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Implementation of Heuristic Methods in Manufacturing Industry

M. Tech. Scholar Shashank Mishra, Prof. Hari Mohan Soni
Department of Mechanical Engineering,
BITS,
Bhopal

Abstract- The Assembly Line Balance (ALB) is known as the classic problem of AL balancing, consisting in the allocation of tasks on a workstation in a way that downtime is minimized, and the precedence constraints are met. The ALB allows achieve the best use of available resources so that satisfactory production rates are reached at a minimum cost. The balancing is necessary when there are process changes, such as adding or deleting tasks, change of components, changes in processing time and also in the implementation of new processes.

Keywords- Heuristic Methods, Assembly Line Balance, Manufacturing Industry.

I. INTRODUCTION

Pattern of business has rapidly changed over the past ten years. Globalization has accelerated which has resulted in business becoming more complex and challenging than before (Branch, 2009). With an increased accessibility to world markets, competition can now turn up from anywhere in the world. This makes globalization the most significant influencing factor on modern industrial competition (Closs & Fawcett, 1993). Today, it is critical to companies in international constellations to have a strong competitive strategy.

A competitive strategy consists of a number of different factors such as resources and management, but the factor which usually is recognized as the most important is the cost factor. Therefore, is critical for companies to formulate and implement a strategy which is cost-productive. (Huang, Boon Leing, &Joo Heng, 2015) Assembly lines were originally developed to run mass production of standardized products in a cost-productive way (Adeppa, 2015).

The assembly line is often recognized as one of the greatest developments in the modern world. To produce goods on an assembly line has proven to be much more productive than finishing each product individually (Thomopoulos, 2014).

An assembly line is a manufacturing process where a product is carried, usually by a mechanical conveyor, through a series of workstations (Nielsen, Ponnambalam, & Mukund Nilakantan, 2017). The workstations are layed out in series and linked by a material handling system (Buzacott, 2013). Operations are performed one-by-one to create the finished product. Installing an assembly line is a high cost and long-term investment. Hence, it is necessary to design a productive assembly line (Nielsen et al., 2017).

Designing an assembly line is a complex task since there are many constraints in industrial problems, for example limited resources, precedencies or incompatibilities between work tasks (Corominas, Ferrer, & Pastor, 2011). By designing a productive assembly line, costs are decreased which allows lower sales prices on goods, stronger competitiveness and better exploitation of markets potential (Adeppa, 2015).

II. PROBLEM DESCRIPTION

This study presents the application of assembly line balancing methods. The methods namely Rank position weight, larger candidate rule, and kill bridge and wester methods are used.

The selection criterion was based on minimum assembly time for all methods. Three assembly line processing layouts were developed based on output of assembly methods.

III. METHODOLOGY ADOPTED

The methodology of this research work was a case study, conducted in FABTECH ENGINEERING, BHOPAL. The study gave an idea of the existing scenario of the sewing assembly line. It also dealt with line balancing, productivity and various factors that lead to making the line imbalanced. So, the research method was a strategy of analysis, which moved from the underlying to research design, and data collection [14].

Although there are other distinctions in the research methods, the most common classification of research methods is into qualitative and quantitative. At one level, qualitative and quantitative refer to distinctions about the nature of knowledge: how one understands the world and the ultimate purpose of the research.

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On another level of discourse, the terms refer to research methods, that is, the way in which data are collected and analyzed, and the type of generalizations and representations derived from the data. So, in this work, mixed research methods have been used.

IV. DATA COLLECTION

The next phase is data collection phase, which aimed at collecting relevant data from the case company. The authors traveled to Bhopal, to conduct observations and collect data from the case study firm (FABTECH ENGINEERING, BHOPAL). The gathering of empirical data was divided into qualitative and quantitative parts.

The qualitative data was collected mainly through interviewing staff from different management levels of the organization, production employees, and examining some past record of the industrial engineering department and planning department of the industry.

Major quantitative data werecollected through direct involvement in the line by observation of the production floor. The data was focused on a production line specifically on the sewing section. The main goal was to collect data that support the process of identifying production bottlenecks. Generally, data was collected through primary and secondary systems

V. EXISTING DATA RELATED TO ASSEMBLY LINE

The first process of line balancing is to break down the garment into sequential operations. The existing operation breakdown was revised to better understand and implement the sequential order of the product processing steps.

During analysis of the selected product, joint precedence graph consisting of all tasks, machine, manpower and actual processing time was created to see the relationship of each operation. Before line balancing, the existing production scenario is measured considering different key performance indicators (KPIs) as illustrated in Table 1.

Table 1. Work Element time and Precedence at Present Assembly Line.

