Productivity Improvement of an Assembly Line

Vivek Kumar[1]
[1]*Department of Mechanical Engineering Sant Longowal Institute of Engineering and TechnologyLongowal, Sangrur, Punjab-148106*

Abstract: Assembly line balancing is a production policy that sets a planned rate of production to yield a product within a particular time frame. Productivity enhancement in assembly lines is vital as it increases the capacity and at the same time reduces the cost. One possible means to increase the capacity is to used parallel assembly lines.
The paper presents a new method to solve assembly line balancing problems in case of multiple lines. The procedure is explained with the help of suitable example. In many cases an industry utilizes more than one line to make same or different products at the same time independently. Working of the lines concurrently with common resources plays a vital role in minimization of the resource resulting in reduced production cost. The proposed system offers a substantial improvement in the assembly line efficiency when more than one line is necessary.
Keywords: Assembly line, Productivity improvement, Line efficiency, Parallel lines, Product

I. INTRODUCTION

Assembly line balancing is a production policy that sets a planned rate of production to yield a product within a particular time frame in such a way, to meet required production rate with minimum or zero ideal time. Manufacturers mostly uses assembly lines to manufacture high volume product. In assembly line workstations are connected in sequence by a suitable material handling system. Also, the assembly line needs to be designed effectually and tasks needs to be distributed between workers, machines and work stations confirming that every line segments in the production cycle must be met within the give time limit and resources. The very purpose of line balancing is to assign workloads to each assigned work station in a manner that every works stations has approximately same amount of work to be done. It is used to assemble components into a final product. The assembly line balancing problem is problem of assigning tasks to workstations in such a way that amount of idle time of the line will minimized while satisfying following conditions.

A. The total task time assigned to each workstation essentially be less than or equal to the cycle time.
B. The task assignments must full fill the precedence requirements.

Assembly lines can be classified generally into following groups: traditional assembly lines (with single and multi/mixed products) and U-type assembly lines (with single and multi/mixed products). No. of studies on traditional assembly line are reported. A state of art review on traditional assembly line has been reported by Baybars [1], Ghosh and Gagnon [2]. Extensive literature is also available on U line [3,4,5,6]. However, only few studies are reported on parallel assembly line. A state of art review on multiple and parallel assembly lines has been presented by Lusa [7].A new mathematical model for assembly line balancing problem with parallel workstations to control the way workstations are 'parallelised' is proposed by *Simaria and Vilarinho* [8].Bard [9] has proposed analgorithm for solving an assembly line-balancing problem with parallel workstations.
In general, most of manufacturing plants consist of one or more assembly lines. It is very common to duplicate the entire assembly line in case of high demand and high-volume product. This provides the advantage of shortening the assembly line, but at the same time may require more equipment, tools and facilities. Another advantage of parallel assembly lines is observed during workstation breakdowns. If equipment problems occur at a workstation, other lines can continue to run. A single serial line must be shutdown resulting in complete stoppage of production whenever there is a failure at any workstation.
The main objective of the present work is to solve line balancing problem in case of more than one assembly line runs together. That is to balance the parallel assembly lines together.

II. PROPOSED HEURISTIC

It is a common condition in a manufacturing unit that more than one line produces the identical or dissimilar products simultaneously and independently. Simultaneously, working of the lines with a common resource and facilities is very important from view of resource minimization. This proposed heuristic for balancing assembly line makes this situation possible.

A. The assumptions of the proposed heuristics are as follows below:

1) Only one product is assmbled at each line.
2) Precedence requirements are well known for each product.
3) Operators are multi-skilled and can work on each line.
4) Same products are assembled with the same cycle time in two different assembly lines.

In present study, productivity improvement can be realized through parallel lines. The present heuristic can be applied when there is a workstation with an idle time, which is equal or more than the half of the cycle time after balancing the line. In this way the efficiency of the lines gets increased by utilizing the ideal time of one line to accomplish one of the eligible task on other line according to the algorithm given below.

B. Algorithm used:The steps used to assign tasks to different workstations according to the proposed heuristics are given below:

1) Balance each line by using any of existing heuristics.
2) Calculate the idle times for each workstation of both lines
3) Find the workstation with ideal time equal or more than half of the cycle time.
4) Assign the task(s) in the above workstation of other line to the operator of concern workstation of first line.
5) Continue above steps for all the workstations.

C. *Problem Statement*

Fig.1 below shows the precedence diagram along with the tasks required to manufacture a single product. The numbers within the circle represents the tasks and the arrow connecting the circles represents the precedence requirement of the tasks. The number above the circle represents the task time for that task. The production time per day is 420 minutes and no. of products required per day are 2520 products.

