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Assembly Line Balancing Methods–A Case Study

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Abstract: ***This paper present 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 The output that represent Cycle time 10 min improved line efficiency to 82.33%,idle time 10.6 min, smoothness index 7.10 and increase production rate from 40 units to 48 units per day.***

Keywords: LCR, KWM, RPW, SALBP

1. Introduction

Process planning is mainly relevant to generating line balancing set of steps required to approach specified aims, with given constraints, as an attempt to enhance a part of the criteria. Balancing assembly lines becomes one of the most important parts for an industrial manufacturing system that should be supervised carefully. The success of achieving the goal of production is influenced significantly by balancing assembly lines. Since then, many industries and for sure researchers, attempt to find the best methods or techniques to keep the assembly line balanced and then, to make it more efficient. Furthermore, this problem is known as an assembly lines balancing problem. An assembly line consists of workstations that produce a product as it moves successively from one workstation to the next along the line, which this line could be straight, u-line or parallel until completed. To balance an assembly line, some methods have been originally introduced to increase productivity and efficiency. These objectives are achieved by reducing the amount of required manufacturing time to produce a finished product, by reduction in number of workstations or both of them .This study involved applying the three heuristic algorithms to study the Ginning machine process planning gaining a reduced production time. In this paper, three assembly 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.

2. Simple assembly line balancing problem (SALBP)

Most of the research in assembly line balancing has been devoted to modelling and solving the simple assembly line balancing problem (SALBP). This classical single-model problem contains the following main characteristics.

- Mass-production of one homogeneous product; given production process
- Paced line with fixed cycle time c
- Deterministic (and integral) operation times tj
- No assignment restrictions besides the precedence constraints
- Serial line layout with m stations
- All stations are equally equipped with respect to machines and workers
- Maximize the line efficiency

$E = t_{sum} / (m^* C)$ with total task time

Table 2.1 shows classification of SALBP

- Type 1 (SALBP-1) of this problem consists of assigning tasks to work stations such that the number of stations (m) is minimized for a given production rate (fixed cycle time, C).
- Type 2 (SALBP-2) is to minimize cycle time (maximize the production rate) for a given number of stations (m).
- Type E (SALBP-E) is the most general problem version maximizing the line efficiency (E) thereby simultaneously minimizing C and m considering their interrelationship.
- Type F (SALBP-F) is a feasibility problem which is to establish whether or not a feasible line balance exists for a given combination of m and C.

Table 2.1: Classification of SALBP

No of workstation m ↓	Cycle Time C →	
	Given	Minimize
Given	SALBP-F	SALBP-2
Minimize	SALBP-1	SALBP-E

3. Case Study

Jadhao Gears PVT LTD has been established in the year 2010. It is a medium scale industry situated in MIDC Amravati.It produces ginning machine are exported to different countries. The details of the existing assembly line for ginning machine is given in Table 4.1and 4.2 .The present production rate is 40 units per day .The company want to increase this rate .So it is decided to balance the assembly line and increase production rate.

4. Existing Assembly Line of Ginning Machine

Table 4.1: 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

Table 4.2: Work Element time and precedence at Present Assembly Line

Sr No	*Time (sec) Tek*	*Precedence relation*
1	209	0
2	211	1
3	269	1
4	574	1,2,3
5	83	1,2,3,4
6	290	1,3,4,5
7	226	3,4,5,6
8	43	3,4,5,6,7
9	74	1
10	28	5
11	81	10
12	58	10,11
13	7	13,6,7,8
14	40	1,3,6,7,8,9
15	69	1,3,6,7,8,9,13,14
16	76	1,15
17	5	1,2
18	241	1,17
19	19	18
20	45	18
21	36	18,19,20
22	120	18,20,21
23	7	22
24	34	22,23
25	8	24
26	110	16,25

