International Conference
on Industrial Engineering and Systems Management

IESM' 2009

May 13 - 15, 2009

MONTREAL - CANADA

Scheduling identical parallel machines and operators within an end job changing mode*

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Abstract

This article addresses the problem of scheduling *n* non-preemptive tasks on *m* identical parallel machines with operators to minimize the makespan criterion. The number of operators being less than the number of machines, an operator can supervise simultaneously several machines. As a consequence, the processing times of the tasks depend on the way operators intervene on the machines. We consider the case where the operator's intervention may only happen at the end of a task. We present five heuristic algorithms to solve the problem, and, for the case of two machines, the worst case analysis for two heuristics. A simulation study is also undertaken to evaluate the average performance of these heuristics.

Keywords: Scheduling, parallel machines, makespan, operators, end job changing mode.

1 Introduction

Research in classical scheduling theory has mainly concentrated on machine and job characteristics such as machine availability, job processing sequence, and so on. The complexity of scheduling problems in the real world and the difficulty to draw an adequate theoretical framework to capture the industrial reality have led to simplify working hypotheses [10]. As a result, these models have ignored in most of the cases considerations linked with operator interventions on the machines by assuming their number infinite. However, one cannot but notice that human resources are getting more and more critical in production systems, and it is not enough to concentrate only on the physical resources in order to expect a reasonable solution. Researchers have so far considered that either the human resources problem is so important that it dominates the machine scheduling problem, or the human resources problem has to be adapted to the machine schedule by the shop manager. The goal of the present paper is to put forward a model that integrates human resources into the problem of machine scheduling. Obviously, this model is still theoretical. Nevertheless, we believe that it may provide a good insight to scheduling problems in the real world.

Few papers in the literature have taken into account simultaneously human resources and machines in the process of building a schedule. And when they do so, the approach has so far consisted of two phases: first, the scheduling of the tasks is determined. Then, the operators are assigned to the machines modifying, if necessary, the initial solution ([5, 6]; [7]), or vice versa as it is done in [8]. Pinedo [10] pointed out the importance of studying models which combine machine scheduling problems with those induced by human resources (operators). The resulting scheduling problem, which integrates operator's assignments to the machines, consists of determining the status of the shop over time [2].

Since the work of Vickson [13, 14], several studies have appeared in the literature in which the processing times are controlled by the quantity of resources allocated to the execution of tasks. Daniels *et al*. [3] considered the identical parallel machines problem with pre-assigned tasks to the machines. A branch and bound algorithm is

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