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Effect of dynamic and static dispatching strategies on dynamically planned and unplanned FMS

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Abstract

Dispatching strategies are crucial in scheduling of flexible manufacturing systems (FMSs), in which each operation of a job may be performed by any of the several machines. This paper presents a study of the effect of dynamic and static dispatching strategies on dynamically planned and unplanned FMS. The proposed simulation model comprised eight machines, storage buffer areas, receiving area, and three robots and pallets. Parts enter and leave the FMS at load/unload stations and transferred between machine centers by available trucks. Based on a number of specific assumptions, 12 different dispatching strategies were considered. A simulation run was made for each strategy, where the design parameters were systematically changed. The analysis of the obtained results showed that an overall improvement could be achieved for dynamic dispatching than that rendered by static dispatching.

Keywords: Dispatching rules; Flexible manufacturing systems; FMS scheduling

1. Introduction

Scheduling plays a crucial role in the efficiency of any production system. The emergence of flexible manufacturing system (FMS) has sparked an increased interest and appreciation of real-time planning, scheduling and control. Dispatching strategies (rules) is a key element to an optimized performance of manufacturing systems [1,2]. Basically, there are two approaches to solve the problem of switching to proper dispatching rules in manufacturing systems: the look-ahead simulation approach and the rule-based (heuristic) approach. For the look-ahead simulation approach, a dispatching rule is determined for each short period just before the implementation time occurs. For the rule-based approach the scheduling of changing dispatching rules is first acquired, and then this knowledge is incorporated into a rule-based system to guide the manufacturing system to make intelligent decisions in real-time. In the past two decades, many researchers have tried to evaluate the performance of dispatching rules in dynamic flexible manufacturing systems.

Chandra and Talavage [3] developed a decision rule for real-time dispatching of parts, each of which may have alternative processing possibilities. For effective use of the systems routing flexibility, an intelligent part-selection strategy that takes into account the current trends of the system was designed and implemented. Ishii and Muraki [4] introduced an extended dispatching rule approach, which applies different dispatching rule combinations in the mechanisms, and a search algorithm, to find an appropriate dispatching rule combination. A 'shift from standard rules' (SFSR) is a simple heuristic dispatching strategy developed by Pierreval and Mebarki [5]. This strategy tackled the dynamic selection of certain pre-determined dispatching rules for a scheduling strategy. Jayamohan and Rajendran [6] presented a comparative study of a set of dispatching rules for the minimization of various performance measures such as mean, maximum and variance of flow time and tardiness in dynamic shops as well as a static rule, which minimizes the number of tardy jobs. An intelligent control scheme presented by Seifert and Morito [7] for releasing parts into a flexible manufacturing system that is based on incremental optimization. The cooperative dispatching concept is implemented in an object-oriented computer simulation model, and experiments with a varying degree of average routing flexibility are performed. Shouman et al. [8] developed a model to study the interactive process between some

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dispatching mechanisms and interrupted machine centers in FMSs, where dispatching mechanisms that have the best performance were identified.

The effect of machines layout was also considered in some other research work. Potts and Whitehead [9] introduced a combined scheduling approach with machine layout problems in flexible manufacturing system. In this model, machines are capable to perform several different types of operations. Each operation type is assigned to only one of the machines, which are positioned around a unidirectional conveyor belt loop. Minimization of the movement of work between machines has been achieved by three-phase integer programming model. The effect of multi-cell and random FMS layouts on dispatching mechanisms were studied by Abou-Ali and Shouman [10]. Twelve different dispatching polices were considered and an FMS model was proposed. This model comprised computer-controlled machine tools, storage buffer areas, receiving area, a load and an unload stations as well as robots and pallets. AGVs were used to transfer parts between machine centers.

A learning-based methodology for dynamic scheduling that explores flexibility and handles uncertainties in distributed manufacturing system is developed by Chiu and Yih [11]. With the goal of minimizing aggregate times required for major sequence-dependent machine setups at a work center, Mahmoodi and Martin [12] developed an efficiency-oriented subfamily queue selection heuristic for the cellular manufacturing environment. This heuristic includes a feature for dynamically assessing variations in a subfamily's arrival rate, enhancing its suitability for realistic transient-state conditions. Rossi and Dini [13] introduced a genetic algorithm model, that capable of generating optimized production plans in flexible manufacturing systems. The developed system was able to generate alternative plans following part-flow changes and unforeseen situations (dynamic scheduling). The key-point was the real-time response obtained by an optimized evolutionary strategy capable of minimizing the number of genetic operations needed to reach the optimal schedule in complex manufacturing systems.

Dispatching rules which deal with dynamic flow shops was tackled by Holthaus and Rajendran [14]. In their study, they dealt with the problem of scheduling in dynamic flow shops with buffer constraints. With respect to different time-based objectives, the best dispatching rules for scheduling in unconstrained shops have been identified from the existing literature. In addition, two new dispatching rules specially designed for flow shops with buffer constraints were proposed. All dispatching rules under consideration were evaluated in dynamic flow shops with buffer constraints.

In this work, 12 dispatching rules are studied for FMSs under the condition that part types and their quantities are dynamically changed over some specified stages or periods of the whole scheduled horizon. Two different phases are considered: in the first phase, the part types with their relative demands are dynamically changed at deterministic dates over the whole scheduled period, while in the second phase the part types are dynamically changed at undeterministic dates.

2. Model assumptions and description

2.1. Model assumptions

For the planned and unplanned cases, the overall scheduled period is basically classified into stages according to the dynamic changes. The throughput of a certain specified part type may be distributed on different stages or single one under the constraint that the first appearance will be in the corresponding stage of their production orders or succeeding stages. In order to make a general comparison between the planned and unplanned conditions it is assumed that the inter break points are identical for both cases under consideration.

For the look-ahead simulation approach, which is followed in this work, a dispatching rule is determined for each short period. The combination of different dispatching rules in a dynamic and multi-pass manner will create better result than applying a single rule in a static manner. The best dispatching rule selected from the set of candidate rules is identified by simulation, that is controlled by objective function, part mix, and performance measures.

Moreover, the model is configured based on the following assumptions:

1. Each part type requires one or more operation(s).
2. There are one or more machine(s) which can process each operation and each machine can process one operation at a time.
3. The part moving time has no effect on lead-time and parts size transporters.
4. System congestion is to be prevented by limiting the total service time of each machine station to the capacity of that station.
5. Tool change-over times are included in processing time and tool magazine capacities are not binding constraints due to the availability of an automatic tool handling system.
6. Data on all alternative routes and processing times can be provided.
7. Arrival rates, due dates, transporter speed, resources, setup and tear down times are deterministic.
8. Each operation can be processed by one machine only at a time.

2.2. Model description

The model consists of eight machines (M/C1, M/C2, M/C3, M/C4, M/C5, M/C6, M/C7, and M/C8) each of which has a storage buffer (BF1–BF8). The model has a receiving area, two load/unload stations (LOAD and