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SMALL SCALE INDUSTRY FOR IMPROVEMENT OF PRODUCTION RATE WITH LINE BALANCING- A CASE STUDY

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ABSTRACT

In this research we aimed to improve a line balancing efficiency of a small scale leather women’s handbag manufacturing industry which was having a very poor line efficiency of 40.5%. So much of wastage of time, manpower and recourses were taking place at the organization. The aim of this paper report was to improve the line efficiency of the organization by using heuristic methods of line balancing i.e. largest candidate rule, Kilbridge & wester column method and rank positional method Then we have done a comparative study in the existing factory with line balancing technologies. First of all we calculated the existing line efficiency of the organization mathematically which was found to be 40.5%. Then we applied largest candidate rule (LCR), Kilbridge and wester column (KWC) and rank positional method (RPW) methods of line balancing in the existing factory to balance the sequence and time duration of work elements. We done mathematical analysis and found that by using largest candidate rule method, line efficiency can be increased to 77.09, Kilbridge & wester column method gives 70.70% line efficiency and rank positional weighted method gives 77.09% line efficiency. It is proposed that we can use the largest candidate rule or rank positional method to increase the line efficiency of the existing organization and thus can improve the productivity.

KEYWORDS- line balancing, productivity improvement, heuristic algorithms, small scale industry, yamazumi chart.

1. INTRODUCTION

An assembly line is a manufacturing process (often called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced. By mechanically moving the parts to the assembly work and moving the semi-finished assembly from work station to work station, a finished product can be assembled faster and with less labor than by having workers carry parts to a stationary piece for assembly. Assembly lines are common methods of assembling complex items such as automobiles and other transportation equipment, household appliances and electronic goods. Assembly lines are designed for the sequential organization of workers, tools or machines, and parts. The motion of workers is minimized to the extent possible. All parts or assemblies are handled either by conveyors or motorized vehicles such as fork lifts, or gravity, with no manual trucking. Heavy lifting is done by machines such as overhead cranes or forklifts. Each worker typically performs one simple operation. The principles of assembly are Place the tools and the men in the sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing. Then Use work slides or some other form of carrier so that when a workman completes his operation, he drops the part always in the same place which place must always be the most convenient place to his hand and if possible have gravity carry the part to the next workman for his own. Afterward Use sliding assembling lines by which the parts to be assembled are delivered at convenient distances.

2. METHODOLOGY

The methodology of this research will have following steps:

2.1 Process Flow Chart: The methodology of the research contains the following processes to be done for the calculation of balance delay and line efficiency so as to increase the productivity of the current organization is shown below in figure 2.1.

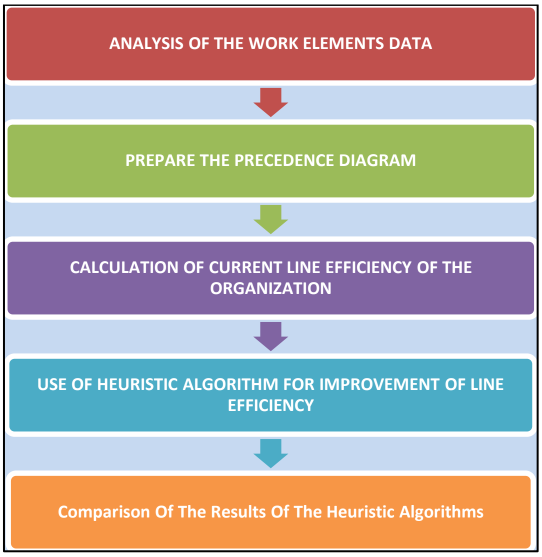

Fig. 2.1 process flow chart of the methodology

2.2 Calculation of current line efficiency of the organization: in this step we will calculate the current line efficiency with the help of current data available of the organization. For this purpose will be requiring number of workstations (N), cycle time (T_c), total work content (T_{wc}). The calculation of the cycle time, number of workstations and line efficiency can be done by using these formulas.

$$\text{Cycle time} = \frac{\text{Available time}}{\text{Desired Output}}$$

$$\text{Number of workstations} = \frac{\sum \text{Task Time}}{\text{Desired Actual Time}}$$

$$\text{Line efficiency} = \frac{\text{Sum Of Task Times}}{\text{Number Of Workstations} \times \text{Desired Cycle Time}}$$

2.3 Use of heuristic algorithm for improvement of line efficiency: in this step we will use the heuristic algorithm such as Largest Candidate Rule, Kilbridge and Wester Column Method and Rank Positional Weighted method to improve the line efficiency. These are very sophisticated method used for line balancing.

