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# Scheduling in dynamic assembly job-shops to minimize the sum of weighted earliness, weighted tardiness and weighted flowtime of jobs

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## Abstract

In many manufacturing systems, jobs that are completed early are held as finished-goods inventory until their due-dates, and hence we incur earliness costs. Similarly, jobs that are completed after their due-dates incur penalty. The objective in such situations would, therefore, be to meet the due-dates of the respective jobs as closely as possible, and consequently minimize the sum of earliness and tardiness of jobs because earliness and tardiness of jobs greatly influence the performance of a schedule with respect to cost. In addition, a job incurs holding cost from the time of its arrival until its completion. Most studies on scheduling in such manufacturing systems assume unit earliness cost, unit tardiness cost and unit holding cost of a job. However, in reality such an assumption need not always hold and it is quite possible that there exist different costs of earliness, tardiness and holding for different jobs. In addition, most studies on job-shop scheduling assume that jobs are independent and that no assembly operations exist. The current study addresses the problem of scheduling in dynamic assembly job-shops (i.e. shops that manufacture multi-level jobs) with the consideration of jobs having different earliness, tardiness and holding costs. An attempt is made in this paper to present dispatching rules by incorporating the relative costs of earliness, tardiness and holding of jobs in the form of scalar weights. In the first phase of the study, relative costs (or weights for) earliness and tardiness of jobs are considered, and the dispatching rules are presented in order to minimize the sum of weighted earliness and weighted tardiness of jobs. In the second phase of the study, the objective considered is the minimization of the sum of weighted earliness, weighted tardiness and weighted flowtime of jobs, and the dispatching rules are presented by incorporating the relative costs of earliness, tardiness and flowtime of jobs. Simulation studies have been conducted separately for both phases of the current study, the performance of the scheduling rules have been observed independently, and the results of the simulation study have been reported.

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The proposed rules are found to be effective in minimizing the mean and maximum values of the measures of performance.


*Keywords:* Dynamic assembly job-shop; Weighted earliness; Weighted tardiness; Weighted flowtime; Dispatching rules; Simulation

## 1. Introduction

Most research on scheduling in dynamic manufacturing systems has dealt with the problem of scheduling in dynamic job-shops. A survey of dispatching rules in dynamic shops was presented by Day and Hottenstein (1970); Blackstone, Phillips, and Hogg (1982); Haupt (1989), and Ramasesh (1990). Of late, efficient dispatching rules in dynamic job-shops and flow-shops have been proposed by Holthaus and Ziegler (1997), Holthaus and Rajendran (1997, 2000, 2002), Jayamohan and Rajendran (2000), and Framinan, Ruiz-Usano, and Leisten (2000). Researchers have attempted to evaluate the performance of dispatching rules in an assembly job-shop environment where assembly operations take place. In an assembly job-shop, the operations of an item are carried out serially by following the precedence relationships, while those of another item belonging to the same assembly may be carried out in parallel (unlike non-assembled or serial jobs where all the operations are performed in series). In this context, an item here may refer to a component, a sub-assembly, or a sub-sub-assembly. As a result, in addition to waiting for a resource, an item may wait for the processing of its mating items, before the required assembly can take place. Moreover, the jobs can have a very simple structure involving just one level of assembly, or can be complicated with several levels of assemblies. Irrespective of the nature of the job structure, processing of components, sub-assemblies and sub-sub-assemblies must be completed in such a way to make the schedule and assembly feasible. This makes the scheduling problem in assembly job-shops quite challenging, when compared to the conventional job-shop (Adam, Bertrand, & Surkis, 1987).

Unlike the job-shop, the amount of research work done in the assembly job-shop environment is rather limited. The measures of performance, used by most of the researchers in the area of dynamic assembly job-shops, to evaluate the performance of the dispatching rules include job flowtime, tardiness, percentage of tardy jobs and assembly delay. Initially, simple job structures were considered, and the performance of simple and composite rules (with the consideration of information about the shop status, job progress in the form of remaining job-time, and slack) was evaluated with respect to the measures of mean flowtime and mean tardiness (e.g. Maxwell & Mehra, 1968; Sculli, 1980, 1987). The good performance of the job due-date rule (Goodwin & Goodwin, 1982) and the non-performance of the other milestones, namely, the operation and assembly due-dates (Phillipoom, Markland, & Fry, 1989) for complex job structures were reported with respect to the minimization of mean flowtime, mean tardiness and percentage of tardy jobs. New dispatching rules, namely, relative remaining operations (RRO), relative remaining processing time (RRP) and importance ratio (IR), were developed with due consideration given to pacing, acceleration and structural complexity (Adam et al., 1987; Phillipoom, Russell, & Fry, 1991) which resulted in minimizing the staging delay. A tie-breaking rule is used when two or more jobs wait in the queue and have the same priority value. The importance of tie-breaking was observed by Adam et al. (1987) when they used the TWKR (total work content remaining or total processing times of remaining operations on the job) rule with their proposed tie-breaking rules, namely,