A New Approach for Mixed-Model Assembly Line Sequencing

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Summary. This paper presents a fuzzy goal programming approach for solving a multi-objective mixed- model assembly line sequencing problem in a just-in-time production system. A mixed-model assembly line is a type of production line that is capable of diversified small lot production and is able to respond promptly to sudden demand changes for a variety of models. Determining the sequence of introducing models to such an assembly line is of particular importance for the efficient implementation of just-in-time (JIT) systems. In this paper, we consider three objectives, simultaneously: minimizing total utility work, total production rate variation, and total setup cost. Because of existence conflicting objectives, we propose a fuzzy goal programming based approach to solve the model. This approach is constructed based on the desirability of decision maker (DM) and tolerances considered on goal values. To illustrate the behavior of the proposed model, some of instances are solved optimally and computational results reported.

1 Introduction

A mixed-model assembly line is a type of production line that is capable of diversified small lot production. The effective utilization of mixed-model assembly line requires to solve two problems in sequential manner: (1) Line design and balancing, and (2) Determination of the production sequence for different models. Monden [10] defines two goals for the sequencing problems: (1) Leveling the load on each station on the line, and (2) Keeping a constant rate of usage of every part used by the line. To handle these problems, Goal chasing I and II (GC- I and GC- II) are developed by Toyota corporation. Miltenburg [8] developed a nonlinear programming for the second goal and solved the problem by applying two heuristic procedures. Miltenburg et al [9] solved the same problem with a dynamic programming algorithm. The objective considered by Bard et al [1] was the minimization of overall line length. Bard et al [2] used Tabu search (TS) algorithm to solve a model involving two objectives: minimizing the overall line length and keeping a constant rate of part usage. Hyun et al [3] addressed three objectives: minimizing total utility work, keeping a constant rate of part usage and minimizing total setup cost. This problem

was solved by proposing a new genetic evaluation. Mcmullen [4] considered two objectives: minimizing number of setups and keeping a constant rate of part usage. He solved this problem with a TS approach. Mcmullen [5,6] has also solved the same problem by using genetic algorithm, and ant colony optimization, respectively.

In this paper, we consider three objectives simultaneously as follows: 1) total utility work, 2) total production rate variation, and 3) total setup cost. The main purpose of this paper is to apply the fuzzy goal programming methodology where simultaneous minimization of the above mentioned objectives is desired. The structure of this paper is as follows. In Section 2, we present a detailed description of the mixed-model assembly line. In Section 3, a fuzzy goal programming based algorithm is proposed. In Section 4, experimental results are given and various test problems are provided. Finally, we present our conclusions in Section 5.

2 Multi-Objective Sequencing Problem in MMAL

2.1 Mixed-Model Assembly Line

An MMAL considered in this paper is a conveyor system moving at a constant speed (v_c). The line is partitioned into J stations. It is assumed that the stations are all closed types. The worker moves downstream on the conveyor while performing his/her tasks to assemble a product. On completion of the job, the worker moves upstream to the next product.

The design of the MMAL involves several issues such as determining operator schedules, product mix, and launch intervals. First, early start schedule is more common in practice and is used in this paper ([4]). Second, the minimum part set (MPS) production, which this strategy is widely accepted in mixed model assembly lines, is also used in this paper. MPS is a vector representing a product mix, such that $(d_1,...,d_m) = (D_1/h, \ldots ,D_m/h)$; where M is the total number of models, D_M is the number of products of model type m which needs to be assembled during the entire planning horizon and h is the greatest common divisor or highest common factor of $D_1,D_2, \ldots ,D_M$. This strategy operates in a cyclical manner. The number of products produced in one cycle is given by $I = \sum_{i=1}^{M} d_i$. Obviously, h times the repetition of producing the MPS products can meet the total demand in the planning horizon. Third, the launch interval (γ) is set to $(\frac{T}{I \times J})$, in which T is the total operation time required to produce one cycle of MPS products ([4]).

2.2 Sequencing Objective Functions

Minimizing Total Utility Work

The utility work is typically handled by the use of utility workers who assist the regular workers during work overload.

Minimizing Total Production Rate Variation

One basic requirement of JIT systems is continual and stable part supply. Since this can be realized when the demand rate of parts is constant over time, the objective is important to a successful operation of the system. Therefore, the objective can be achieved by matching demand with actual production.