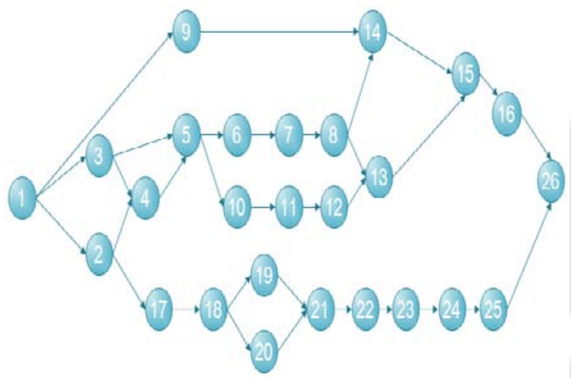

Figure 4.1: Precedence Diagram

Calculation of existing assembly line:

No of operation = 26
Cycle time(C) =12 min
Demand rate =40 units/day
Assembly line operates 1shift/day =8 hours
Sum of idle time =23.07 min
No of workstation (K) =6
Sum of station time (STi) =49.38

Line Efficiency = $\frac{\sum_{i=1}^{N} ST_i}{m*C}$*100

= 68.58%

Smoothness Index= $\sqrt{\sum_{i=1}^{N}(ST_{max} - ST_i)^2}$

= 11.58

Expected Number of Productions

$$Q = \frac{D*SH}{CT}$$

Q=12000 units per year

where 'D' is the number of working days, 'SH' is the net working shift (shift time minus allowed free time) and 'CT' is the cycle time. Assume,

No of working days per year 300
Working shift time per day 480 min

5. Heuristic Methods

After studying Present Assembly line as discuss in section 3 if we want to increase production rate so minimize cycle time from 12 to 10 min for a given number of stations (m). The method to improve production rate by minimizing cycle time is discuss below

5.1 Largest Candidate Rule (LCR) Method

In this approach work elements were arranged in descending order according to their Tek values as presented in Tables (5.1 and 5.2). Worker was assigned by elements at the first workstation by starting at the top of the list and selected the first element that satisfies precedence requirements and does not causing the total sum of Tek at that station to exceed the allowable C when an element is selected for assignment to the station, started backward at the top of the list for the subsequent assignments. The procedure then followed by stating that no more elements could be assigned without exceeding C and proceeded to the next station. Consequently, repeating the previous steps for as many additional stations as possible until all elements have been assigned as shown in the precedence diagram.

Calculation:

Cycle time (C) or Max Station Time (STmax) = 10 min
Sum of idle time =10.61 min
Number of workstation (m) = 6
Sum of Station Time (ST_i) = 49.38 min

Line Efficiency = $\frac{\sum_{i=1}^{N} ST_i}{m*C}$

= 82.33 %

Smoothness Index= $\sqrt{\sum_{i=1}^{N}(ST_{max} - ST_i)^2}$

= 7.11

Production Rate $Q = \frac{D*SH}{CT}$

= 14400 units per year (40 units /day)

where 'D' is the number of working days,
'SH' is the net working shift (shift time minus allowed free time) and
'C' is the cycle time

Table 5.1: 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

Table 5.2: Work Element Arranged According to Tek values 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)

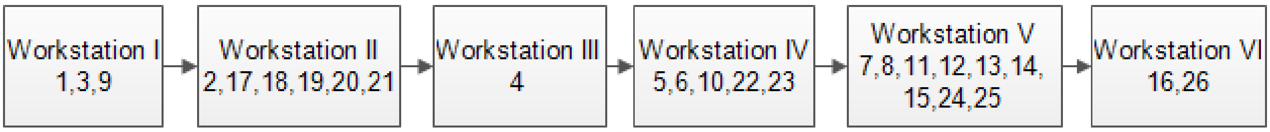

Figure 5.1: Configuration Layout for Assembly Line Following LCR

5.2 Kilbridge and Wester Column (KWC) Method

Work elements in this method are selected for assignment to stations according to their position in the precedence diagram. Therefore work elements were arranged into columns, Figure 5.2 and then organized into a list according to their column, with the elements in the first column listed first. Table 5.3 shows a list of elements of the column method, starting with the highest value of the time for each column. Consequently, repeating the previous steps for as many additional stations as possible until all elements have been assigned as shown in the precedence diagram Fig 5.2

