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Minimizing Machines and Operators in Cyclic Production Systems: A Two-Stage Heuristic Approach

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Abstract

Cyclic production systems are widely used in manufacturing environments with demand for multiple products. In such systems, managers must determine both the minimum number of machines required to satisfy demand and the minimum number of operators needed to perform machine setup activities. These decisions have a significant impact on equipment utilization, labor costs, and overall production efficiency. This problem belongs to a class of NP-hard combinatorial optimization problems. This paper presents a two-stage heuristic approach for minimizing the number of machines and operators in cyclic production systems. In the first stage, products are assigned to identical machines while satisfying production capacity requirements. The problem is modeled as a bin-packing-type optimization problem, and a heuristic procedure is applied to determine machine assignments and the minimum feasible number of machines. In the second stage, machines are assigned to operators responsible for setup activities, ensuring that setup operations assigned to the same operator do not overlap and that operator workload constraints are respected. The proposed methodology was validated using an industrial case study involving multiple products with different demand rates and processing times. The results demonstrate that the approach efficiently generates feasible solutions and achieves substantial reductions in both machine and operator requirements. The method is computationally efficient, easy to implement, and suitable for practical industrial applications where exact optimization methods become difficult to apply. The proposed framework provides production planners with a practical decision-support tool for improving resource utilization and reducing operating costs in cyclic manufacturing environments.

Keywords

Production and Performance Management, Machine Assignment, Operator Assignment, Bin Packing Problem, Heuristic Optimization.

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