RPW METHOD OF LINE BALANCING IN AUTOMOBILE INDUSTRY: CASE STUDY

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Abstract— Assembly line balancing is the method of assigning tasks to workstations so that there will be maximum utilization of human resources and facilities without disturbing the work sequence. Many exact, heuristic and other approaches have been proposed for solving different types of assembly line balancing problems.
This paper mainly focuses on improving overall efficiency of single model assembly line by distribution of work load on each workstation by RPW method for same cycle time proposed in the case study without violating precedence constraints, in order to improve the efficiency of line. Accordingly it resulted in improvement of other parameters of the existing line.

Keywords - Assembly Line Balancing; RPW Method; Efficiency;

I. INTRODUCTION

Assembly lines (ALs) are the most commonly used method in a mass production environment. They allow the assembly of products by workers with limited training and by dedicated machines and/or by robots. Assembly Line design (ALD) involves the design of products, processes and plant layout before the construction of the line itself. The design of efficient assembly workshops is a problem of considerable industrial importance. Assembly Lines are production systems composed of a succession of stations performing a set of tasks on the product passing through them. The assembled product takes its shape gradually starting with one part, with the remaining parts being attached at the various stations which are visited by the product. A paced Assembly Line is a usual topology for medium and high production volumes. In general, for simple products single linear Assembly Lines with possibly parallel stations can do the job. For complex products, the assembly system is mostly decomposed into sub-systems with their own cycle time, reliability, and stations requirements.
Nowadays companies around the world are producing high quality products to sell them at the lowest price possible. This is not because they don't want to earn more money through the sale of products. It is because they are facing the necessity of increasing their participation in the market because competitors also are selling products with high quality at the lowest price possible. There are several techniques to reduce operation costs. One of these techniques is called Line Balancing. The line balancing problem consists of assigning approximately the same amount of workload to each workstation (worker) in an assembly line. Line balancing involves selecting the appropriate combination work task to be performed at each work station so that the work is performed in a feasible sequence and approximately equal amounts of time are required at each of the work stations.
Performance evaluation generally involves two steps: (1) the mathematical model and (2) the model solution. Since it is difficult to find a simple model to describe a studied system, a simulation method must be used. A standardization of performance indices of line layout design must be defined, which could be minimization of the number of workstations, maximization of the production rate, minimization of cycle time etc. However there are some factors that may affect the performance of the system on which attention should be given like equipment cost, correlation between task times etc.
The incremental utilization heuristics simply add tasks to a workstation in order of task precedence one at time until utilization is 100% or is observed to fall. Then this procedure is repeated at the next workstation for the remaining tasks. This is appropriate when one or more task time is equal to or greater than the cycle time. The important advantage of this heuristics is that it is capable of solving line balancing problems regardless of the length of task times relative to the cycle time. Under certain circumstances, however, this heuristic creates the need for extra tools and equipment. If the primary focus of the analysis is to minimize the number of workstations or if the tools and equipment used in the production line are either numerous or inexpensive, this heuristic is appropriate.

II. LITERATURE REVIEW

A review of literature has been undertaken to understand different optimization technique used by different authors on assembly line balancing problems. Some of the recent papers review has helped to identify the suitable method to solve the assembly line problem which is presented below:
Ashish Manoria et. al. (2012) [12], described Rank positional weight method for Type I of the Simple Assembly Line Balancing Problem (SALB P) and multi product assembly line balancing problem (MALBP) for the hybrid system from the automotive industry which considered to assemble two models of commercial vehicles on the same assembly line which had most of their parts in common. The result showed that rank positional weight heuristic rule can produce good solutions for the straight line LBP. It was shown that the addition of an expert algorithm can improve the current solution. The study took a step in the

direction of finding good result for the SALBP and MALBP. The major role of the study was to look these problems and introducing the expert system accordingly to minimize slack time at each work station and get task in shorter period of time.

W. Grzechca et. al. (2014) [2], considered job shop structure connected with assembly line wherein heuristic method such as RPW technique help to obtain feasible solutions very quickly without time consumption. His article shows a method which allows finding a good schedule of complex system (job shop - assembly line and vice versa). Total completion time, number of stations or smoothness index were taken into account for choosing the end solution and results showed that the total completion times of different variant don't differ from each other a lot.

Parudh Mahajan et. al. (2015) [5], presented a heuristic method that was based on critical path method compared to RPW method and SPT method for simple assembly line balancing. The research was mainly concerned with objectives of minimizing the number of workstations, improvement of smoothness index, mean absolute deviation (MAD) and increasing line efficiency. It was concluded that all three methods gave better results than the method used in the industry but heuristic method based on CPM given the better result in the industry considered.

Krantikumar B. Chavare et. al. (2015) [9], presented use of RPW method to develop the assembly line and balancing that line. It was found that RPW method is useful when the less or more data is available. Also with the help of RPW method, it is possible to find out the way to synchronies the work stations for the work flow and sequencing. So the bottlenecking of the assemblies can be reduced. In his case study, numbers of workstations was decided and proper layout was proposed based on RPW method. After the implementation of RPW method, production rate was increased by 25%.

