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No-wait flow shop scheduling using fuzzy multi-objective linear programming

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Abstract

This study develops a fuzzy multi-objective linear programming (FMOLP) model for solving the multi-objective no-wait flow shop scheduling problem in a fuzzy environment. The proposed model attempts to simultaneously minimize the weighted mean completion time and the weighted mean earliness. A numerical example demonstrates the feasibility of applying the proposed model to no-wait flow shop scheduling problem. The proposed model yields a compromised solution and the decision maker's overall levels of satisfaction.

Keywords: No-wait flow shop scheduling; Multi-objective linear programming; Fuzzy multi-objective linear programming; Decision maker

1. Introduction

Scheduling is the assigning of a finite number of resources to a number of jobs over time, often with a decision that optimizes one or more objective. In most manufacturing systems it is required that for completion of a job, a set of processes needs to be performed serially.

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We refer to this as flow shop environment. Emergence of advanced manufacturing systems such as computer-aided design/computer-aided manufacturing (CAD/CAM), flexible manufacturing system (FMS), and computer-integrated manufacturing (CIM) have increased the importance of flow shop scheduling [1].

A flow shop scheduling problem addresses determination of sequencing N jobs needed to be processed on M machines so as to optimize the performance measures such as makespan, tardiness, work in process, number of tardy jobs, idle time, etc. In flow shop scheduling, the processing routes are the same for all the jobs [1]. In the permutation flow shop, passing is not allowed. Thus, the sequencing of different jobs that visit a set of machines is in the same order. In the general flow shop, passing is permitted. Therefore, the job sequence on each machine may be different [2].

Flow shop scheduling problems are popular in the area of scheduling and there are numerous papers that have investigated these problems [3]. Most research is dedicated to single-criterion problems. For example, Pan et al. [4] consider the two-machine flow shop scheduling problem minimizing total tardiness as the objective. Bulfin and M'Hallah [5] propose an exact algorithm to solve the two-machine flow shop scheduling problem with the objective of the weighted number of tardy jobs. Blazewicz et al. [6] analyze different solution procedures for the two-machine flow shop scheduling problem with a common due date and weighted late work criterion. Choi et al. [7] investigate a proportionate flow shop scheduling problem where only one machine is different and job processing times are inversely proportional to machine speeds. The objective is to minimize maximum completion time. Grabowski and Pempera [8] address the no-wait flow shop problem with a makespan criterion and develop and compare various local search algorithms for solving this problem. Wang et al. [9] deal with a two-machine flow shop scheduling problem with deteriorating jobs , minimizing the total completion time.

It is well known that the optimal solution of single-objective models can be quite different from the models consisting of multiple objectives. In fact, the decision maker (DM) often wants to minimize the weighted mean completion time or weighted mean earliness. Each of these objectives is valid from a general point of view. Since these objectives conflict with one another, a solution may perform well for one objective but may give inferior results for others. For this reason, scheduling problems have a multi-objective structure.

While the above studies treated a single objective, consideration of multiple criteria is practically more realistic [3,10]. The multi-objective flow shop scheduling problem has been addressed by some researches. Murata et al. [3] propose a multi-objective genetic algorithm and then apply it to the flow shop scheduling problem with the objective of minimizing makespan and total tardiness. Sayin and Karabati [11] deal with the scheduling problem in a two-machine flow shop environment with the objective of minimizing makespan and sum of completion times simultaneously. To solve this problem, they developed a branch-and-bound procedure that iteratively solves restricted single-objective scheduling problems until the set of efficient solutions is completely enumerated. Danneberg et al. [12] address the permutation flow shop scheduling problem with setup times where the jobs are partitioned into groups or families. Jobs of the same group can be processed together in a batch but the maximum number of jobs in a batch is limited. The setup time depends on the group of jobs. They propose the makespan as well as the weighted sum of completion times of the jobs as the objectives. To solve the problem, they propose and compare various constructive and iterative algorithms. Toktas et al. [10]