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Computer simulation of due-date setting in multi-machine job shops

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Abstract

The due-date setting and operations scheduling problem is addressed in an unbalanced, multi-machine random job shop. The focus of the study is to demonstrate the feasibility of setting reliable static due-dates through operation flow time analysis. Response-surface mapping methodology via regression analysis is employed to model operation flow time characteristics, which are shown to be non-linear and dispatching rule dependent. Discussion points out the advantages and practicality of using static job information as opposed to dynamic shop information in setting due-dates. Simulation results and statistical analyses show the viability of setting due-dates that are tight, reliable, and consistent, using this methodology. A unique characteristic of the proposed method is that it shows simultaneous reductions in variability of manufacturing lead times, tardiness, proportion of tardy jobs, and maximum tardiness without resorting to looser due-dates.

Keywords: Due-date setting; Multi-machine shops

1. Introduction

Recent trends in time based competition and inventory reduction requires products to be completed in shorter time and with more reliable delivery dates. At the operational level, this can be made possible via better scheduling and due-date management. A recent article by Wacker and Hanson (1997) shows that continual improvement for competitive advantage requires control of lead-time variances. Theoretical model and statistical analysis highlight the importance of lead time variances in affecting quality, delivery reliability and time, productivity, and product flexibility. Naturally, due-date reliability at the micro level determines the stability of manufacturing lead times, and consequently a firm's strategic

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competencies. This study focuses on due-date reliability by evaluating order tardiness, which measures the customers' immediate satisfaction level with respect to vendor delivery performance.

Due-dates can be set either externally by the most immediate customer, or internally by the scheduling system. When dates are externally set, the scheduling system is charged with appropriate prioritization and synchronization to accommodate timely flow of operations. Internally set due-dates usually reflect current shop congestion levels, manufacturing system capacity, and job content. In either case, tight due-dates and on-time completion are challenges to the scheduler. More recent industry practices, which utilize advances in computing technology, involve negotiation of due dates with the customer using on-line shop floor information and software that enables finite-scheduling with what-if analysis capability. Although a very powerful tool, such technology-driven scheduling and due-date setting is not wide-spread due to two reasons: (1) the cost of purchasing the software; and (2) the cost of implementation, which can prove to be even costlier than the software itself. This study focuses on the more traditional due-date setting and scheduling approaches with the intent of improving customer service levels, while keeping the nature and magnitude of required information to what is typically available as a matter of course in job shops.

Earlier research has developed various heuristics for job shop scheduling, and static due-date setting rules for steady state systems. More recent research has focused on the dynamically changing shop conditions and proposed several methodologies for adjusting flow allowances based on current shop conditions. Static rules ignore current capabilities of the manufacturing system and therefore may set unrealistic due-dates for individual orders. Dynamic rules on the other hand are known to be more accurate but much more information intensive. In addition, dynamic rules can assign inconsistent due-dates to repeat orders, causing discrepancies in customer delivery date quotes. Also, inconsistent flow allowances cause variable lead times in MRP systems, resulting in overall system nervousness.

The main premise of this paper is that static due-dates can be set tightly, and reliably, by analyzing flow time characteristics of jobs, and workstations. By recognizing that different priority rules, shop configuration, work center utilization, and job characteristics result in different flow patterns, this study attempts to improve due-date performance via better prediction of manufacturing lead times without loosening due-dates. Motivated by findings in previous scheduling research, this paper proposes a methodology to establish tight and reliable estimates for job flow times. The proposed method is *static* in nature and attempts to show that improvements in due-date performance need not require as intensive information as dynamic procedures. Although this study does not make direct performance comparisons between static and dynamic due-date setting rules, it shows improvements that compare favorably with those reported for dynamic rules.

The methodology proposed in this study involves collection and analysis of flow time data. Data collected under traditional due-date setting scenarios are analyzed to build regression equations using static shop and job information such as processing times, average workstation utilization, and number of operations, to predict operation flow times. These predictions are subsequently used, in conjunction with float parameters, to establish operation flow allowances, and ultimately job due-dates. This approach accomplishes two major goals: (1) to strictly control due-date tightness between comparative scenarios as a requirement of sound experimental methodology; and (2) to show that at the same overall due-date tightness level, the shop can achieve significantly improved due-date performance. In this context, we use due-date tightness, (or shop tightness), as a surrogate measure for the average length of promised delivery lead-times.

The remainder of this paper is organized as follows: a survey of relevant research is presented to cover