2.3.1 Largest-Candidate Rule (LCR)

This is the easiest method to understand. The work elements are selected for assignment to stations simply on the basis of the size of their T_e values.

Procedure:

Step 1. List all elements in descending order of T_e value, largest Te at the top of the list. Step 2. To assign elements to the first workstation, start at the top of the list and work done, selecting the first feasible element for placement at the station. A feasible element is one that satisfies the precedence requirements and does not cause the sum of the T_{ej} value at station to exceed the cycle time T_c.

Step 3. Repeat step 2.

2.3.2 Kilbridge and Wester's Column Method (KWC)-

It is a heuristic procedure which selects work elements for assignment to stations according to their position in the precedence diagram. This overcomes one of the difficulties with the largest candidate rule (LCR), with which elements at the end of the precedence diagram might be the first candidates to be considered, simply because their values are large.

Procedure:

Step 1. Construct the precedence diagram so those nodes representing work elements of identical precedence are arranged vertically in columns.

Step 2. List the elements in order of their columns, column I at the top of the list. If an element can be located in more than one column, list all columns by the element to show the transferability of the element.

Step 3. To assign elements to workstations, start with the column I elements. Continue the assignment procedure in order of column number until the cycle time is reached (T_c).

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2.3.3 Ranked Positional Weighted Method (RPW)

It Combined the LCR and K-W methods. The RPW takes account of both the Te value of the element and its position in the precedence diagram. Then, the elements are assigned to workstations in the general order of their RPW values.

Procedure:

Step 1. Calculate the RPW for each element by summing the elements T_e together with the T_e values for all the elements that follow it in the arrow chain of the precedence diagram.

Step 2 List the elements in the order of their RPW, largest RPW at the top of the list. For convenience, include the T_e value and immediate predecessors for each element.

Step 3. Assign elements to stations according to RPW, avoiding precedence constraint and time cycle violations.

By using all these three algorithms we need to find out the balance delay and line efficiency of the organization in each case.

3. RESULT ANALYSIS

The following work element data relates to a small scale women handbag manufacturing company namely Gagan Leather House Private Limited, Indore, Madhya Pradesh, India.

3.1 Analysis of line efficiency of the current factory

3.1.1 Analysis of Work Element Data of Current Factory

Table 3.1.1 Analysis of Work Element Data

Task	Task Time (Sec)	Immediate Predecessor
1 (Cutting)	55	-
2 (Skewing)	47	1
3 (Glue Adding)	24	2
4 (Painting)	55	1
5 (Hot Marking)	22	1
6 (Swing)	108	3,4,5
7 (Painting)	74	6
8 (Drying)	139	7,9
9 (Zipper Setting)	114	6
10 (Manual Material Handling)	61	8
11 (Cloth Adding)	99	10
12 (CNC Swing)	60	11
13 (Hot Work)	34	11
14 (Logo Punch)	32	11
15 (Final Swing)	120	12,13,14
16 (Final Zipper Setting)	130	12,13,14
17 (Finishing)	61	15,16
18 (Quality Control)	30	17
19 (Packaging)	14	18
Total Task Time	1279	

3.1.2 Preparation of Precedence Diagram

The below shown diagram shows the precedence diagram of the existing factory

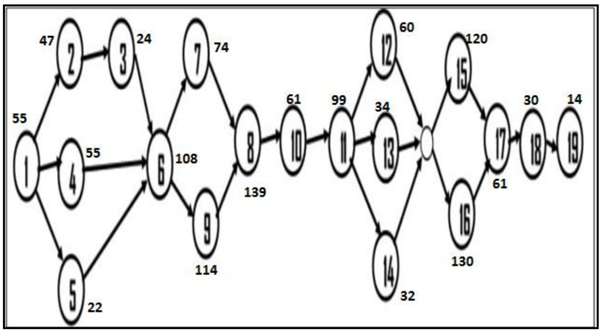

Fig. 3.1.2 precedence diagram of existing unit

3.1.3 Calculation of Line Efficiency and Balance Delay

Demand per month of hand bags = 6250 pieces

Working day in a month = 24 days

Working hour in a day = 12 hours

Number of workstation (N) = 19

Total work content = 1279 seconds

So cycle time is calculated as follows

$$\text{Cycle time} = \frac{\text{Available time}}{\text{Desired Output}}$$

T_c = 1036800 / 6250

(Cycle time or takt time) T_C = 165.89 ……… (1)

