

CHAPTER 26

Scheduling Manufacturing Systems

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26.1 PROBLEM IDENTIFICATION

Scheduling is concerned with determining when, and using which, resources, jobs or orders in a factory when they are competing for the same resources (machines, tools, materials, personnel, etc.). This determination is essential for the operative part of any production planning system.

The importance of scheduling is a consequence of the demand trend to increase product variety which results in decreasing lot size, an adverse side-effect. Behind this trend lies the intention to shoulder the requirements of the market with more flexibility of the production. The main idea behind the JIT philosophy (Just-In-Time). Besides flexibility, cost reduction is also an objective of JIT. JIT aims at the reduction of stock which, traditionally, served not only to provide enough products to satisfy the market demand but also served as a buffer between different production stages (or workcells). With or without drastically reduced buffers, graceful interaction between different production processes becomes a must. This interaction again creates the role of scheduling.

However, scheduling is not a stand-alone process, and a process which is finished once executed. Instead, it is an ongoing process, highly dependent on current data in order to react to unforeseen events that might disturb the current schedule. Figure 26.1 shows scheduling as a part of a closed feedback loop together with production control and production processes. As scheduling takes place in a complex and rapidly changing environment, it is a demanding task. Better method dynamic scheduling. In effect, the efficiency and accuracy of schedules have an important impact on the success of an enterprise. Though not being the only factor, scheduling is one of the key factors used to gain flexibility and to reduce costs.

In literature as well as in the factory, the terms *planning*, *scheduling* and *dynamic scheduling* are often used as synonyms, though each has a different meaning. Therefore, classification of the terminology is necessary. Besides the definition of basic terms, the characterization of scheduling, based upon the three dimensions, *time horizon*, *production scope* and *optimal method*, has proved to be very useful and will be discussed. The final concept of section 26.2 is the representation of decision-making; therefore, GSAI nets are introduced.

Scheduling problems is a highly complex task; for example, for an subsequence of orders, $n = 8$ to be scheduled for $m = 3$ sequential machines, the number of possible schedules is, according to $y = y(n, m) = 8! = 65,000,000,000,000$. If a computer needs only 9.3 msec to compute a schedule and to evaluate it, about 205 years would be required to review all schedules. In complexity theory, the scheduling problem is known to be NP-complete; it is not likely that there exists an algorithm which can solve the problem with a time requirement not higher than a polynomial on the number of variables. Thus, it is not possible to find the optimal schedule for realistic problems by mere calculation. Instead, the task of a scheduler is to compute a good schedule; that is, a schedule which at least satisfies the most important objectives at hand. A number of methods to reduce the set of possible solutions with respect to certain objectives is commonly used. Sections 26.4 and 26.6 present some OR (Operation Research) and AI (Artificial Intelligence) methods for solving the scheduling problem. Examples of current implementation are given in section 26.5. They illustrate the use of both OR and AI techniques. Finally, section 26.6 discusses some pros and cons of the AI and the OR approach to scheduling.

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