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Line Balancing and Simulation of a Diesel Genertor Assembly Line for Productivity Improvement

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Abstract—*Line balancing is an effective tool to improve the throughput of assembly line while reducing non-value-added activities, cycle time. The present study deals with balancing of Assembly line of a Leading Brand of Diesel Generators. The whole assembly line suffers due to the absence of established standard time for activities carried out by operators, non-value added activities and improper deployment of workers on the assembly line. Optimization of Assembly line and Balancing needs to be derived by Time Study of all the work Stations and the longest time consumption is workstation will be identified as a bottleneck workstation. The line is balanced by using Rank Position Weighted Method. ProModel simulation software is used to model the production line.ProModel simulation modeling software is a powerful yet easy-to-use simulation tool for modeling all types of systems and processes. Here, ProModel software is used to compare the Performance measures in terms of percentage Utilization, production rate etc. of the Assembly line before and after Balancing.*

Keywords*: Diesel Generator, Assembly line, Line balancing, Pro Model.*

1. INTRODUCTION

The present study deals with study of Assembly line of a Leading Brand of Diesel Generators that are used in Service Industries, Mobile Towers etc. in India and other countries. Different models of Generators are assembled on a single assembly line as per the orders of the customers (Make to Order Assembly). Out of the various models of Generators, 10 KVA model is selected for the study.The Assembly line consists of 13 stations and at each workstation the processing time is different. The whole assembly line suffers due to the absence of established standard time for activities carried out by operators, non-value added activities and improper deployment of workers on the assembly line.

Initially the time study is carried out of all the 13 stations and this data is used to carry out a simulation run on ProModel Software to findthe percentage Utilization, Total No. of exits, Operation time, Blocked time Etc. The line is balanced by using Rank Position Weighted Method.

2. RANK POSITION WEIGHTED METHOD.

In this method,work element having highest positional value is assigned first. Positional value is the sums of the times of all the elements that are directly follow it in the precedencediagram plus the time particular task itself.

Procedure to solve assembly line balancing problem with the help of RPWmethod is as follows:

Step 1: Draw the precedence diagram for operations or activities.

Step 2: Calculate the positional value for each operation or activity.

Step 3: Rank an operation or activity with highest positional value as first.

Step 4: Rank operations or activities in descending order of RPW.

Step 5: Assign an operation or activity to a station. Choose the highest rank positionalweight operation or activity and combine it with the next operation or activity.Continue till takt time of the line is not violated. Follow the precedence constraintsalso.

Step 6: Repeat step 5 till all operations are allotted to one station.

3. PROMODEL SIMULATION SOFTWARE

This study employed ProModel package as a tool to compare performance measures of the line before and after balancing the line.The Simulation run was carried out for 11 Hours (daily Productive working hours) based on the times obtained by time study. It was found that the total number of Generators assembled in 11 hours were 28 because some of the work stations were under-utilized due to improper design of workstations Layout. Thus the assembly line is not well balanced and the line is to be balanced by RPW line Balancing Method.

