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IMPLEMENTATION OF ANALYTICAL HIERARCHY PROCESS (AHP) IN LINE BALANCING

Aishwary Choubey[1] and Praveen Kumar Sharma[2]

[1]*Research Scholar, Mechanical Engg. , UEC , Ujjain.*
[2]*Assistant Professor, Mechanical Engg ., MIT, Ujjain.*

ABSTRACT

Assembly lines are special flow-line production systems which are of great importance in the industrial production of high quantity standardized commodities. In this article, assembly line balancing problem is formulated as a multi objective (criteria) problem where four easily quantifiable objectives (criteria's) are defined. Objectives (criteria's) included are line efficiency, balance delay, smoothness index, and line time. In this paper, focus is made on the prioritization of assembly line balancing (ALB) solution methods (heuristics) and to select the best of them.

Keywords
Simple Assembly Line Balancing (SALB), Pair Wise Comparison Scale, Analytical Hierarchy Process (AHP)

1. INTRODUCTION

The assembly line balancing problem (ALBP) is one of the classic problems in industrial engineering and is considered as the class of NP-hard combinatorial optimization problems (Amen, 2006). Therefore, heuristic methods have become the most popular techniques for solving such problems. (Arcus, 1965; Helgeson and Birnie, 1961; Khaw and Ponnambalam, 2009). This paper is organized as follows. Section 2 discusses the literature review on multi objective (criteria) assembly line balancing problems. Section 3 addresses the heuristics for the solution of assembly line balancing problem. While section 4 presents the performance measures (objectives criteria's) of assembly line balancing problem. Section 5 presents the MCDM approaches-AHP Section 6 methodology adapted. Section 7 result. Section 8 conclusion and scope for the future research.

2. LITERATURE REVIEW ON MULTI OBJECTIVE (CRITERIA) ASSEMBLY LINE BALANCING PROBLEMS

Jolai *et al*. (2009) proposes a data envelopment analysis (DEA) approach to solve an assembly line balancing problem. A computer-aided assembly line balancing tool as flexible line balancing software is used to generate a considerable number of solutions alternatives as well as to generate quantitative decision-making unit outputs. The quantitative performance measures were considered in this article. Then DEA was used to solve the multiple-objective assembly line balancing problem. An illustrative example shows the effectiveness of the proposed methodology. In this article, the evaluation criteria are West Ratio (Dar-El, 1975), Task Time Intensity, Task Time Distribution (Scholl, 1999), Balance Delay (Kumar, 2006), Smoothness Index (Moodie and Young, 1965) and Balance Efficiency. (Fanrkhondeh *et al.*, 2011), propose a model, using multi-objective decision making approach to the U-shaped line balancing problem, to offer enhanced decision maker flexibility, by allowing for conflicting goals. The assembly line operation efficiency is the most significant aim in our study, and this efficiency relates to management of resources and the solution of line balancing problem. First, the U-shaped line balancing problem is solved considering the model's goals. Then, the index function of assembly line balancing is determined and the efficiencies of the optimal solution outputs are evaluated using Data Envelopment Analysis (DEA). In this article, the 47evaluation criteria are Smoothness Index (SI) (Driscoll and Thilakawardana, 2001), Temporary Worker (TW), No. of Workstations (M), Productivity Level Index (PLI), Worker

Crossover Index (OCI), Balance Efficiency (BE). Gede Agus Widyadana (2009), in this research, U-type line balancing using goal programming for multi objective model with two goals, i.e., minimized the Number of Temporary Workers and Cycle Time in each station. Different amount of time for temporary worker to accomplish their tasks were generated. The cycle time in each station goal and the number of temporary workers goal are conflicting goals. When one goal has a higher priority, then the other one will be unsatisfied. The result also shows that in some cases U-line balancing model has better performance than straight line balancing model and in some cases both of them are equal. This study shows that the U-line balancing has more benefit than the straight line balancing, but the U-line balancing could not be interesting since it needs more walking time.

3. HEURISTICS FOR THE SOLUTION OF ASSEMBLY LINE BALANCING PROBLEMS

The large combinational complexity of the ALB problem has resulted in enormous computational difficulties. To achieve optimal or at least acceptable solutions, various solution methodologies have been explored. The Heuristic approach bases on logic and common sense rather than on mathematical proof. Heuristics do not guarantee an optimal solution, but results in good feasible solutions which approach the true optimum. Most of the described Heuristic Solutions in literature are the ones designed for solving single assembly line balancing problems (SALBP). Moreover, most of them are based on simple priority rules (Constructive Methods) and generate one or a few feasible solutions. In the following section five different heuristics found in the literature are presented along with the required steps to obtain the solution are as follows:

The steps involved in the (Helgeson and Birnie, 1961) positional weight method are as follows:

1) Determine the positional weight (PW) for each task. (Time of the longest path from the beginning of the operation through the remainder of the network.)
2) Rank the work elements based on the PW. The work element with the highest PW is ranked first.
3) Proceed to assign work elements (tasks) to the workstations, where elements of the highest positional weight and rank are assigned first
4) If at any workstation additional time remains after assignment of an operation, assign the next succeeding ranked operation to the workstation, as long as the operation does not violate the precedence relationships, and the station times do not exceed the cycle time.
5) Repeat steps 3 and 4 until all elements are assigned to the workstations.
heading should be in Regular.

