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MULTIPRODUCT ASSEMBLY LINE BALANCING BY HEURISTIC APPROACH USING EXPERT SYSTEM CODED IN C++

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Abstract

Assembly lines are production flow-lines made up of purely assembly operations, which are of great importance in the industrial production of high quality, standardize commodities. Recently assembly lines even gained importance in low volume production of customize product. Due to high capital requirement when installing or redesigning a line its configuration planning is of great relevance for practitioners, hence this attract attention of plenty researchers who tried to support real world configuration planning. By suited optimization model, (assembly line balancing problem). Inspite of the enormous academic effort in assembly line balancing it has been observed that there remains a considerable gap between the requirement of the real configuration problem and the status of the research. The paper provides a classification scheme of assembly line balancing and the various optimization techniques, which are used for solving the problem of ALB. Assembly line have been conventionally classified into two types i.e. type I focuses on minimizing the number of work stations for a given cycle time and type II minimizing the cycle time for a fixed number of work stations.

The present study is based on the heuristic method for simple assembly line balancing problems. The Ranked Positional weight method is used in this case and type II problem has been taken into consideration i.e. to calculate the optimum cycle time for given number of workstations.

In this paper, Heuristic based Ranked Positional weight method (RPW) has been adopted for handling the problem in the automobile manufacturing industries. The programme is coded in C++. The software shows the satisfactory result when run on given data by giving the optimum solution to the present assembly line workstation for the product thereby the reducing the manpower required for the existing setup.

Keywords: Assembly line balancing, Cost oriented assembly balancing, Heuristic method, Multi-product line balancing, Optimization techniques for assembling balancing.

1. INTRODUCTION

An assembly line a flow-oriented production system where the productive units performing the operations, referred to as stations, are aligned in a serial manner. The work pieces visit stations successively as they are moved along the line usually by some kind of transportation system, e.g. a conveyor belt [1]-[2].

Originally, assembly lines were developed for a cost efficient mass-production of standardized products, designed to exploit a high specialization of labour and the associated learning effects [3]. Since the times of Henry Ford and the famous model-T, however, product requirements and thereby the requirements of production systems have changed dramatically [4]. In order to respond to diversified costumer needs companies have to allow for an individualization of their products. For example, A car manufacturer can offer a catalogue of optional features which theoretically results in different models Multi purpose machines with automated tool swaps allow for facultative production sequences of varying models at negligible setup costs. This makes efficient flow line systems available for low volume assembly to-order production and enables modern production strategies like mass-customization which in turn ensures that the thorough planning and implementation of assembly systems will remain of high practical relevance in the foreseeable future [5].

Due to the high level of automation assembly systems are associated with considerable investment costs. Therefore, the (re)-configuration of an assembly line is of critical importance for implementing a cost efficient production systems Configuration planning generally comprises all tasks and decisions which are related to equipping and aligning the productive units for a given production process before the actual assembly process can start.

This includes setting the system capacity (cycle time number of station, station equipment) as well as assigning the work content to productive units (task assignment sequence of operations). [6]-[8]

In light of the high practical relevance, it is not astounding that a massive body of academic literature covers configuration planning of assembly system. In the scientific discussion, the tern assembly line balancing (ALB) is used to subsume optimization models, which seek to support this decision process. Since the first mathematical formalization of ALB was given by Salveson [9] academic work mainly focused on the core problem of the configuration which is the assignment of tasks to stations because of the numerous simplifying assumptions underlying this basic problem this field of research was labeled simple assembly line balancing (SALB) in the widely accepted review of Bay bars. [10] Subsequent works however, more and more attempted to extend the problem by integrating practice relevant aspects. Like U-shaped lines, parallel stations or processing alternatives [10]. In spite of these efforts, which are referred to as general assembly line balancing (GALB), there seems to be a wide gap between the academic discussion and practical applications? Empirical surveys stemming from the 70s and 80s revealed that only a very small percentage of companies were using a mathematical algorithm for configuration planning at that time. The apparent that this gap still exists or even has widened.

