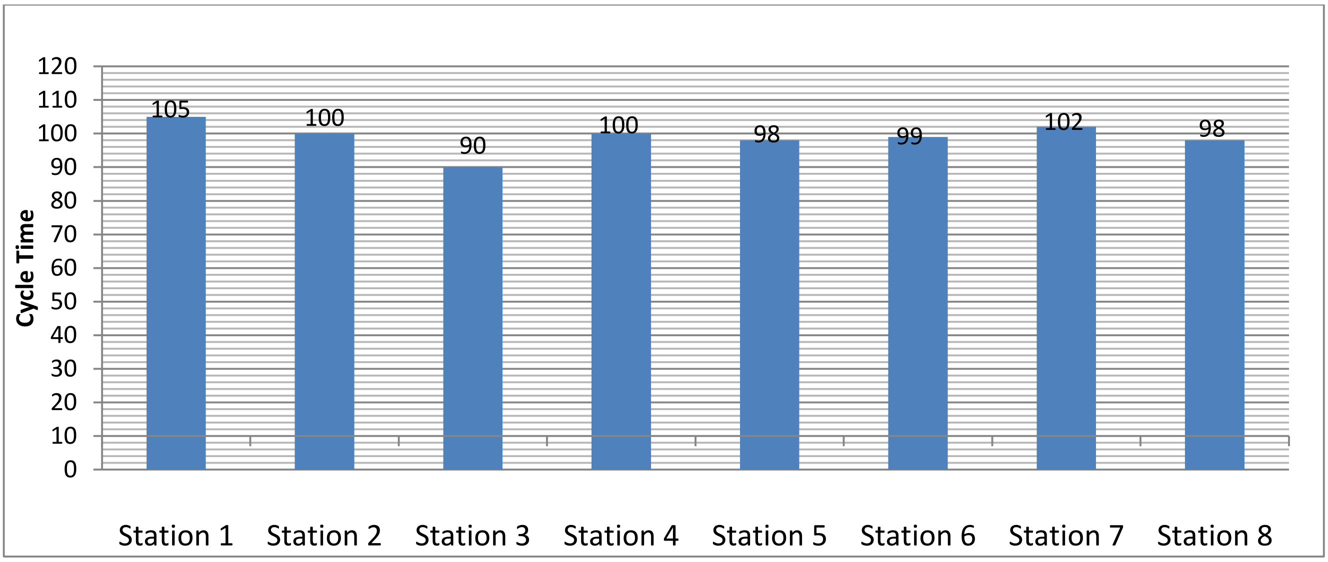


Chart 4.3: Variation of Cycle Time After Improvement

5. CONCLUSION

On observation and studying the existing conditions of Drive Head Assembly Line, it was observed that the shift target of 170 components was not achieved due to reasons such as high cycle time, idle time, stoppages and delays. The objective of this work was, therefore, to minimize the workload while meeting the daily output through cycle time reduction and line balancing.

Collection and analysis of data were done and new work elements and sequences were suggested after line balancing was done. The study results infer that if the proper allocation of activities, proper arrangement of tasks and work sequences to individual workstations is done, the production can be increased by more than 18% in Drive Head Assembly Line of leading to an optimum level of production thereby reaching the daily targets.

The suggested work elements and sequences after line balancing were discussed with the manager in charge of the department and will be implemented in the near future after approval by the higher authority.

6. REFERENCES

[1] Hiten Patel, Sanjay C. Shah, “Review on Cycle Time Reduction in Manufacturing Industries”, Journal of Emerging Technologies and Innovative Research (JETIR), ISSN-2349-5162, Dec 2014 (Volume 1 Issue 7), pp. 955-957.
[2] Kanagaraj A et al. “Line Balancing through Cycle Time Reduction”. International Journal of Advance Industrial Engineering; Vol.4, No.3 (Sept 2016), pp. 102-106.
[3] Amith J Prakash, Aneesh K S, “Cycle Time and Idle Time Reduction in an Engine Assembly Line”, International Journal of Science Technology & Engineering; Volume 2, Issue 5, Nov 2015, pp. 139-143.
[4] Ahmad Naufal Adnan et al. “Assembly Line Balancing to Improve Productivity using Work Sharing Method in Apparel Industry”, Global Journal of Researches in Engineering, Vol 14, Issue 3, 2014.
[5] Ahmad Naufal Adnan et al. “Improvement of Overall Efficiency of Production Line by Using Line Balancing”. ARPN Journal of Engineering and Applied Sciences; Vol 11, No. 12, June 2016, pp. 7752-7758.
[6] www.isixsigma.com.
[7] www.goleansixsigma.com