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ARTICLE



# Cost-based hybrid flow shop scheduling with uniform machine optimization using an improved tiki-taka algorithm

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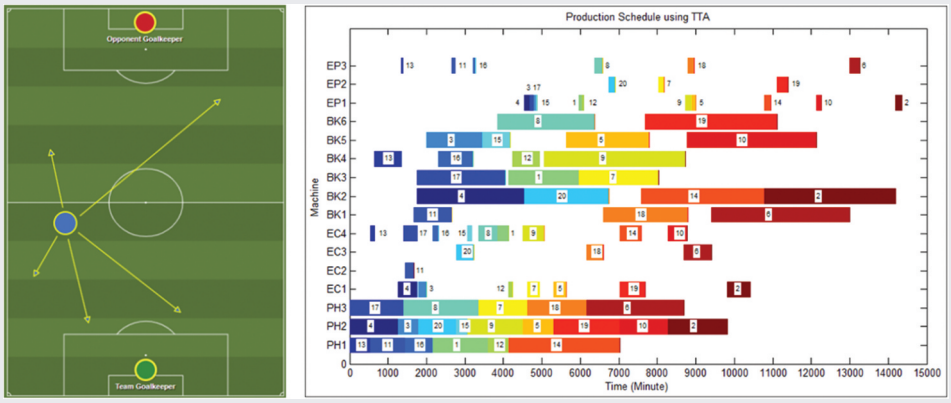
**ABSTRACT**

Cost is the foremost factor in decision-making for profit-driven organizations. However, hybrid flow shop scheduling (HFSS) research rarely prioritizes cost as its optimization objective. Existing studies primarily focus on electricity costs linked to machine utilization. This paper introduces a comprehensive cost-based HFSS model, encompassing electricity, labor, maintenance, and penalty costs. Next, the Tiki-Taka Algorithm (TTA) is improved by increasing the exploration capability to optimize the problem. The cost-based HFSS model and TTA algorithm have been tested using benchmark and case study problems. The results indicated that the TTA consistently outperforms other algorithms. It delivers the best mean fitness and better solution distribution. In industrial contexts, the TTA able to reduces costs by 2.8% to 12.0% compared to other approaches. This holistic cost-based HFSS model empowers production planners to make more informed decisions. Furthermore, the improved TTA shows promise for broader applicability in various combinatorial optimization domains.

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## 1. Introduction

Hybrid flow shop scheduling (HFSS) combines flow shop scheduling and parallel machine scheduling problems and is widely implemented in industries such as general machining shops, the garment industry, the plastic industry, and the electronics industry. The HFSS involves several jobs to be processed on several stages of workstations or machines. Each stage has a number of machines capable of performing similar processes [1].

Several HFSS variants exist, but the most basic versions comprise identical HFSS, uniform HFSS, and unrelated HFSS. Identical HFSS refers to a scheduling problem where all machines in each processing stage are similar. Therefore, the processing time for a particular job is similar for all machines. Uniform HFSS consists of machines that can perform similar processes in a stage but with different processing times. Some machines are consistently faster than other machines for any job, which may be due to different models, capacities, and technologies. Unrelated HFSS is roughly similar to the uniform type, but the processing time does not depend on the machine model [2], so some machines may have faster processing times for one job but not for another [3].

Many similar studies have been published before with different objective functions and optimization techniques. According to a review paper, more than 200 papers were published on HFSS between 2010 and 2019 [4]. Eighty-three percent of these papers utilized a metaheuristic approach to optimize the problem in comparison to exact and heuristic approaches. Seventy percent of the papers focused on minimizing

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