Number of work stations N = 19

Line efficiency calculation:

Balance Delay = $\{(NT_C - T_{WC}) / (NT_C)\} \times 100$

Balance Delay =

$\{(19\times 165.89 - 1279) / (19\times165.89)\} \times100$

Balance Delay = 0.594 = 59.4 % ………………………… (2)

So now

Line efficiency (ɳ) = 1- Balance Delay

Line efficiency (ɳ) = 1- 0.594

Line efficiency (ɳ) = 0.405 = 40.5 % ………………………… (3)

The figure 3.1.3 shown below shows the processes with their respective times

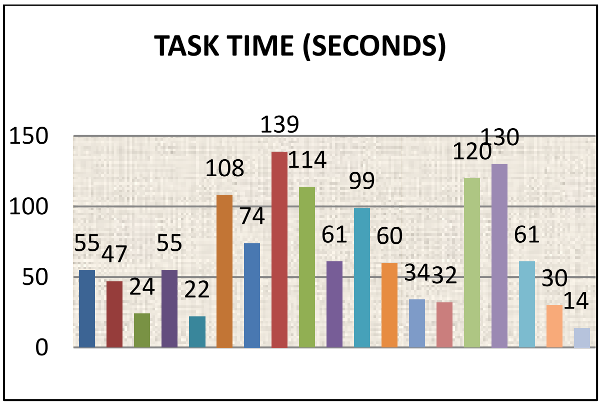

Fig 3.1.3 processes with their respective times

3.2 New Layout by Using Largest Candidate Rule of Line Balancing

By following largest candidate rule method we have found out the optimum number of workstations to be 10. The line efficiency and balance delay calculation shown below-

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3.2.1 Calculation of Line Efficiency and Balance Delay

Demand per month of hand bags = 6250 pieces

Working day in a month = 24 days

Working hour in a day = 12 hours

Number of workstation (N) = 10

Total work content = 1279 seconds

So cycle time is calculated as follows

$$\text{Cycle time} = \frac{\text{Available time}}{\text{Desired Output}} \quad \ldots\ldots(1)$$

Tc = 1036800 / 6250

(Cycle time or takt time) **Tc = 165.89** ….. (2)

Number of work stations **N = 10**

Line efficiency calculation:

Balance Delay = $\{(NT_C - T_{WC}) / (NT_C)\} \times 100$

Balance Delay =

$\{(10\times 165.89 - 1279) / (10\times165.89)\} \times100$

Balance Delay = 0.229 = 22.9 % …… (3)

So now

Line efficiency (η) = 1- Balance Delay

Line efficiency (η) = 1- 0.229

Line efficiency (η) = 0.779 = 77.9 % ……...(4)

The below 3.2.1 table shows the summary of line balancing with the help of LCR.

Table 3.2.1 Summary of line balancing with the help of LCR.

Workstations	Processes	Time Duration (Sec)
1	(Cutting,Painting,Skewing,)	157
2	(Glue Adding,Hot Marking,Swing)	154
3	(Zipper Setting)	114
4	(Painting)	74
5	(Painting)	139
6	Manual Material Handling,Cloth Adding)	160
7	(Cnc Swing,Hot Work, Logo Punch)	126
8	(Final Zipper Setting)	130
9	(Final Swing)	120
10	(Finishing, Quality Control,Packaging)	105

The below shown figure 3.2.1 shows the line balancing by LCR.

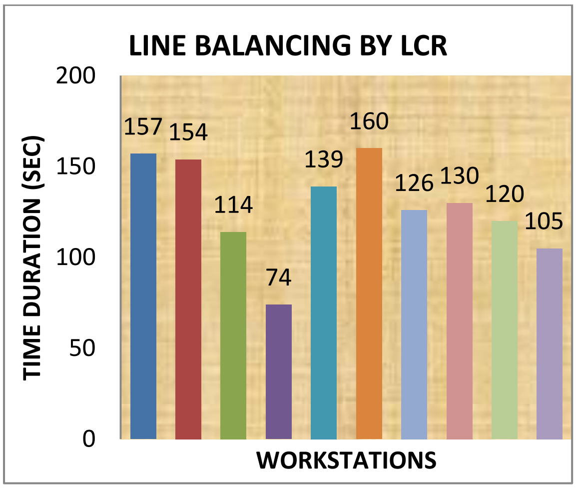

Fig 3.2.1 line balancing by LCR

3.3 New Layout by Kilbridge & Wester Column Rule of Line Balancing

By following kilbridge and wester column method we have found out the optimum number of workstations to be 13. The line efficiency and balance delay calculation shown below-