Operation		Time	Workstation No
1	3	689 sec (11.48min)	I
4	5	657sec (10.95min)	II
6	9	633 sec (10.55 min)	III
10	16	359 sec (5.98 min)	IV
17	19	265 sec (4.42min)	V
20	26	360 sec (6min)	VI

VI. RESULTS AND DISCUSSION

1. Heuristic Methods:
After studying Present Assembly line as discuss in chapter, 3if we want to increase production rate so minimize cycletime from 12 to 10 min for a given number of stations (m).

The method to improve production rate by minimizing cycletime is discuss below:
2. Largest Candidate Rule (LCR) Method:
Largest Candidate Rule is commonly used method for line balancing to evenly distribute workload amongst workstations. It ensures smooth flow of work in progress (WIP) through the line with minimal or no buffer among the workstations. However, bottlenecks are often occurred because the assembly are difficult to balanced perfectly [18].

LCR considers the cycle time and precedence relationship in line designing. In this method, the work elements are assigned to workstations based on size of elements time, Te (work elements time) values. The cycle time, minimum no of workstations, balance delays, line efficiency, and line smoothness index of assembly line were calculated.

Table 2. Work Element Arranged in Descending Order.

Element	*Tek(Sec) (Descending order)*	*Preceding by*
4	574	1,2,3
6	290	1,3,4,5
3	269	1
18	241	1,17
7	226	3,4,5,6
2	211	1
1	209	None
22	120	18,20,21
26	110	16,25
5	83	1,2,3,4
11	81	10
16	76	1,15
9	74	1
15	69	1,3,6,7,8,9,13,1
12	58	10,11
20	45	18
8	43	3,4,5,6,7
14	40	1,3,6,7,8,9
21	36	18,19,20
24	34	22,23
10	28	5
19	19	18
25	8	24
13	7	1,3,6,7,8
23	7	22
17	5	1,2

Worker was assigned by elements at the firstworkstation by starting at the top of the list and selected thefirst element that satisfies precedence requirements and doesnot causing the total sum of Tek at that station to exceed theallowable C when an element is selected for assignment tothe station, started backward at the top of the list for thesubsequent assignments.

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The procedure then followed bystating that no more elements could be assigned withoutexceeding C and proceeded to the next station.Consequently, repeating the previous steps for as manyadditional stations as possible until all elements have beenassigned as shown in the precedence diagram.

Table 3. Work Element Arranged According to Tekvalues for LCR.

Element	Tek sec	Preceding by	Station no	Station time sec
1	209	None		
3	269	1	I	552
9	74	1		
2	211	1		
17	5	1,2		
18	241	1,17		557
20	45	18	II	(9.28min)
19	19	18		
21	36	18,19,20		
4	574	1,2,3	III	574 (9.56min)
22	120	18,20,21		
5	83	1,2,3,4		
6	290	1,3,4,5	IV	528
10	28	5		(8.8min)
23	7	22		
7	226	3,4,5,6		
11	81	10		
12	58	10,11		
8	43	3,4,5,6,7		
14	40	1,3,6,7,8,9	V	566
24	34	22,23		(9.43min)
25	25	24		
13	7	1,3,6,7,8		
15	69	1,3,6,7,8,9,1		
26	110	16,25	VI	186
16	76	1,15		(3.1min)

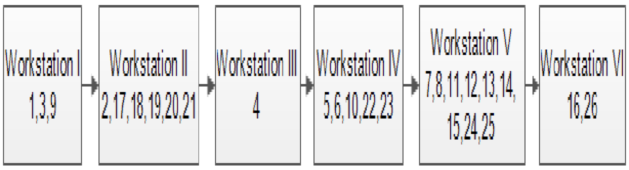

Fig 1. Configuration Layout for Assembly Line Following LCR.

3. Kilbridge and Wester Column (KWC) Method:

Kilbridge and Wester (column) method is a heuristic procedure that selects work elements for assignment to stations according to their positions in the precedence diagram (Jaggi&Chaubey, 2015). Work elements that arranged in the precedence diagram are divided into columns (Make &Faisae, 2017).

The elements are then organized into a table according to their columns, with an element in the first column with highest task time listed first. For assigning the elements to the first station, the work is started at the top of the list, selecting the first feasible element for the placement at the station. One that satisfies the precedence constraints is a feasible element, and finally, it does not cause the sum of the task time at the station to exceed the maximum available cycle time, C.

Table 4. Work Element Assigned According to Column Method.

Element	Tek sec	Column	Preceding by
1	209	A	None
3	269	B	1
2	211	B	1
9	74	B-G	1
4	574	C	1,2,3
17	5	C	1,2
18	241	D	1,17
5	83	D	1,2,3,4
6	290	E	1,3,4,5
20	45	E	18
10	28	E	5
19	19	E	18
7	226	F	3,4,5,6
11	81	F	10
21	36	F	18,19,20
22	120	G	18,20,21
12	58	G	10,11
8	43	G	3,4,5,6,7
14	40	H	1,3,6,7,8,9
13	7	H	1,3,6,7,8
23	7	H	22
15	69	I	1,3,6,7,8,9,13,14
24	34	I	22,23
16	76	J	1,15
25	8	J	24
26	110	K	16,25

Table 5. Work Element Arranged According to Tekvalues for KWM.