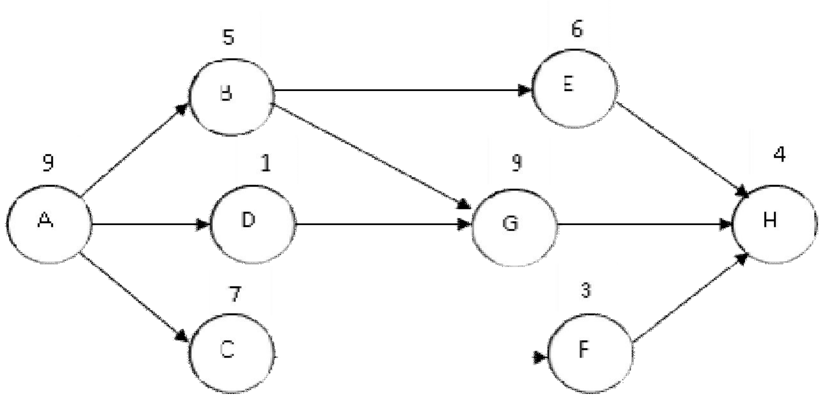

Fig. 1: Preedence diagram with tasks

The cycle time and theoretical minimum no. of required workstation are calculated [10] by Eq. 1 and Eq. 2 respectively.

$$Cycle\ time = \frac{Production\ time\ per\ day}{Output\ per\ day} \quad (1)$$

$$Theortical\ min.no.of\ workstation = \frac{Sum\ of\ task\ times}{Cycle\ time} \quad (2)$$

Using above relations cycle time was found as 10 and theoretical minimum no. of workstations as 5 (4.4~5). When the proposed procedure's steps are followed, the first job to be done is to balance the line by using a line balancing method. In this paper longest operation time (LOT) heuristic is used to balance the line and step wise procedure for task assignment is given below:

1) Assign first the task having longest operation time while maintaining the precedence requirement
2) Calculate the time station has left to contribute. If the station can contribute more time than, from the available task assign the task with longest operation time. Otherwise return to ste
3) Continue until all the tasks have been assigned.

The efficiency of the assembly line is calculated by using the relation given in Eq. 3:

$$\eta = \frac{Total\ time\ required\ at\ workstations}{Total\ time\ avaliable\ at\ workstations} \quad (3)$$

he different tasks assigned to workstations according to LOT are presented in Table 1. The assignments in Table 1 are also valid for both assembly lines, that is, a total of 10 workstations should be constructed for two assembly lines.

TABLE I: WORKSTATON ASSIGNMENT ACCORDING TO LOT HEURISTIC

Workstation No.	Tasks Assigned	Task time	Time available at workstations	Required workstation time	Ideal Time
1.	A, D	9	10	10	0
2.	C, F	7,3	10	10	0
3.	B	5	10	5	5
4.	G	9	10	9	1
5.	E, H	6,4	10	10	0

According to the above assignment according to longest operation time heuristic the line efficiencies are:
Efficiency of line 1= 88 %
Efficiency of line 2= 88 %
From Table it can be noticed that the third workstation has idle time of 5 seconds and this is equal to half of the cycle time. So, the worker working on line 1 at workstation 3 can utilizes the its ideal time to complete the same task on line 2. The assignment of task is presented in Fig. 2. Theoretically, the assembly line 2 has only 4 workstations as it utilizes the idle time of worker at third workstation of line 1 to complete task B. Now, the new line efficiency becomes:

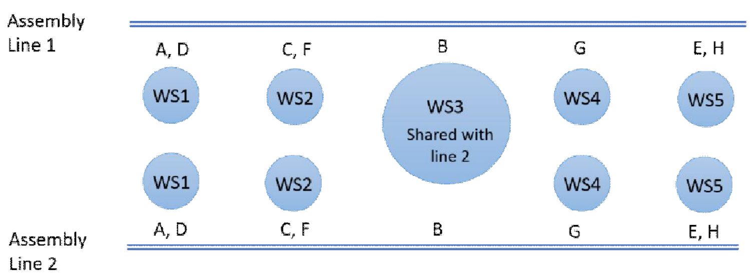

Fig. 2: Task allocation on assembly line

Efficiency of line 1= 98 %
Efficiency of line 2= 97.5 %
The number of workstations required after assigning task to the workstations according to the proposed heuristic reduces to 9. This means that the number of workstations gets reduced by one and efficiencies of the lines gets improved by 10% for line 1 and 9.5 % for line 2.
In the present paper an attempt has been made to improve the efficiency of the line by constructing parallel stations after balancing the lines, independently. The lines can be balanced by applying any of the available methods. In present work, longest operation time rule is used to balance the line. As there are multiple product entries in this procedure, the flexibility of the lines is increased.

III. CONCLUSIONS

In this paper, a new approach on the single model assembly line balancing problem with parallel lines has been proposed to improve the productivity of an assembly line. To establish the correctness and effectiveness of the proposed heuristic a line balancing problem is solved. The effectiveness of the proposed heuristic is established by application to a line balancing problem. It has been found that the proposed method delivers a significant improvement in the line efficiency in case of requirement of two or more lines to cater the demand for high volume product. Also, the method can also be applied for line assembling different products, the flexibility of the present system is much more than the simple traditional or U- shaped assembly line.

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