OPTIMIZING TOTAL IDLE TIME IN A MIXED-MODEL ASSEMBLY LINE THROUGH WORKLOAD ADJUSTMENT

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ABSTRACT

The fundamental of ALBP is to minimize and assign the number of workstations; minimize balance delay; and line balancing loss, idle time minimizing, minimizing CT. The purpose of the ALBP is to distribute the activities equally to the available workstations, this in turn increases the utilization of human resourced and the available facilities.

The MMuALB is used to optimize for the best performance to reduce the losses. Four models with different quantities of production are treated for assembly line optimization. The TNOS required for optimise allocation are considered. The algorithm was used to demonstrate 19 task problem which minimizes balancing and system loss. The quantities of models to be producedare10eachforallthe four models. The algorithm developed is based on branch and bound technique. Buxey 29 task based problem is considered for solution for least idle time of the work stations.

KEYWORDS: Allocation Of Tasks, Line Optimization, Minimization, Models Load, NOS, Idle Time Of Each Station, Iterations, Balancing Load, Minimize The Balance Delay

AL Production basically used for mass production system. Each task is identified by a processing time for the operation it represents and a set of relationships for precedence, which specifies the allowable ordering of the tasks. ALB is defined as a process in which a group of tasks to be performed are allocated on an systematic sequence of an AL.

The Cost associated and its reliability, complexities involved in tasks, selection of equipment, operating criteria of assembly line, multiple constraints, scheduling methodologies, allocation of stations, control of inventory, buffer control. Systematic design of assembly lines is not a simple & easy task for the designers. Manufacturers and Designers have to deal with their existing layout.

(Gutjahr and Nemhauser, 1964) [2] it has consistently developed algorithms to obtaining optimal solutions. Helgeson and Birnie, 1961 [4]; Hoffman, 1963 [5]; Mansoor, 1964 [6]; Arcus, 1966[7]; Baybar, 1986a [8] and exact methods of ALB problems. (e.g. Jackson, 1956 [9]; Bowman, 1960[10]; Van Assche and Herroelen,1978[11]; Mamoud,1989[12]; Sarinetal.,1999[13]).

The MMAL problem is a complex and many variables as product models. These models are in a line for assembly simultaneously. MALB-P identifies and assigs the tasks to the WS.

It's more complex since it has the additional considerations of the interactions between the assembled models. Designing an AL considering good efficiency, smooth production, less balance delay, cost effectiveness optimized time, overall

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labour efficiency and just in time production (JIT). The aim of Using this model is to exploit optimal methods. This method will be most effective and optimum for solving any ALBP.

2. PROPOSED ALGORITHM

a. Predict the ANOOF STATIONS=NOOF TASKS /3
b. Round off the NOOF STATIONS as to the lower int.
c. Assign a new station [1] with a cycle time T = MINCYCLETIME
d. Determine all the tasks having no predecessor TASKSWOPRED= {i, j,…., n}
e. Assign one task in TASKSWOPRED to STN [1]
f. EXCLUDE the tasks that is allotted to STN [1] from the graph and update it as TASKSWOPRED = {j, k,…., n}.
g. Update the SCT as T= MINCYCLETIME-ti
h. Redo steps e to g, till T is positive and T is updated TASKSWOPRED each time.
i. When shifts to negative, assign for other tasks in TASKSWOPRED to fit in STN [1], but the T should remain positive.
j. When T value becomes zero or negative TASKSWOPRED, create another new stn as STN [2].
k. Repeat steps to.
l. Repeat step Eto feasible solutions.
m. Get the solutions determined NOS. If not feasible, then repeat the steps to k after update the T as MINCYCLETIME+1.
n. Store the updated T for feasible solutions.
o. Decrease the NOS to 1 lesser than NOOF STATIONS and run.
p. Increase the NOS to 1 more than the NOOF STATIONS and run.
q. Freeze the NOS with best performance as NOOFSTATIONS Define the NOM as NUMMOD
r. Define the model quantity to be produced as MOD_i , i=1,2,3..M
s. Calculate the entitled load bearing capacity of all stations quality as ENT_CAP, i=1,2,3..M
t. Calculate the time required for completion of all tasks by each station for each model for the required quality as ACT_LOAD, i=1,2,3..M
u. Calculate the Smoothed load assignment SMT_LOAD_ASSGN = ENT_CAP- ACT_LOAD, i=1,2, 3..M
v. Determine the maximum of the SMT_LOAD_ASSGN, i=1,2,3..M
w. Increment the MOD_i for which the SMT_LOAD_ASSGN is maximum
x. Repeat the steps tow.
y. Run the step y for predetermined number of times and choose the quantity of each model based on the criteria of total of SMT_LOAD_ASSGN, fori=1,2... M, is minimum.