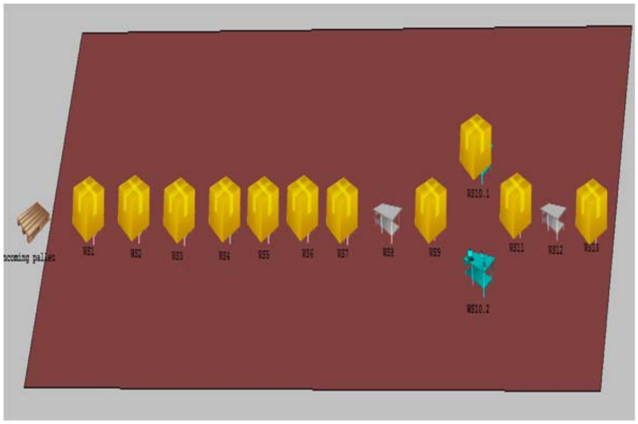

Fig. 1. ProModel Simulation Model of the Layout

4. LINE BALANCING

Theoretical Calculations

Cycle time = (Total available production time)/ no. of units to be produced

=660/40 =16.5 min

Theoretical or Minimum no of work stations= (Total Task time) / cycle time

=145.05/16.5 = 8.79= 9 work stations

Table 1: Work Elements with time and Precedence

Ele-ment	Time (min)	Predecessor	Element	Time (min)	Predecessor
1	2.40	0	17	4.03	16
2	5.52	1	18	1.60	17
3	6.25	2	19	7.52	16
4	7.00	0	20	5.38	16
5	0.83	4	21	3.32	19,20
6	2.38	4	22	2.25	21
7	3.87	4	23	0.75	18
8	0.92	4	24	1.25	18
9	3.02	4	25	0.97	18
10	2.25	4	26	5.60	16
11	2.45	4	27	3.97	25
12	7.47	3,5,6,7,8,9,10,11	28	15.03	22,23,24,26,27
13	4.75	12	29	4.12	28
14	4.63	13	30	8.90	29
15	2.63	14	31	1.22	30
16	12.67	15	32	10.12	31

Step 1: To balance the line by RPW method, all the work is divided into number of individual work Elements and a Precedence Table is constructed (Table.1).

Step 2:Calculate the positional value for each operation or activity. It is calculated by summing time of the work elements and the other times for elements that follow that element. (Table .2)

Step 3: Listing all the Positional Weight in decreasing order of Magnitude. (Table .3)

Table 2: Calculating Positional Weights

Element	Time (min)	RPW	Element	Time (min)	RPW
1	2.40	122.34	17	4.03	51.95
2	5.52	119.94	18	1.60	41.73
3	6.25	114.42	19	7.52	52.47
4	7.00	130.88	20	5.38	50.33
5	0.83	109.00	21	3.32	44.95
6	2.38	110.55	22	2.25	41.63
7	3.87	112.03	23	0.75	40.13
8	0.92	109.08	24	1.25	40.63
9	3.02	103.52	25	0.97	44.32
10	2.25	110.42	26	5.60	44.98
11	2.45	110.62	27	3.97	43.35
12	7.47	108.17	28	15.03	39.38
13	4.75	100.70	29	4.12	24.35
14	4.63	95.95	30	8.90	20.23
15	2.63	91.32	31	1.22	11.33
16	12.67	88.68	32	10.12	10.12

Table 3. Arranging in decreasing order of RPW

Element	RPW	Time(in min)	Element	RPW	Time(in min)
4	130.88	7.00	19	52.47	7.52
1	122.34	2.40	17	51.95	4.03
2	119.94	5.52	20	50.33	5.38
3	114.42	6.25	26	44.98	5.60
7	112.03	3.87	21	44.95	3.32
11	110.62	2.45	25	44.32	0.97
6	110.55	2.38	27	43.35	3.97
10	110.42	2.25	18	41.73	1.60
8	109.08	0.92	22	41.63	2.25
5	109.00	0.83	24	40.63	1.25
12	108.17	7.47	23	40.13	0.75
9	103.52	3.02	28	39.38	15.03
13	100.70	4.75	29	24.35	4.12
14	95.95	4.63	30	20.23	8.90
15	91.32	2.63	31	11.33	1.22
16	88.68	12.67	32	10.12	10.12

Table 4: Assigning Elements to work stations

Workstation	Element	Time	Station time
1	4	7.00	**14.92**
	1	2.40	
	2	5.52	
2	3	6.25	**14.95**
	7	3.87	
	11	2.45	
	6	2.38	

	10	2.25	
	8	0.92	
	5	0.83	
3	12	7.47	**14.48**
	9	3.02	
	13	4.75	
	14	4.63	
4	15	2.63	**12.02**
5	16	12.67	**12.67**
	19	52.47	
6	17	51.95	**11.55**
	20	50.33	
	26	44.98	
7	21	44.95	**15.27**
	25	44.32	
	27	43.35	
	18	41.73	
	22	41.63	
8	24	40.63	
	23	40.13	**9.82**
9	28	39.38	**15.03**
	29	24.35	
10	30	20.23	**14.23**
	31	11.33	
11	32	10.12	**10.12**

Step 4: Assign the work Elements into various work stations without violating the Precedence Constraints.

(Table. 4)

The Balanced line was Evaluated and Validated By ProModel and was compared with the Old line.

Results and Discussions

The Model for the balanced line containing 11 work stations is created and is compared with old line containing 13 workstations. (Fig. 2).

