Chapter 15
Using Cuckoo Search Algorithm for Hybrid Flow Shop Scheduling Problems Under Makespan Criterion

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ABSTRACT

In this chapter, cuckoo search algorithm (CSA) is used to solve the multistage hybrid flow shop (HFS) scheduling problems with parallel machines. The objective is the minimization of makespan. The HFS scheduling problems are proved to be strongly non-deterministic polynomial time-hard (NP-hard). Proposed CSA algorithm has been tested on benchmark problems addressed in the literature against other well-known algorithms. The results are presented in terms of percentage deviation (PD) of the solution from the lower bound. The results indicate that the proposed CSA algorithm is quite effective in reducing makespan because average PD is observed as 1.531, whereas the next best algorithm has result of average PD of 2.295, which is, in general, nearly 50% worse, and other algorithms start from 2.645.

INTRODUCTION

Scheduling is one of the most important decision making process in production and operation management. The hybrid flow shop (HFS) environment is a combination of parallel machine and flow shop environments. The HFS scheduling problem was first addressed by Arthanari and Ramamurthy (Arthanari & Ramamurthy, 1971). The HFS scheduling problems are NP-hard type combinatorial optimization problems (Gupta 1988; Hoogeveen et al. 1996). The HFS is also called as flow shop with multiple processors (machines), flexible flow shop (FFS), multiprocessor flow shop, or flow shop with parallel machines (Ribas et al. 2010).

Cuckoo search algorithm is a population based meta-heuristic algorithm based on the obligate brood parasitic behavior of some cuckoo species in combination with the Lévy flight behavior of some birds and flies in the nature (Yand & Deb, 2009). Yang and Deb (Yang & Deb, 2010) solved various optimization problems using the CSA. CSA has been proposed for solving knapsack problems (Layeb, 2011; Gherboudj, 2012), steel structure optimization problems (Kaveh et al. 2012; Gandomi et al. 2013), scheduling problems (Marichelvam, 2012; Marichelvam et al. 2014), multimodal optimization problems (Jamil & Zepernick, 2013), travelling salesman problems (Ouyang et al. 2013), reliability optimization problems (Valian et al. 2013) and machining parameters optimization problems (Yildiz, 2013). Cuckoo search and tabu search algorithms are hybridized to solve the quadratic assignment problems (Dejam et al. 2012). Detailed review on cuckoo search algorithm can be found in (Fister et al. 2013). Also there are new promising algorithms like neighborhood field and contour gradient optimization which initially designed for continuous optimization but soon to be adapted for scheduling problems (Wu et al., 2013).

Though wide variety of heuristics and meta-heuristics has been applied to solve HFS scheduling problems, the applications of recently developed bio-inspired meta-heuristic algorithms are very limited. Hence, in this paper, we propose the recently developed metaheuristic cuckoo search algorithm (CSA) for solving the multistage HFS scheduling problems with makespan objective. Its results will be compared against another recent algorithm (Bat algorithm) and others from the literature. The rest of the paper is organized as follows. Section 2 presents the problem definition. Section 3 will describe the proposed meta-heuristic algorithms in detail. An overview of the computational experiments and results are given in Section 4. In Section 5, overall conclusions are drawn and future research paths are briefly highlighted.

PROBLEM DEFINITION

In a HFS scheduling problem, a set of n jobs are available simultaneously to be processed sequentially on different stages. Each job j has its fixed processing time for every stage s, $s\epsilon\left\{1,2,\ldots,M\right\}$ and at each stage there is a set of identical parallel machines $m\epsilon\left\{1,2,\ldots,m_s\right\}$ where some production stages may have only one machine, but at least one production stage must have multiple machines. Each job may consist of different operations. These operations will be performed by any one of the machines at different stages. The jobs arrive at first stage where the corresponding operations are to be performed and the jobs are delivered to the next stage for the completion of succeeding operations. The jobs have to pass through all the stages sequentially. The objective of scheduling is to assign jobs to the machines at the corresponding stages and determine the processing sequences on the machines so that the makespan (Cmax), i.e., the maximum completion time is minimized.

The HFS problem is known as NP-hard. In the basic model where HFS restricted to two processing stages, even in the case when one stage contains two machines and the other one a single machine, it's proved that the HFS is NP-hard based on the results of Gupta (1988). Moreover, the special case where there is a single machine per stage, known as the flow shop, and the case where there is a single stage with several machines, known as the parallel machines environment, are also NP-hard (Ruiz and Vazquez-Rodriguez, 2010).

The HFS problem has attracted a lot of attention and found in all kinds of real world scenarios including the electronics, paper and textile industries. Examples are also found in the production of concrete,

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