3. SIMULATION RESULTS

For experimental; purpose, the front grill manufacturing in the bus body building industry is considered. It has got total of 19 tasks. FRP front grill manufacturing in a moulding section where they manufacture different FRP parts for 04 different bus models. The FRP products they manufacture are dashboard assembly, rear board, front grill, engine-hood etc. There are about 25 workers in this section and execute 19 different tasks for manufacturing the final product. The main tasks are die preparation, mould preparation, preparation of glass fibre sheets, applying PVA, applying gel and other coatings, grinding, inspection etc. This line needs to manufacture the required number of products for different models for the monthly schedule. This section has the challenge to meet the production as per the requirement during the peak time. The work distribution is not so good because of which idle time is more for the workers and NOS are more.

Fig. 1: Precedence diagram of 19 tasks FRP Front Grill Assembly

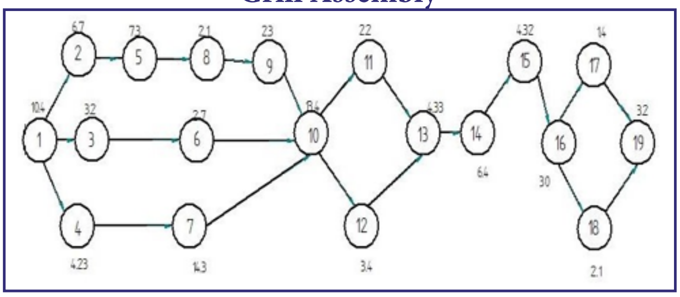


Table: 1 lists the precedence matrix with respect to 19 tasks shown in precedence diagram Fig. 1. There are 4 models to be processed on the assembly line. All the 04 models are to be manufactured in approximately 10 quantities. The task time of mixed-model is provided in table 1 at the bottom. Now it is required to determine the quantities of the models to be processed on the AL and the tasks needs to be assigned for the least total system time.

Table 1: Precedence matrix 19 tasks for FRP-Assembly of Front Grid

Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Model	Task Times																		
Model 1	9.20	6.40	3.10	3.80	6.80	2.30	13.50	1.83	2.00	13.14	1.94	2.86	4.12	5.83	3.89	28.43	1.36	2.03	2.98
Model 2	9.60	6.80	2.90	4.10	7.10	2.50	13.80	1.72	1.97	13.26	1.86	2.92	4.09	5.94	4.26	30.64	1.43	2.19	3.14
Model 3	10.20	6.20	3.30	4.20	7.40	2.60	14.10	1.98	2.12	13.13	2.13	3.36	4.29	6.36	4.38	29.65	1.45	2.32	3.26
Model 4	12.60	7.60	3.50	4.70	7.90	3.40	15.80	2.87	3.11	13.07	2.87	4.46	4.82	7.47	4.75	31.28	1.36	1.86	3.42
Average	10.40	6.70	3.20	4.23	7.30	2.70	14.30	2.10	2.30	13.40	2.20	3.40	4.33	6.40	4.32	30.00	1.40	2.10	3.20

By running the proposed algorithm for the average task times of all the 04 models, totally 12 solutions were obtained. These 12 solutions are provided in Table 2. Solution 1 is the best solution among 85 feasible solutions since the total station time is 136 minutes.