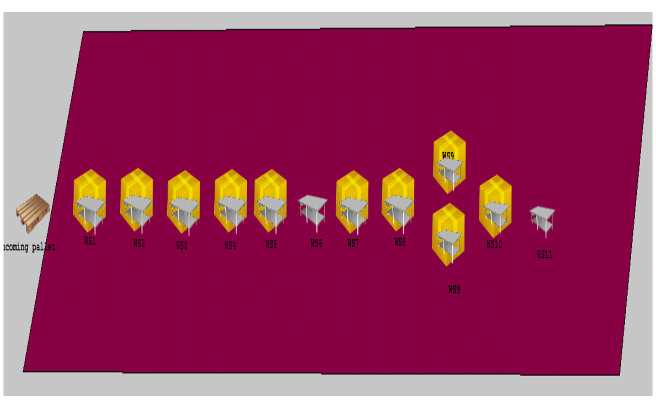

Fig. 2: ProModel Simulation for the balanced Assembly line

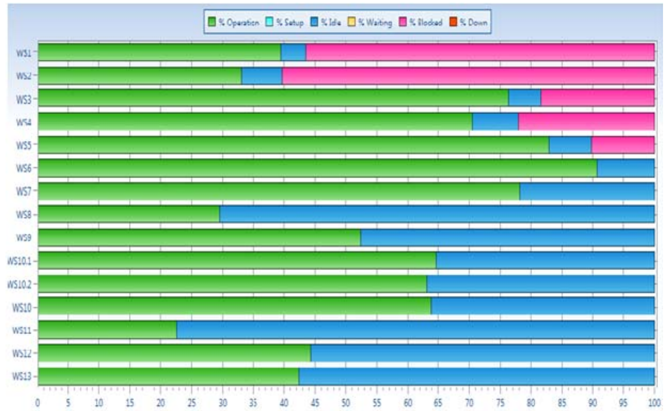

Fig. 3: Work Station Utilization before balancing.

The workstation utilization graph is as shown (Fig. 3 and Fig. 4). The Utilization of the underutilized workstations considerably after Balancing as shown by the green color in the Graph.The Idle time and the Blocked time is reduced considerably as shown by the Blue and Pink Color in the Graph.

Table 5: Simulation Output of station wise utilization of line

Station (Location Number)	% Utilization (Old Line)	% Utilization (Balanced Line)
1	96.02	92.04
2	93.37	92.22
3	94.70	88.91
4	92.62	72.24
5	93.12	74.72
6	90.68	66.73
7	78.09	86.03
8	29.50	53.92
9	52.36	74.75
10	63.88	73.22
11	22.58	51.68
12	44.27	---
13	42.42	---

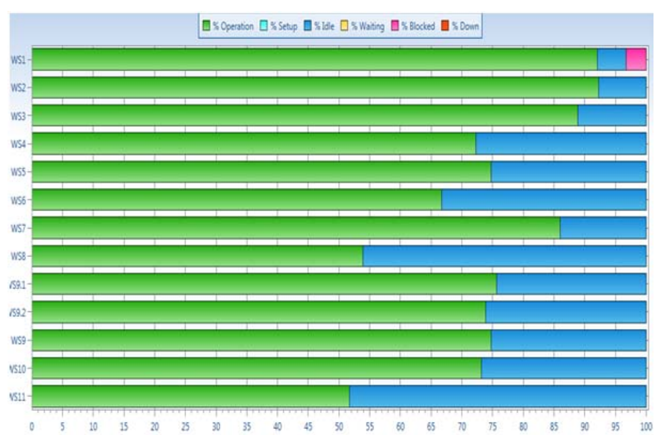

Fig. 4. Work Station Utilization after Balancing

5. CONCLUSIONS

Study of old unbalanced assembly line shows lesser Workstation Utilization, More Idle time, More Blocked time etc. resulting into Lesser Productivity and more time and Space Consumption. With conventional methods it is very difficult to validate Capacity constraints of the assembly line. From this perspective ProModel is very useful tool that can organize and accelerate the process for all kinds of products.

Table 6. Shows the results of some of the Parameters for 11 hours run (i.e Daily productive time). The Monthly Output will also be accordingly.

Table 6: Comparison between the old and the new line.

Parameters	**Old line**	**New line**
Line Assembly	67.59%	79.88
No of DG assembled in 11 hours	28	34

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