Element	Tek	Column	Preceding by	Station	Station time
1	209	A	None	I	552 (9.2min)
3	269	B	1		
9	74	B	1		
2	211	B	1	II	557 (9.28min)
17	5	C	1,2		
18	241	D	1,17		
20	45	E	18		
19	19	E	18		
21	36	F	18,19,20		
4	574	C	1,2,3	III	574 (9.56min)
5	83	D	1,2,3,4		
6	290	E	1,3,4,5	IV	540 (9min)
10	28	E	5		
11	81	F	10		
12	58	G	10,11		
7	226	F	3,4,5,6		
22	120	G	18,20,21	V	554 (9.23min)
8	43	G	3,4,5,6,7		
14	40	H	1,3,6,7,8,9		
13	7	H	1,3,6,7,8		
23	7	H	22		
15	69	I	1,3,6,7,8,9,13,14		
24	34	I	22,23		
25	8	J	24		
16	76	J	1,15	VI	186 (3.1min)
26	110	k	16,25		

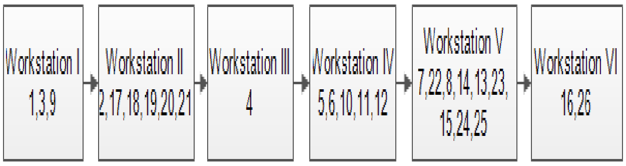

Fig 2. Configuration Layout for Assembly Line Following KWM.

4. Ranked Positional Weight (RPW) Method:
The ranked positional weight method used and computed for each element. The method accounted for Tek value and its position in the precedence diagram.

Table 6. Work Element Arranged According to RPW.

Element	*Tek sec*	*Preceding by*	*RPW(Descending)*
1	209	None	2963
2	211	1	2411
3	269	1	1954
4	574	1,2,3	1685
5	83	1,2,3,4	1111
6	290	1,3,4,5	861
17	5	1,2	625
18	241	1,17	620
7	226	3,4,5,6	571
10	28	5	429
11	81	10	401
9	74	1	369
20	45	18	360
8	43	3,4,5,6,7	345
19	19	18	334
12	58	10,11	320
21	36	18,19,20	315
14	40	1,3,6,7,8,9	295
22	120	18,20,21	279
13	7	1,3,6,7,8	262
15	69	1,3,6,7,8,9,13,14	255
16	76	1,15	186
23	7	22	159
24	34	22,23	152
25	8	24	118
26	110	16,25	110

Table 7. Work Element Assigned to Station According toTek values for RPW.

Element	*Tek sec*	*Preceding by*	*Station No*	*Station Time*
1	209	None	I	499(8.31min)
2	211	1		
9	74	1		
17	5	1,2		
3	269	1	II	574 (9.56min)
18	241	1,17		
20	45	18		
19	19	18		
4	574	1,2,3	III	574
5	83	1,2,3,4	IV	599 (9.98min)
6	290	1,3,4,5		
7	226	3,4,5,6		
10	28	5	V	565 (9.26min)
11	81	10		
8	43	3,4,5,6,7		
12	58	10,11		
21	36	18,19,20		
14	40	1,3,6,7,8,9		
22	120	18,20,21		
13	7	1,3,6,7,8		
15	69	1,3,6,7,8,9,13,14		
16	76	1,15		
23	7	22		
24	34	22,23	VI	152 (2.53min)
25	8	24		
26	110	16,25		

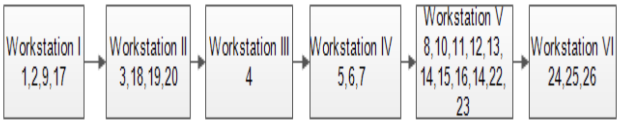

Fig 3. Configuration Layout for Assembly LineFollowing RPW.

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 4.5). Then rearrange the values of time using the previous steps, work elements are listed according to RPW value in Table (4.6).

VII. CONCLUSION

This study involved applying the three heuristical gorithms to study the process planning IN a reduced production time. In this study, threeassembly balancing methods were studied. Largest Candidate Rule (LCR), Kilbridge and Wester (KWC), and Ranked Positional Weight (RPW) to select best one for Manual Assembly Line of Ginning machine.

After applying balancing methods to existing assembly line by reducing cycle time 12 min to 10 min then methods give a more efficient assignment of work element with improvement of line efficiency from 68.58 % to 82.33 % reduced idle time from 23.07 min to 10.6 min, smoothness index reduced from 11.58 to 7.10, increase production rate of 40 units to 48 units. So, any one method from three methods is applicable for balancing of existing assembly line because of very slight difference.

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