Table 2: Stations task times for 6 stations 19 tasks assembly problem.

Solution ->	1	2	3	4	5	6	7	8	9	10	11	12
Station 1	30	35	43	35	43	30	36	36	37	36	37	36
Station 2	29	24	24	27	24	32	29	29	28	29	28	29
Station 3	33	33	33	33	33	33	33	33	33	33	33	33
Station 4	5	5	5	5	5	5	5	5	5	5	5	5
Station 5	33	33	32	32	33	32	32	33	32	33	33	32
Station 6	6	6	7	7	6	7	7	6	7	6	6	7
Total Time	136	136	144	139	144	139	142	142	142	142	142	142

Table 3 shows the assignment of tasks to each station for the 12 solutions. As explained above, by assigning the tasks of solution 1 to the station index mentioned in cells of the table 3, the total station time required is 136 minutes.

Table 3: Feasible solutions 19 tasks and 6 stations AL problem

Task ->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Solution 1	1	1	1	1	2	1	2	2	2	3	3	3	3	3	4	5	6	5	6
Solution 2	1	1	1	1	1	2	2	2	2	3	3	3	3	3	4	5	6	5	6
Solution 3	1	2	1	1	2	2	1	2	2	3	3	3	3	3	4	5	5	6	6
Solution 4	1	1	1	1	1	2	2	2	2	3	3	3	3	3	4	5	5	6	6
Solution 5	1	2	1	1	2	2	1	2	2	3	3	3	3	3	4	5	6	5	6
Solution 6	1	1	1	1	2	1	2	2	2	3	3	3	3	3	4	5	5	6	6
Solution 7	1	1	1	2	1	1	2	1	2	3	3	3	3	3	4	5	5	6	6
Solution 8	1	1	1	2	1	1	2	1	2	3	3	3	3	3	4	5	6	5	6
Solution 9	1	1	2	1	1	2	2	1	1	3	3	3	3	3	4	5	5	6	6
Solution 10	1	1	1	2	1	2	2	1	1	3	3	3	3	3	4	5	6	5	6
Solution 11	1	1	2	1	1	2	2	1	1	3	3	3	3	3	4	5	6	5	6
Solution 12	1	1	1	2	1	2	2	1	1	3	3	3	3	3	4	5	5	6	6

Table 4: Idle time (IT) of 06 stations and iteration for 19 tasks problem

	Smoothing-Model 1	Smoothing-Model 2	Smoothing-Model 3	Smoothing-Model 4	Total Smoothing	Model 1 - Qty	Model 2 - Qty	Model 3 - Qty	Model 4 - Qty	Incrementing model
Iteration 1	125.4833	96.4333	122.85	180.5667	525.33	10	10	10	10	0
Iteration 2	157.2833	126.1133	155.54	198.6233	637.56	10	10	10	11	4
Iteration 3	189.0833	155.7933	188.23	216.68	749.79	10	10	10	12	4
Iteration 4	220.8833	185.4733	220.92	234.7367	862.01	10	10	10	13	4
Iteration 5	252.6833	215.1533	253.61	252.7933	974.24	10	10	10	14	4
Iteration 6	252.6833	215.1533	233.205	252.7933	953.83	10	10	11	14	3
Iteration 7	284.4833	244.8333	265.895	270.85	1066.06	10	10	11	15	4
Iteration 8	265.2317	244.8333	265.895	270.85	1046.81	11	10	11	15	1
Iteration 9	297.0317	274.5133	298.585	288.9067	1159.04	11	10	11	16	4
Iteration 10	297.0317	274.5133	278.18	288.9067	1138.63	11	10	12	16	3
Iteration 11	277.78	274.5133	278.18	288.9067	1119.38	12	10	12	16	1
Iteration 12	309.58	304.1933	310.87	306.9633	1231.61	12	10	12	17	4
Iteration 13	309.58	304.1933	290.465	306.9633	1211.20	12	10	13	17	3
Iteration 14	290.3283	304.1933	290.465	306.9633	1191.95	13	10	13	17	1
Iteration 15	322.1283	333.8733	323.155	325.02	1304.18	13	10	13	18	4
Iteration 16	322.1283	313.8367	323.155	325.02	1284.14	13	11	13	18	2
Iteration 17	353.9283	343.5167	355.845	343.0767	1396.37	13	11	13	19	4
Iteration 18	353.9283	343.5167	335.44	343.0767	1375.96	13	11	14	19	3
Iteration 19	334.6767	343.5167	335.44	343.0767	1356.71	14	11	14	19	1
Iteration 20	334.6767	323.48	335.44	343.0767	1336.67	14	12	14	19	2