III. CASE STUDY

The problem was taken from International Journal published by Ankur Malik et. al. (2016) [1], which is presented below.

Table 1 shows the operations and time taken for the entire Lamp to produce. The line consists of 14 work stations. From the hourly production report, it was calculated that, for 8 hours production, the maximum production was 800pcs/day. So, the hourly output in assembly line would be 80pcs. A schematic scenario of present assembly line section layout is given in the Table 1.

This paper uses the data of the same problem and RPW methodology is applied to solve the same.

Table 1: Present assembly line section layout

Task No	Task Description	Task Time (Min)
1	Reflector inspection	0.17
2	Lens inspection	0.17
3	Hot melt robot	0.28
4	Lens pressing	0.28
5	Leak testing	0.3
6	Bulb holder spring fitment	0.23
7	Bulb fitment	0.35
8	Dust cap Vent tube fitment	0.23
9	Full assy dust cap fitment	0.23
10	Parking wire fitment	0.54
11	U shape ventube fitment	0.54
12	Photometric light testing	0.45
13	Final inspection	0.2
14	Packing	0.53

IV. RPW METHOD (PROPOSED)

RPW method combines the strategies of the Largest-Candidate rule and Kilbridge and Wester's method. A ranked positional weight value (call it the RPW for short) is computed for each element. The RPW takes account of both the task time value of the element and its position in the precedence diagram. Then, the elements are assigned to work stations in the general order of their RPW values.

Steps Involved in RPW method

Step 1: Draw the precedence diagram

Step 2: For each work element, determine the positional weight. It is the total time on the longest path from the beginning of operation to the last operation of the network.

Step 3: Rank the work elements in descending order of ranked positional weight (R.P.W).

Step 4: Assign the work element to a station. Choose the highest RPW element. Then, select the next one. Continue till cycle time is not violated. Follow the precedence constraints also.

Step 5: Repeat step 4 till all operations are allotted to one station.

Table 2 depicts the precedence relationship and immediate predecessor between these tasks.

Table 2: Task Precedence Relations and Immediate Predecessors

Task Description	**Task Time (Min)**	**Immediate Predecessor(s)**
Reflector inspection	0.17	-
Lens inspection	0.17	1
Hot melt robot	0.28	2
Lens pressing	0.28	3
Leak testing	0.3	4
Bulb holder spring fitmen t	0.23	5
Bulb fitment	0.35	-
Dust cap Vent tube fitmen t	0.23	7
Full assy dust cap fitment	0.32	8,6
Parking wire fitment	0.25	9
U shape ventube fitment	0.2	10
Photometric light testing	0.45	10
Final inspection	0.27	11,12
Packing	0.22	13,14

Considering the precedence constraints positional weight for each work element is determined followed by arranging the work elements in descending order of the positional weight.

Table 3: Positional Weight of each element

Task No	Task Description	Task Time (Min)	Immediate Predecessor	Positional Weight
1	Reflector inspection	0.17		3.92
2	Lens inspection	0.17	1	3.75
3	Hot melt robot	0.28	2	3.58
4	Lens pressing	0.28	3	3.3
5	Leak testing	0.3	4	3.02
6	Bulb holder spring	0.23	5	2.72
7	Bulb fitment	0.35		3.07
8	Dust cap Vent tube filament	0.23	7	2.72
9	Full assy dust cap fitment	0.32	8,6	2.49
10	Parking wire fitment	0.25	9	2.26
11	U shape ventube fitment	0.2	10	1.27
12	Photometric light testing	0.45	10	1.18
13	Final inspection	0.27	11,12	0.73
14	Packing	0.22	13	0.53

Thus after the application of RPW method we could arrange the work elements in 8 work stations which is shown below:

Table 4: Workstations assigned using RPW Method

Station	Task Assigned	Station Time (Min)
1	Reflector inspection Bulb fitment	0.52
2	Lens inspection Hot melt robot	0.45
3	Lens pressing Dust cap Vent tube filament	0.51
4	Leak testing Bulb holder spring	0.53
5	Full assy dust cap fitment Parking wire fitment	0.57
6	Photometric light testing	0.45
7	U shape ventube fitment Final inspection	0.47
8	Packing	0.22

RPW Method Outcomes :

No of workstations = 08
Cycle time(C) = 0.6 min
Line Efficiency = 77.5%
Smoothness Index = 0.411

V. RESULTS AND DISCUSSIONS

It is clear from the outcomes of RPW method that this methodology gives the improved result for the line balancing problem. Comparing this with the Largest Candidate rule methodology (keeping the cycle time as same) we can observe that the line efficiency and Smoothness index is somewhat closer in both the methodology. However, if we minimize the manpower used in the workstation 8, the line will be a lot more improved in terms of performance parameters and also save money together with improved utilization of resources.

VI. CONCLUSION

From the result of the case study taken we can conclude that the Ranked Positional Weight Method can give improved results in the existing assembly line problem. The objective of the line balancing problem does not end here, and it can be addressed further by reducing the cycle time (if required) or reducing the number of workstation.

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