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Local and Global Dominance Relations for No-Wait Flowshops with Bounded Setup Times

Muberra Allahverdi
Department of Mathematics
Faculty of Engineering and Natural Sciences,
Ankara Yıldırım Beyazıt University, Ankara, Turkey
mu.allahverdi@gmail.com

Ali Allahverdi
Department of Industrial Engineering
Faculty of Engineering
Gazi University, Ankara, Turkey
aliallahverdi@gazi.edu.tr

Abstract

In modern manufacturing systems, the measurement and control of total completion time play a crucial role in evaluating overall operational efficiency. This performance criterion has gained particular importance with the widespread adoption of lean manufacturing principles, which emphasize waste reduction, faster throughput, and improved responsiveness to customer demand. As global competition continues to intensify, manufacturing firms are under increasing pressure to streamline their production processes, and minimizing total completion time has become a key strategy for maintaining and enhancing competitiveness in the marketplace. In certain production settings, technological or material-related constraints impose strict timing requirements between successive operations. Specifically, some materials or intermediate products cannot tolerate waiting periods between processing stages due to issues such as deterioration, temperature sensitivity, or chemical instability. Manufacturing systems that operate under these constraints are commonly referred to as no-wait flowshop environments, where each job must proceed immediately from one machine to the next without any delay. Such environments arise in a wide range of industrial applications, including but not limited to semiconductor fabrication, printed circuit board manufacturing, chemical processing, plastics production, and various metalworking industries. This study focuses on a two-machine no-wait flowshop scheduling problem in which setup times are not fixed but instead vary within known lower and upper limits. These uncertain yet restricted setup durations are referred to as bounded setup times. The primary objective of the scheduling problem is to minimize the total completion time of all jobs, a goal that is directly aligned with improving production efficiency and throughput in no-wait manufacturing systems. A major challenge in this setting stems from the variability of setup times. Because setup durations can take on different values within their specified bounds, a single job sequence may not remain optimal across all possible realizations of these setup times. Consequently, identifying one universally optimal schedule is generally not feasible. Instead, the problem shifts toward finding and managing a set of schedules that are potentially optimal under different scenarios. To address this challenge, the concept of dominating sets becomes particularly relevant. The aim is to reduce the size of these sets by eliminating schedules that are consistently inferior to others, regardless of how the bounded setup times are realized. In this context, we introduce both local and global dominance relations that enable systematic comparison among job sequences. These dominance relations serve as powerful tools for pruning the solution space, thereby reducing computational complexity while preserving all potentially optimal schedules. Through the application of these

dominance rules, the scheduling problem becomes more tractable, allowing for more efficient decision-making in uncertain no-wait flowshop environments.

Keywords
No-wait Flowshop, total completion time, uncertain setup times.