4. METHODOLOGY

The scheme for generating the feasible combinations and balancing the line, station by station, is as follows:

1) Search left to right in the code number for a zero.
2) Select the element which heads the column in which zero is located.
3) Subtract the element's time from the cycle time remaining.
4) If the result is positive go to step 5.
5) 4a. If the result is negative go to step 6.
6) Subtract from the code number the row corresponding to the element selected and use this result as a new code number. Go to step 6.
7) Go to step 1 and start search one element to the right of the one just selected and repeat step 1- 6 until all the columns have been examined, then go to step 7.
8) Subtract the remaining cycle time (the slack time) from the slack time of the previous combination generated (If this is the first, then subtract from the cycle time).

9) If zero or negative go to step 4a. If positive, then this set of elements just generated becomes the new combination for this station. Go to step 10.

9) Go back one code number and go back to step 1 starting one element to the right of the element which had been selected from the code number. Repeat this procedure until the last column of the first code number has been tested; the result is that the last combination generated by step 8 is the one having the maximum elemental time for this station.

10) Replace the first code number with the last code number corresponding to the previous result. (This eliminates from further consideration the elements already selected.)

11) Repeat the previous steps until all the elements have been assigned. (Code number is entirely negative.)

Table.1 **Objectives (Criteria) for the evaluation of assembly line**

S. No.	Criteria	Optimization
1	Line Efficiency	Maximize Line Efficiency
2	Balance Delay	Minimum Balance Delay
3	Smoothness Index	Maximize Smoothness Index
4	Line Time	Minimize Line time

5. MCDM APPROACHE

5.1 Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. In most cases the criteria are further broken down into sub criteria, sub-sub criteria, and so on, in as many levels as the problem requires (Figure 1). The hierarchy can be visualized as a diagram like the one below, with the goal at the top, the alternatives at the bottom, and the criteria filling up the middle.

Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations. For this purpose a pair wise comparison scale is used, which is shown in the Table.2 given below. After that AHP converts the evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable

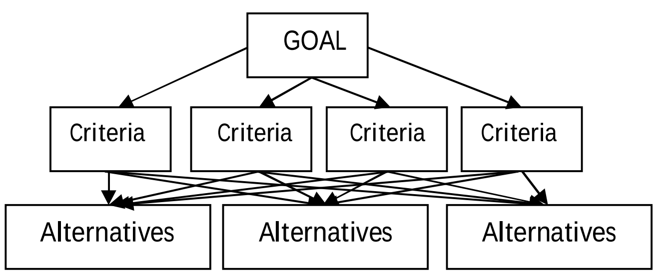


Figure 1. Hierarchical Structure for AHP (Hackman *et al.*, 1989; Saaty, 1990)

Table2. Pair Wise Comparison Scale (Saaty, 1990; Saaty, 1977; Kottas and Lua, 1973)

The Fundamental Scale for Pair wise Comparisons		
Intensity	Definition	Explanation
1	Equal Contribution	Two elements contribute equally to each other
3	Moderate Importance	Experience and judgement favours equally
5	Strong importance	Experience and judgement Favours strongly each other
7	Very Strong importance	Experience and judgement Favours strongly each other and one dominate the other
9	Extreme importance	The evidence favoring one element over another of the highest possible order of affirmation

Table 3. Precedence relationship

Task No	Task Time (sec.)	Precedence Relationship
1	6	-
2	2	1
3	5	1
4	7	1
5	1	1
6	2	2
7	3	3, 4, 5
8	6	6
9	5	7
10	5	8
11	4	9, 10

Analytical Hierarchy Process (AHP) calculations

In this approach, weights for different criteria were calculated using AHP software