3.3.1 Calculation of Line Efficiency and Balance Delay

Demand per month of hand bags = 6250 pieces

Working day in a month = 24 days

Working hour in a day = 12 hours

Number of workstation (N) = 13

Total work content = 1279 seconds

Line efficiency calculation:

Balance Delay = $\{(NT_C - T_{WC}) / (NT_C)\} \times 100$

Balance Delay =

$\{(13\times 139 - 1279) / (13\times139)\} \times100$

Balance Delay = 0.292 = 29.2 % … (3)

So now

Line efficiency (η) = 1- Balance Delay

Line efficiency (η) = 1- 0.292

Line efficiency (η) = 0.707 = 70.7 % …..(4)

3.3.2 Distribution of work elements to workstation according to KWC method-

The distribution of work elements to workstation according to KWC method is shown below in figure 3.3.2.

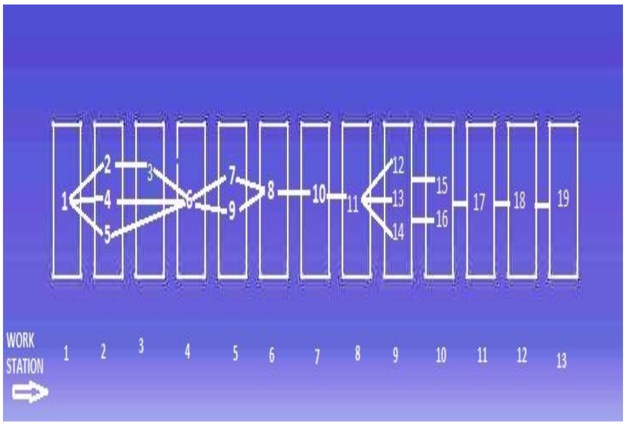

Fig 3.3.2 Distribution of work elements to workstation

The below shown figure 3.3.3 shows the line balancing with KWC method

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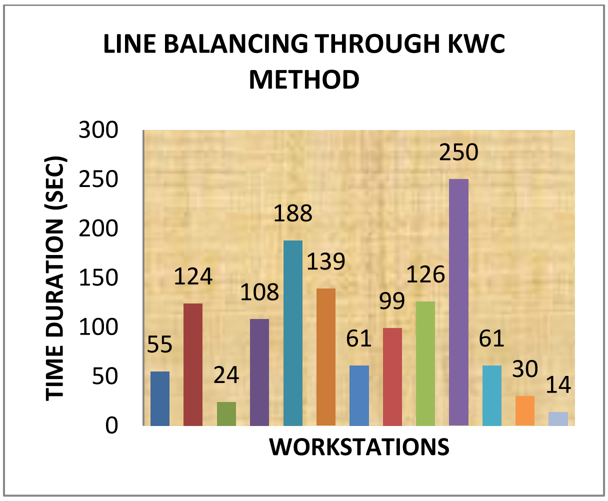

Fig 3.3.3 Line Balancing With KWC Method

3.4 New Layout by rank positional weighted method of Line Balancing

3.4.1 Calculation of Line Efficiency and Balance Delay

Demand per month of hand bags = 6250 pieces

Working day in a month = 24 days

Working hour in a day = 12 hours

Number of workstation (N) = 10

Total work content = 1279 seconds

Line efficiency calculation:

Balance Delay = $\{(NT_C - T_{WC}) / (NT_C)\} \times 100$

Balance Delay =

$(10\times 165.89 – 1279) / (10\times165.89)\} \times100$

Balance Delay = 0.229 = 22.9 %

……… (3)

So now

Line efficiency (ɳ) = 1- Balance Delay

Line efficiency (ɳ) = 1- 0.229

Line efficiency (ɳ) = 0.7709 = 77.09 %

………..(4)

The below table 3.3.1 shows the optimum number of workstation according to KWC method

