

Research Article

Assembly Line Efficiency Measurement and Line Balancing-A Case Study on Automobile Cluster Assembly Line

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Abstract: Factors which affect the performance of assembly lines are difficult to be assessed and solved by mathematical model. This study attempts a practical solution to the stochastic Automobile Instrument cluster assembly line balancing problem. The factors influencing the assembly time in manufacturing systems are analysed, the precedence diagram model for the above assembly line is built and the effects of factors on the line balancing problem are considered. Lastly, the balancing results of the deterministic model are compared to the real world data from industries for the effective usage of the altered model.

Keywords: Assembly line balancing techniques, automobile instrument cluster assembly line, kilbridge wester method, stochastic factors

INTRODUCTION

One of the main problems in the manufacturing industries was line balancing (Roher, 2000; Schaefer *et al.*, 2001). In the line balancing the major problem is implementing the set up. It cannot be done in trial and error basis, as its cost involvement is high. The recent development in the field of simulation is one of the best ways to solve this issue. For any simulation model the concept starts with the better understanding of traditional mathematical modelling techniques for this purpose an automobile instrument cluster manufacturing assembly line is taken and its behavior is studied.

TPA to proficiently achieve numerous auditing tasks in a group way, i.e., concurrently. Finally, the security result of proposed effort illustration shows the fast performance of the design in terms of data integrity and data accountability.

LITERATURE REVIEW

Elasticity and automation in assembly lines can be attained by the use of robots. For robotic assembly line, the Robotic Assembly Balancing (RALB) problem is definite, also that different robots could be allocate to the assembly tasks and for all robot needs separate assembly times to do a given assignment, because of its ability and interest. By taking effort for optimal task of robots to the line stations and a balanced supply of work between different stations is the solution for RALB problem. Production rate of the line is increased if the specified problem is rectified. A Genetic Algorithm (GA) is introduced here to find a solution to this problem. For acclimatize the GA to the RALB

problem two procedures were introduced, by assigning robots with dissimilar potential to workstations are initiated: a recursive assignment procedure and a consecutive assignment procedure. The results of the GA are enhanced by a local optimization work-piece swap process. Various tests were carried out on a set of randomly produced problems; show that the Consecutive Assignment procedure achieves better solution (Levitin *et al.*, 2004).

Khouja *et al.* (2000) implies statistical clustering measures to plan robotic assembly cells. The author introduced two approaches initially a fuzzy clustering algorithm is employed to group similar tasks as one so that they can be allocated to robots as sustain a balanced cell and achieving a preferred production cycle time. In the next stage, a Mahalanobis distance process is used to decide robots suitable for the assignment set is explained by Mahalanobis (1936) and Everitt (1974). At the same time as their work focuses on a robotic cell design, it look for that the approach can be extensive to design of a line of cells with alike cycle times. Though, in an assembly line, task elements may be allocated to a single robot based on the robot potential and not on task comparison, as considered in their work.

A segregative genetic algorithm for "I"/"U"-shaped assembly line balancing problem is presented by the author. It uses a fundamental genetic algorithm and a characteristic function that links a time sketch of the workstations to all chromosomes. The similarity based clustering in the feature space persuades subpopulations of chromosomes. Each subpopulation totally subjugated and sends its centroid to an associative tabu search mechanism. A number of selected new individuals are

used to generate clusters that signify new parts of search space. The fatigued subpopulations are replaced by new ones through the evolution. The performance of dynamic segregative genetic algorithm leads to a better trade-off between investigations, made by many clusters, completed by the center on each subpopulation. Experimental result shows that the segregative approach is steadier and analytically produces better results than the basic genetic algorithm (Brudaru, 2010).

PROPOSED METHODOLOGY

Automobile cluster instrument assembly line: In this paper an automobile cluster assembly line is taken. The instrument cluster is as shown in below Fig. 1 and it has 13 work task elements which are arranged in a U shaped line layout fashion as shown in Fig. 2.

Various factors which influence the Performance of the assembly lines were as follows (Rosenberg and Ziegler, 1992; Baybars, 1986; Amen, 2000).

Task times: In this model task time is considered as constant, the main reasons for consideration are the model is assumed to be deterministic.

Manning level: In this deterministic model for each workstation one labor is employed i.e., Manning level is taken as one.

Number of workstations: The number of workstations in this deterministic model is 13.

Demand rate: The Demand rate is taken as 100 Instrument clusters per day for 540 min of effective production time.

The work elements of each work stations along with their elemental task times are given in Table 1.

Table 1: Work elements and their task times

Name of the workstation/work elements	Processing time/operation time (min) (t _i)
Stepper motor assembly	2
Stepper motor soldering	5
LCD assembly	3
LCD soldering	8
Dial assembly	4
Back cover assembly	10
Pointer driving	5
Auto calibration	12
Crystal assembly	5
Functionality check	5
Illumination testing	5
Visual inspection	5
Pointer foil stamping	4
Total Work Content (TWC) =	73

Assembly line balancing techniques: Many of scholars have tried Traditional line balancing techniques along with non traditional techniques i.e., metaheuristic searches like Genetic algorithms, Ant colony optimization, PSO etc., along with hybrid techniques. For all these implementations base lies in the knowledge application of traditional line balancing techniques.

According to Mahto and Kumar (2012). Among the traditional line balancing techniques the popular methods were:

- Kilbridge Wester Heuristic Approach
- Helgeson-birnie approach

In this study the above selected cluster assembly line problem is solved by Kilbridge Wester Heuristic Approach.