Three theoretical reasons might explain the aforementioned deficit: (i) Researchers have not considered the "true" real-world problem so far. (ii) The problem were covered, but could not be solved to satisfaction, (iii) Scientific results could not be transferred back to practical applications, e.g. because solutions for special case studies could not be extended to general problems.

Any of these reasons might result from a fundamental problem in communication, which is expressed by an inconsistent use of terms and definitions for the various types of balancing problem [11]. This is not only impeding the communication within the research community, but also the knowledge transfer to practice.

A first, yet decisive step to resolve this problem lies in a consistent, authoritative classification of assembly line balancing problems including all relevant constants and objectives. A uniform classification enables practitioners to compare their individual problem settings with those covered by research and to single out suitable solution techniques. Furthermore future research challenges can be identified by structuring the existing body of literature according to the classification scheme. The primary aim of this article is to develop such a classification.

Apparently, the existing distinction of SALB and GALB introduced by Bay bars has become insufficient to reflect the heterogeneity of GALB problems (12). Especially now, when the problem structure of SALB is will examined and powerful solution techniques exist, it is to be expected that future publications will mainly focus on GALB problem, some of which might show a similar problem structure as SALB, whereas other will deviate considerably. Gosh and Gagnon extended Bay bars efforts by further distinguishing special characteristics of GALB problems which had been covered by academic work at that time [13]. However, their list lacks a systematic approach and is long outdated because a great variety of additional constraints has been introduced in the meantime. Several researchers have tried to overcome this weakness by developing individual names for their considered problem extensions, which were mostly oriented towards the existing nomenclature. Although these efforts certainly help experts in the field to recognize particular problem characteristics, it might also lead to confusion as long as no guidelines exist as to when an extension is different enough in order to receive a new label or when two extensions with individual names are to be combined. In any case, this policy hardly reveals relations between problems and therefore cannot replace a classification in structuring the literature.

Before a new classification is proposed, the subject to be classified has to be characterized unambiguously. Therefore, the following sections will start out with a description of the core problem of ALB, which will be used as a basis for the presented classification scheme, explanation of those elements of ALB, which are mainly ignored or extremely simplified in the SALB formulation, which leads to the classification scheme. Then, the classification scheme is applied to structure and a first interpretation of achieved results and aims at providing hints on how to close the gap between research and practice by identifying promising areas of future research and characterizing practice relevant problem extensions which have not been covered so far.

Due to very different conditions in industrial manufacturing, assembly line production systems and corresponding ALB problems show a great diversity. In the following, we characterize the relevant properties of assembly lines, which have to be considered when balancing those lines.

Number and variety of products: If only one product or several products with (almost) identical production processes are assembled, the production system can be treated as a single-model line. In modem production systems, however, several products or different models of the same base product often share the same assembly line. In general, two different forms of organization are distinguished:

A mixed-model line produces the units of different models in an arbitrarily intermixed sequence. The sequence is important with respect to the efficiency of a line, because the task times may differ considerably between models. Therefore, the mixed-model ALB problem is connected to a sequencing problem, which has to find a sequence of models to be produced such that inefficiencies like utility work, line stoppage, and off-line repair are minimized. However, the balancing and the sequencing problem usually cannot be solved simultaneously, because the sequence depends on the short-term model-mix which is typically not known at the time when the line has to be balanced. Instead, the balancing problem is often based on an average model-mix. In order to anticipate the later sequencing problem adequately, a horizontal balancing objective is usually utilized which attempts to equalize the work content of stations over all models.

A multi-model line produces a sequence of batches (each containing units of only one model or a group of similar models) with intermediate setup operations. Therefore the ALB problem is not only connected to (batch) sequencing but also to a lot sizing problem. However, both additional problems are typically not part of the long/medium term configuration decisions.

In a U-shaped assembly line, the stations are arranged along a rather narrow "U", where both legs are closely together. Stations in between those legs may work at two segments of the line facing each other simultaneously (crossover stations). This means, that work pieces can revisit the same station at a later stage in the production process without changing the flow direction of the line.

