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A Benders Decomposition-Based Hybrid Approach to the Dual Resource Constrained Flexible Job Shop Scheduling Problem

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We study the dual resource constrained flexible job shop scheduling problem with the objective of minimizing makespan, where each operation requires simultaneous assignment to an eligible machine and a qualified operator. We propose a hybrid decomposition framework based on logic-based Benders decomposition that integrates constraint programming and tabu search to combine exact and heuristic strengths. Addressing a key gap in the literature, our tabu search uses a new disjunctive graph-based neighborhood. Computational experiments across 262 benchmark instances demonstrate the effectiveness of the proposed methods. Overall, the hybrid approaches reduce the average optimality gap from 37.21% for standalone constraint programming to 5.97% and 6.35%, respectively, while achieving the best upper bounds. As a standalone method, tabu search attains average deviations of 0.74% and 0.19% from constraint programming solutions, requiring average runtimes below 5 and 24 minutes, respectively, and outperforming existing neighborhood search approaches from the literature when operators are scarcer than machines or when longer runtimes are permitted.