Table 4 shows the balance and system loss for the 04 models,19 task and 6 station assembly line. Observed from the table that iteration1 is best solution when the total system loss is considered.

Fig. 2: Idle time of 6-stations for each iteration

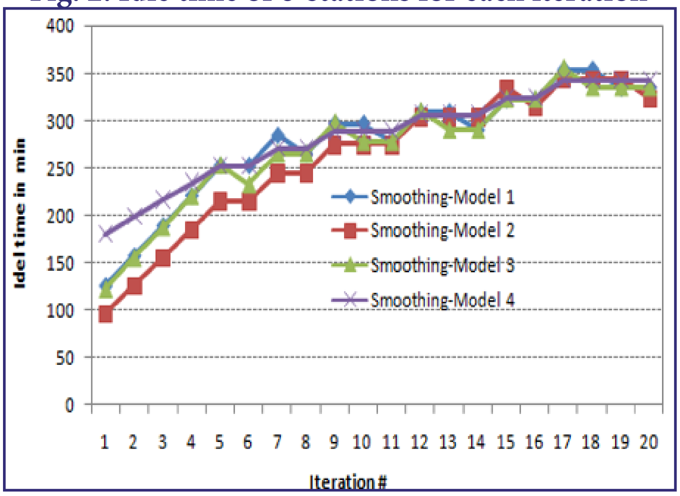
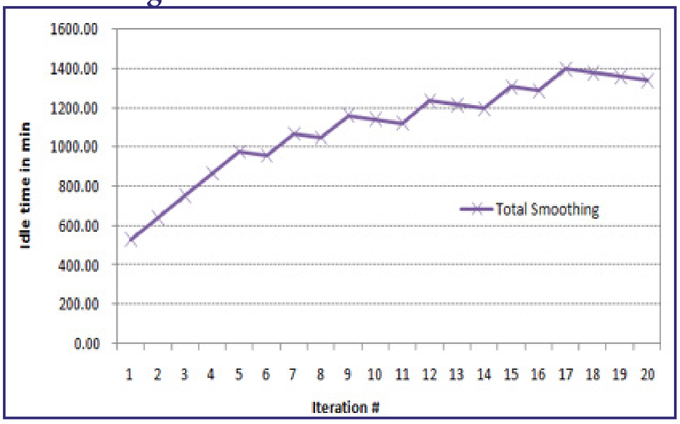


Fig. 3: Total Idle time of stations.



Figs. 2 and 3, reveal that iteration 1 is the best solution for the least balance and system loss. There are 04 models and quantities to be produced is 10 unit each.

CONCLUSIONS

The algorithm was used to demonstrate 19 task problem which minimizes balancing and system loss. From the algorithm the total time saved for this model is 28.92 percent. Shows the balance and system loss for the 04 models, 19 task and 6 station assembly line. Observed from the table that iteration 1 is the optimal solution where the total system loss is considered. Figs. 2 and 3, reveal that iteration 1 is the solution for the least balance and system loss for all models. The quantities of models to be produced are 10 each for all the 04 models. The algorithm developed is based on B&B technique which is generic in nature and can solve complicated ALBP.