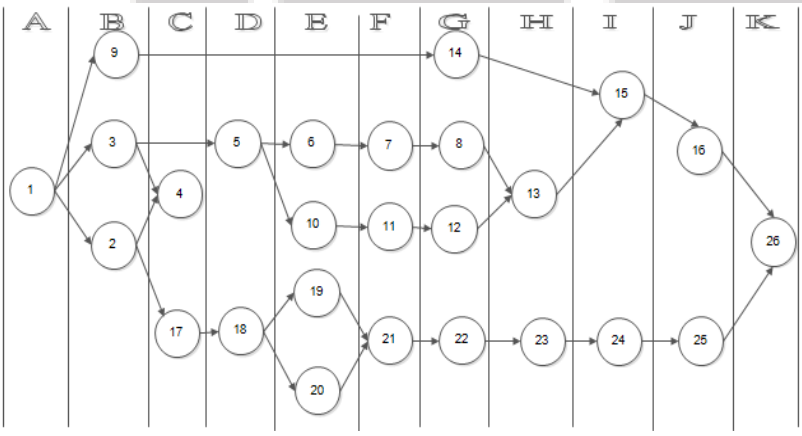

Figure 5.2: Work Element Arranged into Column for the KWM

Table 5.3: 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 5.4: Work Element Arranged According to Tek values 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		

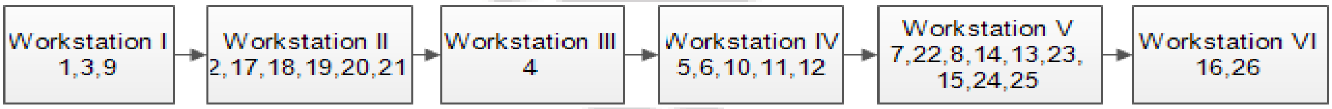

Figure 5.3: Configuration Layout for Assembly Line Following KWM

5.3 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 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 5.5). Then rearrange the values of time using the previous steps, work elements are listed according to RPW value in Table (5.6).

Table 5.5: 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 5.6: Work Element Assigned to Station According to Tek 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		

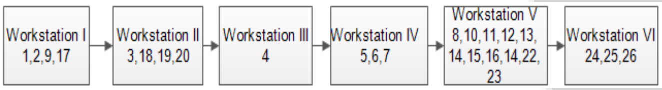

Figure 5.4: Configuration Layout for Assembly Line Following RPW

6. Comparison of Three Methods

Table 6.1: Comparison of Result obtained from above Methods

Sr No	*Parameter*	*Present Assembly Line*	*LCR Method*	*KWM Method*	*RPW Method*
1	Cycle time(min)	12	10	10	10
2	Idle time	23.07	10.6	10.6	10.87
3	Line Efficiency	68.5%	82.33%	82.33%	82.33%
4	Smoothness Index	11.58	7.11	7.10	7.7
5	Production Rate per day	40units	48 units	48 units	48units
6	Balance Delay	32	17.68	17.68	17.68
7	No of Workstation	6	6	6	6

7. Conclusion

After applying balancing methods to existing assembly line by reducing cycle time 12 min to 10 min then methods give an 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 above three methods is applicable for balancing of existing assembly line because of very slight difference.

References

[1] Sotirios G. Dimitriadis “Assembly line balancing and group working: A heuristic procedure for workers’ groups operating o the same product and workstation” Computers & Operations Research 33, 2006, pp.2757–2774.

[2] Nils Boysen , Malte Fliedner and Armin Scholl , “A classification of assembly line balancing problems” European Journal of Operational Research 183 ,2007, pp.674–693.

[3] Nuchsara Kriengkorakot and Nalin Pianthong “The Assembly Line Balancing Problem: Review articles” KKU Engineering Journal, Vol. 34, 2007, pp.133 – 140.

[4] Houshang Taghizadeh and Amin Zeinalzadeh,“A Study of Cycle Time Role in Product Safety Margin in Assembly Systems (Case Study)” World Applied Sciences Journal 12 ,2011, pp.1931-1938.

[5] Seamus M. McGovern, Surendra M. Gupta “A balancing method and genetic algorithm for disassembly line balancing”. European Journal of Operational Research Vol.179, 2007, pp.692–708.

[6] Hu Xiaofeng, Wu Erfei, Jin Ye “A station oriented enumerative algorithm for two-sided assembly line balancing”. European Journal of Operational Research Vol.186, 2008, pp.435–440.

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