ELSEVIER

Journal of Materials Processing Technology 107 (2000) 466–477

Journal of Materials Processing Technology

www.elsevier.com/locate/jmatprotec

The interactive process between some dispatching mechanisms and interrupted machine centers in FMSs

M.A. Shouman*, G.M. Nawara, A.H. Reyad, A.M. El-sadek

Industrial and Systems Engineering Department, Faculty of Engineering, Zagazig University, Sharkie, Egypt

Abstract

Scheduling in flexible manufacturing systems (FMSs) differs from that conventional job shop because each operation of a job may be performed by any one of several machines. In the current paper, the interactive process between routing flexibility index (single route index up to 192 route index are classified into nine route flexibility indices), different interruption ratios (zero up to 100% are classified into six interruption indices), as well as 16 dispatching polices are studied. The dispatching mechanism that will perform the best with the considered measuring performance criteria for each route flexibility index and model configuration has been determined. Global conclusions and trend of variations have been highlighted. © 2000 Published by Elsevier Science B.V.

Keywords: Flexible manufacturing systems; FMS scheduling; Interruptions in FMS; Flexibility of FMS

1. Introduction and literature review

Product deliverability is becoming more important in today's competitive markets. While it used to suffice to manufacture products of high quality and low price, today's manufacturing practices necessitate on-time product deliveries for customer satisfaction. Thus scheduling plays a crucial role not only in the efficiency of operating the system but also in customer satisfaction. The emergency of flexible manufacturing system (FMS) has sparked an increased interest and appreciation of real-time planning, scheduling and control. FMS is defined as a manufacturing system consisting of automatically reprogrammable machines, automated tool deliveries and changes, automated material handling and transport, and coordinated shop floor control. Pertinent areas of interest include job releases, loading sequences, deadlocks, and response to resource disruptions such as machine break downs (interruptions) or tool failure. Drake et al. [1] introduced a flexible simulation technique that facilitates automated experimentation of different scheduling rules. An enhanced version of Arena/SIMAN is used to develop an extremely high fidelity model of the manufacturing system. A procedure for design and scheduling of cellular manufacturing systems for implementation in small-to-large size manufacturing systems has been developed by Logen [2]. This procedure has focused on group scheduling, machine break downs and batch size, increasing flexibility by increasing process plans of part types. The combined interactive process between material handling systems and dispatching mechanisms in FMS has been studied by Shouman and Husien [3]. It has been noticed that the considered interactive process has a great influence on the performance of the system. The rules that perform the best have been determined. The interaction between planning and scheduling stages in a hierarchical production planning system is developed by Hatchuel et al. [4]. The results show that significant lead time performances improvements result from a specific combination between MRP, PERT, and some dynamic priority rules. 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 has been advised by Ishii and Muraki [5]. The study showed better effectiveness as an on-line scheduling frame work for batch process management. A classification scheme for scheduling problems in FMSs based on an analysis discussion of scheduling decisions in an FMS has been presented by Liu and MacCarthy [6]. The scheme identifies and describes all the major factors that affect the modeling of, and the solution to, FMS scheduling problems. A new shop-based and predictive scheduling heuristic for cellular manufacturing has been developed by Mahmoodi and Martin [7]. This heuristic includes a feature for dynamically assessing variations in a subfamily's arrival rate, enhancing suitability for realistic transient-state conditions as well as minimizing aggregate times required for major sequence-dependent machine set-ups at a work center. An effective tabu search (TS) approach

* Corresponding author.
E-mail address: mtr_hti@hotmail.com (M.A. Shouman).