Table 3.3.1 optimum number of workstation according to RPW method

Workstation	Processes	Time Duration (sec)
1	(Cutting, Skewing, Painting)	157
2	(Glue Adding, Hot Marking, Swing)	154
3	(Zipper Setting)	114
4	(Painting)	74
5	(Drying)	139
6	(Manual Material Handling, Cloth Adding)	160
7	(CNC Swing, Hot Work, Logo Punch)	126
8	(Final Zipper Setting)	130
9	(Final Swing)	120
10	(Finishing, Quality Control, Packaging)	105

The below shown figure 3.4.1 shows the line balancing through RPW method

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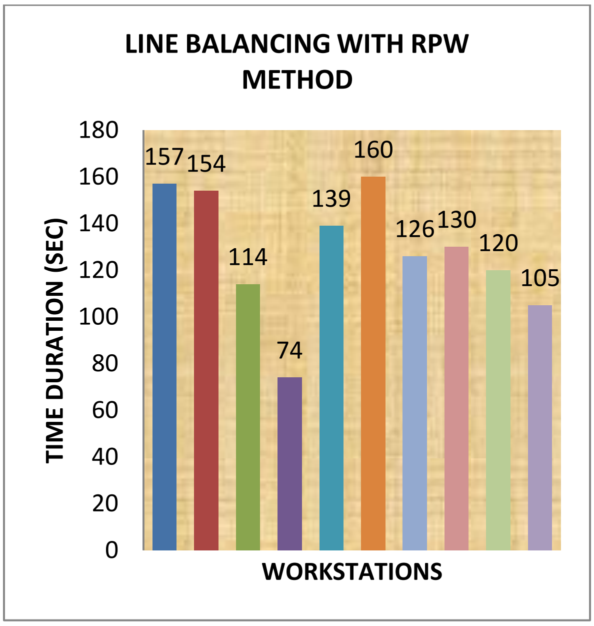

Figure 3.4.1 Line Balancing Through RPW Method

3.5 Result summary

We have done the numerical analysis of the line efficiency of the current organization with existing setup and then analyzed numerically for line balancing with three heuristic methods i.e. largest candidate rule, Kilbridge and wester column method and rank positional weighted method respectively.

Table 3.5.1 Result Summary of line efficiencies of LCR, KWC & RPW methods.

Sr. No.	Line Balancing Methods	Line Efficiency
1	Current Factory	40.50%
2	Largest Candidate Rule (LCR)	77.09%
3	Kilbridge And Wester Column(KWC)	70.70%
4	Rank Positional Weight (RPW)	77.09%

The below shown figure 3.5.1 shows the line efficiency comparison of existing, LCR, KWC and RPW line balancing efficiencies

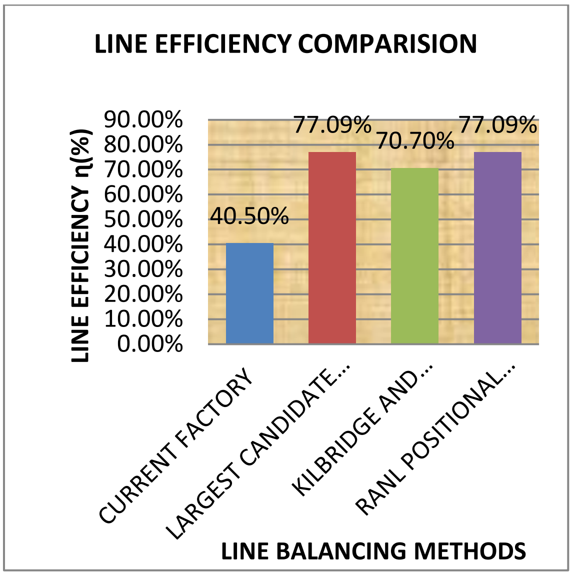

Fig 3.5.1 Line Efficiency Comparison

4. CONCLUSION

In this research we have study and analyzed the line efficiency problem of a women hand bag manufacturing industry. At first we have calculated the current line efficiency of the organization which was very poor only 40.5%. So we used some heuristic methods of line balancing which are largest candidate rule, Kilbridge & wester column and rank positional weighted method of line balancing for the organization to balance the sequence and time duration of work elements. We done mathematical analysis and found that by using largest candidate rule method, line efficiency can be increased to 77.09, Kilbridge & wester column method gives 70.70% line efficiency and rank positional weighted method gives 77.09% line efficiency. Hence we can use the largest candidate rule or rank positional method to increase the line efficiency. All of the three heuristic method of line balancing i.e. largest candidate rule, Kilbridge & wester column method and rank positional weighted method were studied for the line balancing of the existing women hand bag manufacturing organization.

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