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REFERENCES

1. Salveson, M.E. (1955). The assembly line balancing problem. J. Ind. Engng., 6 (3), 18-25.
2. Gutjahr, A., Nemhauser, G., 1964. An algorithm for the line balancing problem. Management Science 11,308–315
3. Kilbridge, M.D. and L. Wester (1961). A heuristic method for assembly line balancing. Journal of Industrial Engineering, 12, 292-298.
4. Helgeson, W. B. and D. P. Birnie (1961). Assembly line balancing using the ranked positional weight technique, J. Ind. Engng, 12 (6), 394-398.
5. Hoffmann, T. R., 1963. Assembly Line Balancing with a Precedence Matrix. Management Science. Vol. 9.
6. Mansoor, E.M., 1964. Assembly Line Balancing -An Improvement on the Ranked Positional Weight.
7. Arcus A.L., 1966. COMSOAL: A Computer Method of Sequencing Operations for Assembly Lines. International Journal of Production Research. Vol. 4, No.4: pp.259-277.
8. Baybars, I. (1986). A survey of exact algorithms for the simple assembly line balancing, management Science, 32, 909-932.
9. Jackson, J.R. (1956). A computing procedure for the line balancing problem. Management Science, 2.
10. Bowman, E.H. (1960). Assembly line balancing by linear programming, Operations Research, 8 (3).
11. Van Assche, F. and Herroelen, W. S., 1978. An Optimal Procedure for the Single-Model Deterministic.
12. Mamoud, K. I., 1989. A Generalised Assembly Line Balancing Algorithm. PhD. Dissertation, University.
13. Sarin, S.C., E. Erel and E.M. Dar-El., 1999. A Methodology for Solving Single-Model, Stochastic Assembly.
14. Boysen, N., Fliedner, M., 2007.A versatile algorithm for assembly line balancing. European Journal of Operational.
15. Scholl, A. and Klein, R., 1999. ULINO: Optimally balancing U-shaped JIT assembly lines. International Journal of Production Research. Vol. 37, No.4: pp.721-736.
16. Becker, C.; Scholl, A., (2006), A survey on problems and methods in generalized assembly line balancing. European Journal of Opera-tional Research, 168(3), 694-715.
17. Boctor, F., (1995), A multiple-rule heuristic for assembly line balancing. Journal of the Operational Research Society, 46, 62-69.
18. Amen, M., (2001), Heuristic methods for cost-oriented assembly line balancing: A comparison on solution quality and computing time. International Journal of Production Economic.
19. Pinnoi, A.; Wilhelm, W. E., (1998), Assembly system design: A branch and cut approach. Management Science, 44, 103-118.
20. Bukchin, Y.; Rabinowitch, I., (2006), A branch- and-bound based solution approach for the mixed-model assembly line-balancing problem form minimizing stations and task duplication costs. European Journal of Operational Research, 174, 492-508.
21. Peeters, A., (2006), Linear programming based lower bound for the simple assembly line balancing problem. European Journal of Operations Research, 168(3), 716-731.
22. Grabau, M. R.; Maurer, R. A.; Ott., D. P., (1997), Using simulation to generate the data to balance an assembly line. Proceeding of the 1997 Winter Simulation Conference, WSC, (Atlanta, GA, December 7-10), 733-738.
23. McMullen, P. R.; Frazier, G. V., (1998), Using simulated annealing to solve a multi objective assembly line balancing problem with parallel workstations. International Journal of Production Research, 36(10), 2717-2741.
24. Baybars, I. (1986). A survey of exact algorithms for the simple assembly line balancing, Management Science, 32, 909-932.
25. Ghosh S. and R. J. Gagnon., 1989. A Comprehensive Literature Review and Analysis of the Design, Balancing and Scheduling of Assembly Systems. International Journal of Production Research.
26. Erel, E. and S.C. Sarin., 1998.A Survey ofthe Assembly Line Balancing Procedures. Production Planning.
27. Scholl, A. 1993. Data of Assem line Balancing problems. Retrieved fromhttp://www.wiwi.uni-jena.de/Entscheidung/alb/.