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An integrated production planning and scheduling system for hybrid flowshop organizations

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Abstract

In this paper, a production system organized in serial shops (hybrid flowshop) is presented. A brief enumeration of the essential constraints that characterize this kind of organizations is given. Then, the objectives of a decision support system (DSS) are stated. The different elements composing this DSS are described. The DSS is composed of two main ingredients: (1) decomposition into planning and scheduling, and (2) closed loop or feedback mechanism. The approach adopted in this paper is mainly defined with respect to the decomposition ingredient. Special attention is also paid to the interaction between loading and scheduling. The feedback mechanism is done by simulation. In fact, a simulation model is developed for the whole production system taking into account all its specific characteristics. An illustrative example explains in detail the feature of the proposed DSS. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Decision support systems; Simulation; Production planning; Scheduling

1. Introduction

In relation to the requirements of real-life production planning and scheduling problems, the main objective is to find a good schedule which generates a lower inventory level, a high plant efficiency and in which most due dates are respected. The inventory level concerns in process stock and finished goods inventory. The efficiency of the plant means high machine and labor utilization. To meet these objectives an effective scheduling system is to be developed using appropriate combination of rigorous methods of manufacturing system states analysis, rules of thumb, artificial intelligence and simulation techniques.

To be effective, a scheduling system must be an integral part of a control methodology, which influences decision making at all levels. At the operational level decisions on scheduling flow of work are made on the basis of the different measures of shop floor's performance. These performance measures play another role at the strategic level. They provide management with objectives for guiding long and medium term actions [1]. Control requires monitoring of performance but it also needs targets based on the real capabilities of the manufacturing system and with regard to which the performance measures are evaluated. In fact, the characteristics or the capabilities of a manufacturing system can be affected by many changes in system design or demands pattern, and by specific realizations of random factors (machine

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breakdowns). One must have at his disposal a decision support system (DSS) which enables the necessary rapid process analysis to devise corrective actions or to revise the suggested set of hierarchical control solutions whenever a deviation from targets occurs.

The problems arising in production scheduling are as diverse as the techniques and tools proposed for solving them. These problems are difficult in the technical sense. The optimal allocation of resources to activities over time is known to be combinatorially complex [2]. Exact methods are prohibitive to use because of their unrealistic computing requirements. This is particularly true for enumerative methods, which are often applicable where analytic procedure cannot be found. Actual production scheduling problems involve a large number of tasks and resources subject to a diverse set of resource utilization constraints and objectives [3]. It is then not surprising that mathematical programming solutions or even formulations are rather cumbersome.

The manufacturing environment uncertainty contributes to the difficulty of the production scheduling problems. Some of them can be coped with in practice through simple approximate methods or rules. To tackle these complex problems efficiently, one seeks to break down the combinatorial complexity inherent to the nature of production scheduling in developing some approached methods based on some empirical rules or some intuitive trials.

2. Hybrid flowshop

'*Hybrid flowshop*' is a skillful combination of the 'serial' shop organization and the 'parallel' shop organization, see Fig. 1. In the former, the product flows sequentially from one stage or workshop to the next, while the 'parallel' shop organization consists of several facilities that are present at each stage to perform the associate manufacturing phase (to be qualified as hybrid flow shop, at least one stage in such organization must have several facilities).

Following more or less standard notation in the scheduling literature, the problem of concern to us may be specified as $n/W, g_w, m_g, F//$ criteria under consideration, where n is the cardinality of the set of products (jobs) $I = \{i \mid i = 1, 2, \ldots, n\}$ to be scheduled without preemption on W workshops. Each workshop consists of g_w centers of m_g identical machines. A job is composed of W 'operations' or 'tasks', one for each workshop. The machines are different from one center to another within the same workshop. The flow of products is unidirectional from workshop 1 to workshop W, which explains the 'F' in the above designation. The

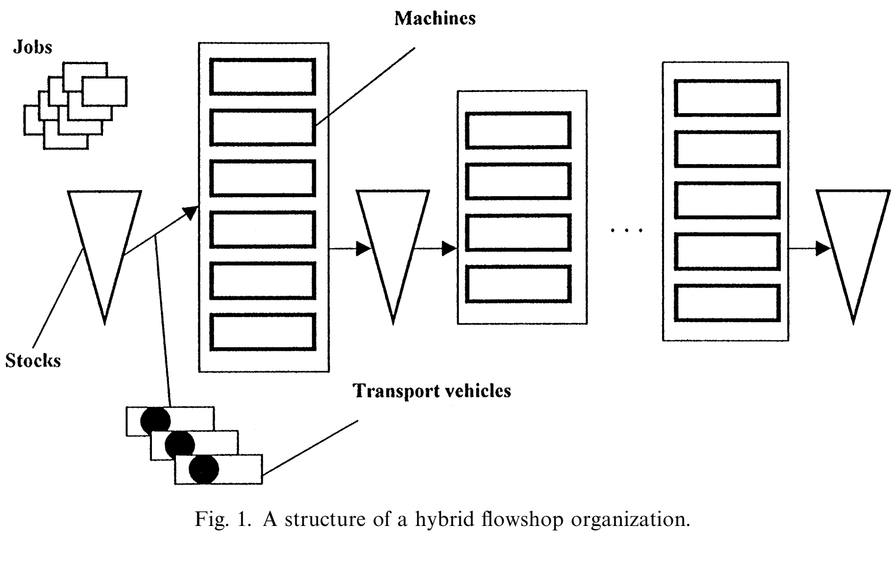

Fig. 1. A structure of a hybrid flowshop organization.

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