PROBLEM FORMULATION

For the purpose of problem formulation, a study was done in a renowned automotive company assembling the light duty and heavy-duty commercial vehicles. The company had a Straight cum U shaped line layout for assembling, and was having fifteen work stations in assembly line and the cycle time (maximum) was 7.5 mins. The company has two major types of vehicles apart from other types. In addition, the number of workers required was much more than the regular models.

As has been discussed any assembly line balancing problem will at least consist of three basic elements. A precedence diagram for the problem which comprise all tasks to be assigned, the workstations related to the tasks are assigned and objective (Reduce cycle time or increase efficiency of assembly line) to be optimized.

Problem Solution:

The data for the solution and process has been collected for assembly work .For this problem an Expert system been decided to develop, which is based on heuristic method of RPW was applied and the program was coded in 'C++'.

Ranked Positional Weight Method:

Helgeson and Birdie introduced this Heuristic (Ranked Positional Weight) Method and its procedure. It is a method gives good solutions quickly as compared to other methods describe previously. It combines the strategies of the Largest Candidate Rule, kilbridge and wester's method .In this method a ranked positional weight (RPW) is calculated for each element for assembly line.

This Approach assigns operations to the stations in an order that corresponds to the length of the time each control through the remainder of the network.

The assignment of element to work station is then carried out in the following manner.

1. The work with the highest positional weight is selected and assigned it to the first workstation.
2. The unassigned time is calculated for the workstation by calculating the cumulative time of all works units assigned to the station and this sum is subtracted from the cycle time.
3. The work unit is selected with the next highest positional weight and attempted to assign it to the work-station after making the following check:
   (a) The list of already assign work units .If the immediate precedent work unit has been assigned ,precedence will not be violeted; we proceed to step 4(b).If the immediate precedent has not been assigned proceed to step 4.
   (b) The work unit time is compared with the unassigned time .If the work unit time is less then the workstation unassigned time assign the work unit and recalculate unassigned time .If the work unit time is greater then the unassigned time proceed to the step 4.
4. Selecting, checking and assigning is continued to if possible until one of the two conditions are met:
   (a) A combination is obtained where the remaining unassigned time is less then, equals the slack units available (five is to proceeded).
   (b) No unassigned work unit remain that can satisfy both the 'Precedence' and the 'unassigned time' requirements.
5. Unassigned work unit is assigned with the highest positional weight to the second workstation, and proceeded through the preceding step in the same manner.

Assigning the work unit is continued .At this time a solution to the assembly line balancing problem is found.

By compiling the data in the programme and run the programme for the optimum solution for workstation requirement, the Expert system gave very satisfactory results by giving improved workstation allocation. The efficiency was also increased as compared with the existing system.

Result at a glance showing the comparison of Traditional Method used in the company and the result obtained by Expert system.

Table 1. Result Analysis

	Traditional Method	Expert System
Efficiency	71 %	84%
Work station	15	15
Manpower	22	22
Actual Production Rate	60 Nos	63 Nos
Cycle Time	7.5 mins	7.13 mins

CONCLUSION

The various assembly lines balancing type had been seen are looked for improvements for SALB. Two different approaches have been proposed to incorporate processing alternatives into ALB .the first is known as the equipment selection problem. It is based on the assumption that there is a fixed set of equipments (complete set of resources) exactly one of which has to be selected and assigned to a station. The alternative approach consists in assigning processes to tasks. In addition to line balancing, for each task exactly one processing alternative has to be chosen out of a set of possible one. because these processes require resources ,the problem can be interpreted as an (implicit)equipment design problem .The chosen processes are usually not independent to each other ,which has to be reflected by considering possible synergies arising from jointly using resources for several tasks at a station or different types of assignment restrictions.

The expert system shows that it has a good potential to solve the current industrial problem of assembly line balancing for multi products to have an optimum utilization of the resources, furthermore the problem can be extended to solve the effective utilization of manpower for Mixed-model Line Balancing system.

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