PII: S0924-0136(00)00673-7

to the job shop scheduling is applied on 56 test problems by Barnes and Chambers [8]. The procedure starts from the best solution rendered a set of 14 heuristic dispatching solutions. It makes use of the classical disjunctive network representation of the problem and iteratively moves to another feasible solution reversing the order of two adjacent critical path operations performed by the same machine. A vast majority of production scheduling process involves the determination of schedule over a certain time frame assuming all problem characteristics are known. Such schedules are often produced in advance in order to direct production operations and support other planning activities such as tooling, raw material delivery, and resource allocation. The TS approach gives superior solution in some problems and achieves the optimum in the others. A decision rule for real-time dispatching of parts, each of which may have alternative processing possibilities, has been developed by Chandra and Talavage [9]. For the effective use of the system's routing flexibility, an intelligent part-selection strategy that takes into account the current state and trends of the system has been designed. This procedure has been found to achieve better shop performance than some of popular dispatching rules. A two level distributed production control system (DPCS) is developed for on-line scheduling in a multi-cell FMS in case of operating in a produce-to-order environment by Arzi [10]. The DPCS allows autonomous and simultaneous operation of each cell-controller, utilizing only local and short-term information as well as heuristic rules. Simulation experiments show that DPCS achieves good results in throughput, tardiness of orders and WIP inventory level and it is robust to machine and handling device failures. Unfortunately, in a dynamic environment such as the job shop, as soon as the schedule is released to the shop, it is immediately subject to random disruptions which may render the initial schedule obsolete. These disruptions or "rescheduling factors" include machine break downs, delays in the arrival of materials, arrival of rush orders, and cancellation of orders. Deadlocks and response to resource disruptions are vital parameters in FMS performance. As a matter of fact, most rescheduling factors can be modeled as machine break downs [11] and since they involve a disruption in the processing of operations on a machine or machines of a period of time. The main objective of the current work is to study the interactive process between some dispatching mechanisms at different interruption ratios and route indices on disrupted machine centers in FMS.

2. Simulator, model features and study objective

Many simulation softwares are classified at three different levels (system, application, and structural) [12]. Also, many aspects that are considered as essential and desirable features in the selection of simulation software product. Those that are pertinent to manufacturing environment are: input flexibility, modeling conciseness, macro-capability, material handling modules, standard statistics generation, data analysis, animation, interactive model debugging, and micro/mainframe compatibility. According to the above-considered groups of criteria, SIMFACTORY II.5 has an advanced position based on a simulation software survey provided by Hlupic and Paul [13]. In this software no programming is needed, model construction and data input are simplified through the menu-driven interface, there are no arbitrary limits to the number and type of items that the model can include, you can get an animated picture of your factory at the work during the simulation not after the action is over. Moreover, most of the above-cited aspects are provided by SIMFACTORY II.5. Interruption to normal processing activities in FMS can be either planned interruptions which are passive in nature (preventive maintenance) or unplanned interruption, which have priority over any current operation (typically involves the failure of workstation or transporters). Interruption is considered as one of the main affecting parameters on FMS operation concerning system throughput and makespan. No dispatching rule has been shown to consistently produce better results than all other rules under a variety of FMS configuration and operating condition . . . it is impossible to identify any single rule as the best in all circumstances [14]. FMSs are believed to be an important means to improve manufacturing flexibility so as to respond quickly and economically to all customer needs. The assignment of different routes to complete a set of jobs subject to process constraints has a great influence on the system flexibility and its performance. The actual time allocation of the considered machines to the job is referred to as scheduling or dispatching. Sixteen dispatching rules are considered for the evaluation of the present study under different interruption ratios and route indices. These rules are: (1) random, (2) by turn, (3) low usage, (4) high usage, (5) closest, (6) farthest, (7) shortest idle, (8) longest idle, (9) fewest parts, (10) most parts, (11) oldest part, (12) newest part, (13) low station priority, (14) high station priority, (15) low part priority, and (16) high part priority.

3. Problem treatment

The arrangement of workstations inside FMS layout has normally been carried out in the planning phase. The workstations can be increased or rearranged for a well flexible FMS in the case of either changing the design of part type or increasing number of available routes, obsolete facilities, market environments, and poor worker environment. In the current work, nine configurations as route indices for a single part type (gear set) are considered for the tackled problem. These route indices are: single route, double routes, 4 routes, 8 routes, 16 routes, 32 routes, 64 routes, 128 routes, and 192 routes. Six unplanned interruption indices for workstations are considered for each route index. These interruption indices are: zero unplanned interruption, 20% unplanned interruption, 40% unplanned interruption,