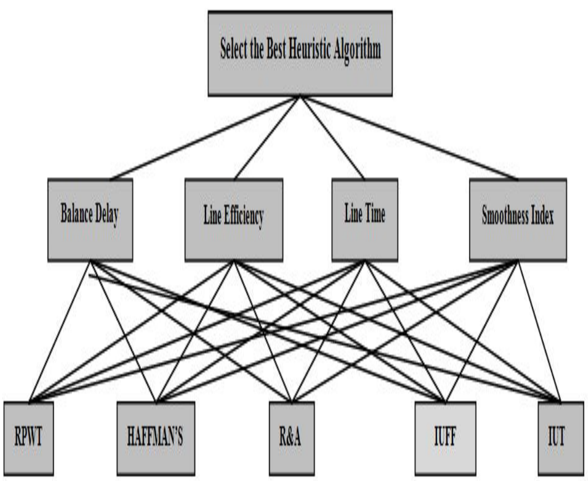
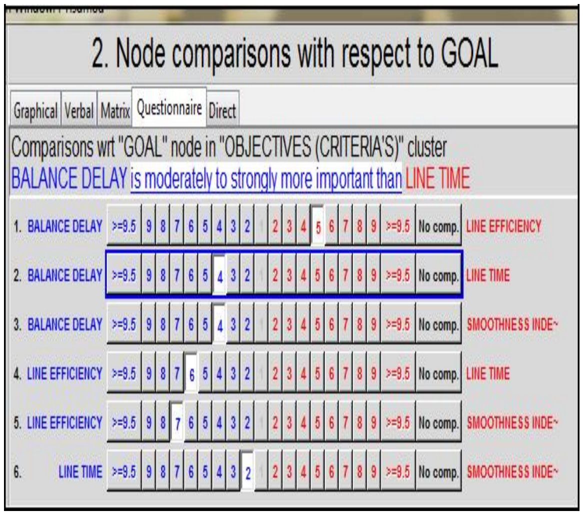


Figure 2 Hierarchical relationship

After creating hierarchical structure of the model, next step is to put the values of pair wise comparisons in the software which can be done as follows (please refer Figure 5).



7. RESULT

Thus, the best assembly line balancing heuristic among the five given heuristics is Incremental Utilization Technique for the solution of simple assembly line balancing problem. Result of above analysis suggests

Incremental Utilization Technique as the best assembly line balancing heuristic. As its relative closeness to the ideal solution is 0.7731, after that *Hoffmann's Precedence*

*Matrix*is suggested as second alternative with relative closeness to the ideal solution of 0.6536 respectively.

8. Conclusion and scope for the future research

In practice, measuring total profit for a given assembly line balancing (ALB) problem is an involved process that is sometimes impossible because of much uncertainty and unavailability of data. In this paper, a combined AHP evaluate and prioritize assembly line problem. Considering heuristics as alternatives and the various performance measures as criteria. The AHP is a popular method for tackling MCDM problems involving quantitative and qualitative criteria, and has successfully been applied to many actual decision making situations so far. Therefore, to exploit the advantages of this method, we considered quantitative criteria Balance *Delay, Balance Efficiency, Line Efficiency and Smoothness Index.* To generate assembly line balancing solutions five heuristics are used. An illustrative example explains the effectiveness of the proposed methodology. In the future researches, this approach could be developed towards considering both of quantitative and qualitative criteria. This approach could be used for all type of assembly line problems and for various types of layouts, especially; a real case-study indicates the effectiveness of the existing framework raises the value of this research in the future.

References:

Amen, M. (2006). Cost-oriented assembly line balancing: Model formulations, solution difficulty, upper and lower bounds. *European Journal of Operational Research*. *168*, 747-770**.**

Arcus, A.L. (1965). COMSOAL: a computer method of sequencing operations for assembly line. *International Journal of Production Research*. *4(4)*, 25-32**.**

Baybars, I. (1986). A survey of exact algorithms for the simple assembly line balancing problem. *Management Science*. *32*(8), 909–932.

Bhattacharjee, T.K., & Sahu, S. (1990).Complexity of single model assembly line balancing problems. *Engineering cost and sand production economics*. *18*(3), 203-214.

Bowman, E.H. (1960). Assembly line balancing by linear programming. *Operations Research. 8(3)*, 385-389.

Dar–El, E.M. (1975). Solving large single model assembly line balancing problems-A comparative study. *AIIE*

Transactions. *7*(3), 302-310.

Dar-El, E.M., & Curry, S. (1977). Optimal mixed-model sequencing for balanced assembly Lines. *Omega*. *5*, 333-341.

Domschke, W., Klein, R., & Scholl, A. (1993). Antizipative Leistungsabstimmungbeimoderner Variantenfließfertigung. *Zeitschriftfür Betriebswirtschaft*. *66*, 1465–1490.

Driscoll, J., & Thilakawardana, D. (2001). The definition of assembly line balancing difficulty and evaluation of balance solution quality. *Robotics and Computer Integrated Manufacturing.17*, S81–S86.

Elsayed, E. (1994). *Thomas O. Boucher, Analysis and Control of Production Systems*, Prentice-Hall, NJ.

Gamberini, R., Grassi, A., & Rimini, B. (2006). A new multi-objective heuristic algorithm for solving the stochastic assembly line re-balancing problem. *International Journal of Production Economics*. *102*(2), 226-243.