Kilbridge wester heuristic approach: The procedure for solving Assembly line balancing problem is as follows:



Fig. 1: Automobile instrument cluster

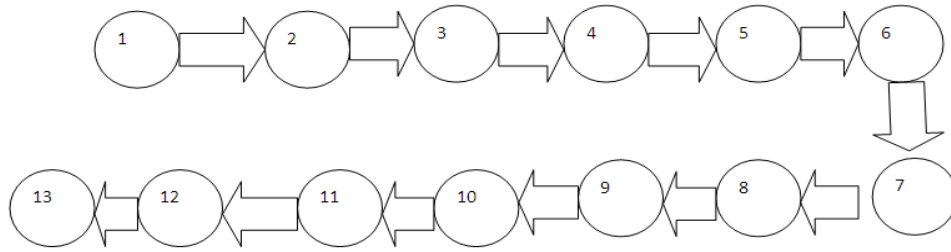


Fig. 2: Precedence logic diagram of cluster assembly line

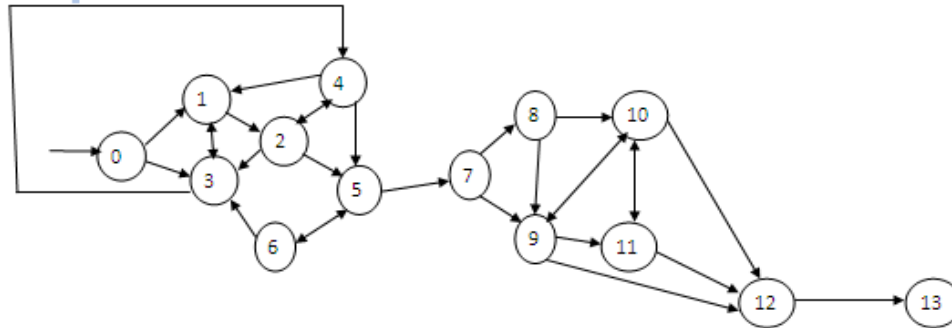


Fig. 3: Precedence logic diagram of cluster assembly line

Table 2: Work station allocation table line

Work station	Work element	Processing time (min) (ti)	Cycle time (min)	Station sum (min)
1	3	3	12	3
	1	2		5
	2	5		10
2	4	8	12	8
	5	4		12
3	6	10	12	10
4	7	5	12	5
	9	5		10
5	8	12	12	12
6	10	5	12	5
	11	5		10
7	12	5	12	5
	13	4		9

- Construct the precedence diagram for work elements.
- Select a feasible cycle time.
- Assign work elements to the work station. So that the sum of elemental task time does not exceeds cycle time.
- Delete the assigned elements from the total number of work elements.
- If the station time exceeds the cycle time due to the inclusion of a certain work element, then this work element should be assigned to next work station.
- Repeat the steps 3 to 5 until all the work elements were assigned to the work stations.

Demand Rate of the product = $D = 100$ parts per 540 mins working shift:

$$\text{Total Work Content} = \text{TWC} = \sum ti = 73 \text{ min} \quad (1)$$

Table 3: Allocation table

Work station	Work element	Effective station time (min)
1	3 (LCD assembly)	10
	1 (stepper motor assembly)	
	2 (stepper motor soldering)	
2	4 (LCD soldering)	12
	5 (dial assembly)	
3	6 (back cover assembly)	10
4	7 (pointer driving)	10
	9 (crystal assembly)	
5	8 (auto calibration)	12
6	10 (functionality check)	10
	11 (illumination testing)	
7	12 (visual inspection)	9
	13 (pointer foil stamping)	

$$\text{Cycle Time} = \text{CT} = \text{Max} (ti) = 12 \text{ min} \quad (2)$$

Above Fig. 3 represents the precedence logic diagram of the cluster assembly line. The numbers inside the circle represents the work elements. 0

represents the starting of process initially work. Element task time for 0 is zero. The elemental task times for other tasks is defined as shown in above Table 1. The allocation table is created as shown in Table 2.

Efficiency calculations:

For existing u layout as per Fig. 1: From (1) Total Work Content (TWC) = 73 min from (2) Cycle Time (CT) = 12 min.

Number of operators = 13:

$$\begin{aligned} \text{Line efficiency} &= (\text{TWC} / (\text{Number of operators} * \text{CT})) * 100 \\ &= (73 / (13 * 12)) * 100 \\ &= 46.7948\% \end{aligned} \tag{3}$$

For modified layout as per Table 2.

From (1) Total Work Content (TWC) = 73 min.

From (2) Cycle Time (CT) = 12 min.

Number of operators = 7:

$$\begin{aligned} \text{Line efficiency} &= (\text{TWC} / (\text{Number of operators} * \text{CT})) * 100 \\ &= (73 / (7 * 12)) * 100 = 86.9047\% \end{aligned} \tag{4}$$

RESULTS AND DISCUSSION

The number of workstations has been reduced to 7 from 13 and 6 workstations can be removed. And also the line efficiency as per (1) can be raised from 46 to 86% i.e., production rate increases approximately by 40%. This shows the effectiveness of mathematical Heuristic approach (Table 3).

From the above it is clear that 13 workers can be reduced to 7 workers. The per shift wages for a person is 400 Rupees. So that we can obtain 2400 Rupees savings per day. Finally annually we can obtain a cost saving of Rupees 7,20,000/-per one assembly line which operates 300 shifts/year.

RECOMMENDATIONS

These types of heuristics can be applied for all types of practical societal scheduling problems. Although

numerous metaheuristic approaches like GA, PSO, ACO etc., were developed the base concept of task selection and allocations will always lies on the mathematical models and traditional heuristic approach.

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