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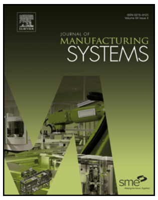

An effective heuristic for no-wait flow shop production to minimize makespan

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ABSTRACT

In no-wait flow shop production, each job must be processed without any interruption from its start time on the first machine to its completion time on the last machine. To minimize makespan in no-wait flow shop production is one of the main concerns in industry. In this paper, we propose an average departure time (ADT) heuristic for minimizing makespan in no-wait flow shop production. Based on the computational experiment with a large number of instances of various sizes, the ADT heuristic performs better than three existing best-known heuristics in the same computational complexity environment.

1. Introduction

No-wait flow shop production is an important production mode in many manufacturing systems such as petrochemical processing [1], steel rolling [2], and plastic molding [3]. For no-wait flow shop scheduling, the orders of n jobs processed on m machines are the same, and all jobs are available to start at time zero. Furthermore, each job must be processed continuously from the start to the end, i.e., no waiting time allowed on intermediate machines from the first machine to the last. Consequently, the start time on the first machine could be postponed to avoid waiting time on any intermediate machine. Take food processing as an example; the quality of food will change as time goes by. Therefore, there should be no waiting between operations during the processing; otherwise the quality of food will be jeopardized, even causing safety issues. For more details about applications of no-wait flow shop production, please refer to Hall and Sriskandarajah [4].

To minimize maximum completion time or makespan, min ($C_{\max}$), is one of the most meaningful objectives for no-wait flow shop production [5]. Makespan is the completion time of the last job on the last machine. There are also several other objectives commonly used to optimize the performance of no-wait flow shop production, such as to minimize total completion time [6], to minimize weighted mean completion time [7], and to minimize total tardiness [8].

To minimize $C_{\max}$ is NP-hard for no-wait flow shop production when the number of machines is larger than 2 [9]. Due to the NP-hardness of no-wait flow shop production to min ($C_{\max}$), it is extremely time consuming for exact algorithms to seek optimal solutions, even for moderate-scale problems [10]. Therefore, it is practical to use heuristics to seek optimal or near-optimal solutions in a reasonable time, especially for large-scale production problems in industry.

The NEH heuristic [11] has been widely regarded as the best constructive heuristic for permutation flow shop production to min ($C_{\max}$) [12] and also has been applied in no-wait flow shop scheduling [13]. The NEH heuristic initially sequences jobs in a non-ascending order by the sum of processing times of a job on all machines. The first two jobs are then selected from the initial sequence, and the partial sequence of these two jobs is fixed by the one with better makespan. The remaining unsequenced jobs, each in turn in the order of the initial sequence, are used to create a set of temporary sequences by inserting each job one-by-one at each position in the current sequence and calculating its $C_{\max}$. The temporary sequence whose job position has the minimum $C_{\max}$ is selected, the job positions are then frozen as the current sequence, and the next job in the initial sequence is examined. A final sequence is generated until all jobs are sequenced.

Gangadharan and Rajendran [14] proposed their GR heuristic for n-job m-machine no-wait flow shop production to min ($C_{\max}$). Given processing times of job j on machine i, $p_{j,i}$, where $j = 1, \ldots, n$, and $i = 1, \ldots, m$, we can calculate the sum of processing times of job j on all machines by $T_j = \sum_{i=1}^{m} p_{j,i}$, and an index for job j by $P_j = (\sum_{i=1}^{m} j \times p_{j,i})/T_j$. The GR heuristic has three steps to construct

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