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Scheduling unrelated parallel batch processing machines with non-identical job sizes and unequal ready times

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Abstract

This research analyzes the problem of scheduling a set of n jobs with arbitrary job sizes and non-zero ready times on a set of m unrelated parallel batch processing machines so as to minimize the makespan. Unrelated parallel machine is a generalization of the identical parallel processing machines and is closer to real-world production systems. Each machine can accommodate and process several jobs simultaneously as a batch as long as the machine capacity is not exceeded. The batch processing time and the batch ready time are respectively equal to the largest processing time and the largest ready time among all the jobs in the batch. Motivated by the computational complexity and the practical relevance of the problem, we present several heuristics based on first-fit and best-fit earliest job ready time rules. We also present a mixed integer programming model for the problem and a lower bound to evaluate the quality of the heuristics. The small computational effort of deterministic heuristics, which is valuable in some practical applications, is also one of the reasons that motivates this study. The results show that the heuristic proposed in this paper has a superior performance compared to the heuristics based on ideas proposed in the literature.

Keywords: Scheduling, Unrelated parallel batch machines, NP-hard, Makespan, Heuristics.

1. Introduction

Batch scheduling problems consists of grouping jobs on each machine into batches, where a batch is a group of jobs that have to be processed jointly. The jobs in a batch can be processed by the machines in serial (s-batching machines) or in parallel (p-batching machines). On a s-batching machine, the processing time of a batch is the sum of the processing times of all the jobs in the batch. A p-batching machine allows several jobs to be processed simultaneously in a batch, the processing time of a batch is equal to the largest processing time of the jobs in the batch and all jobs in the same batch have the same completion time. In this paper we address a p-batching scheduling problem, which is also known as the scheduling of a batch processing machine (BPM) [1].

In recent years, there has been an increasing interest in parallel BPM scheduling problems because of their great application potential. These scheduling problems are frequently encountered in many modern manufacturing industries, such as chemical, food and mineral processing, pharmaceutical and metalworking, wafer fabrication process, stress screening chamber fabrication, etc. [2] [1].

A practical application of parallel BPM arise in the final testing stage of electronic circuits manufacturing. Semiconductor manufacturing involves numerous batch processing operations like oxidation, diffusion, deposition, etching, e-beam writing and heat treatment of wafer fabrication, baking of wafer probing and burn-in operation of device testing [3]. In the burn-in operation, a series of thermal stress tests is performed for integrated circuits (ICs or chips) to make sure that they meet complex specifications and to force the

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