ELSEVIER

Mechatronics 14 (2004) 199–225

MECHATRONICS

Suitable switching policies for FMS scheduling

J. Somló *

Department of Manufacturing Engineering, Budapest University of Technology and Economics, Egry József Str. 1, H-1111 Budapest, Hungary

Received 5 December 2001; accepted 18 January 2003

Abstract

Switching server, otherwise known as *hybrid dynamical* approaches can be used highly effectively to solve *flexible manufacturing systems scheduling* problems. Papers published in this field have accepted that the demand rates determining the production tasks have some given values. In the present paper it is shown that the *demand rates should be selected from some given domains*. The "control variables" to realize suitable processes are the switching policies, and the demand rates. These uniquely determine the processes through the switching time sequences. In the present paper, two variants: the *single machine processing*, *and the multiple machine processing cases are analyzed*. It is very problematic to use continuously coupled parts flows for stable and effective production. To eliminate this difficulty, in the present paper, the method called *controlled buffer technique* is proposed, which uses the opportunity that the computer controlled "virtual buffers" can be filled up before the regular working time, and used for part flow compensation.

Keywords: Switching server; Hybrid dynamical approach; Flexible manufacturing system (FMS); Scheduling; Demand rates; Single and multiple machine processing; Virtual buffer; Controlled buffer technique

1. Introduction

Manufacturing automation is highly connected with the use of CNC machine tools, robots and other mechatronic devices. These and the information processing subsystems are integrated into flexible systems of different type. Flexible

* Tel.: +36-1-463-2514; fax: +36-1-463-3176.
E-mail address: somloj@eik.bme.hu (J. Somló).

0957-4158/$ - see front matter © 2003 Published by Elsevier Ltd.
doi:10.1016/S0957-4158(03)00030-8

manufacturing systems are ones of the most importants from those. One of the most important tasks of the production planning subsystem on this level is the scheduling.

Recently, methods have been proposed for solving flexible manufacturing system (FMS) scheduling problems, using hybrid dynamical approach. These give an opportunity to significantly increase the effectiveness of work organization of these high value systems.

Scheduling problems in manufacturing industry have been frequently solved by heuristic methods. A developed form is, when these are based on priority rules. If a priority rule is given, it fully determines the schedules. Of course, the scheduling algorithms may also contain the combination of different rules, taking into consideration not only the priority indices values, but other factors, too. The schedules are usually given by GANTT diagrams, or by the corresponding tables.

Recently, the new approach has changed the character of the task definition. Instead of the requirement to produce pieces of a given part type in a given number (these are the batches) during a given time period, *demand rates* are given. The demand rate is the requirement to produce a given number of parts continuously during unit time. Because of the special formulation of the tasks (see: later) this number may have a not integer value, too. Then, the part flows are considered continuous, and fluid analogs can be used.

By the demand rates requirements, the production tasks are reformulated. We use, in this paper, the word task to indicate the need to produce a batch of parts. The reformulation of the tasks means that instead of only the final goal requirement, the part production demands are continuously present as the inputs at the servers in parallel during the overall production time. By *servers* we understand a group of equivalent machines (it can be one machine, too). Of course, the production based on the demand rates should fulfill the overall production goals, too.

Earlier, the production could only be realized in batch processing manner. Indeed, the set up, transport, manipulation, etc., processes were not automatised, took a lot of time. The change of conditions was a costly procedure. To divide the batches to parts could not be justified (sometimes it could).

Recently, the set up, transport, manipulation, etc., processes are highly automatised, allowing to use new principles. The hybrid dynamical approach, in fact, realizes overlapping production of parts. The production of parts at the servers changes from parts to parts. The processes are fully determined by the switching rules.

The *hybrid dynamical*, or switched server approach has a dynamical character. So, it makes necessary to formulate stability and process quality requirements. Stability problem determination was formulated by Perkins and Kumar [2]. Qualitative theory of hybrid dynamical systems was developed by Matveev and Savkin [4]. Many other works discuss the different aspects of the switched control of the processes.

Nevertheless:

- The literature of the given field did not deal with the determination of the demand rates. It was accepted that these were given. In the present paper, it is shown that the demand rate should not be given as a value determined in an unknown way, but it should be determined as a *value from some given permissible domains*.