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A prototype of a feature-based multiple-alternative process planning system with scheduling verification

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Abstract

The primary objective of this research was to develop a prototype feature-based multiple-alternative process planning system in which the process plan would be generated directly from design and available factory facility information. An overall removable volume is generated by graphically comparing the 3D part and 3D workpiece blank. The manufacturing features are decomposed into a series of general manufacturing features by using a mixed graph-based and rule-based algorithm. The multiple-alternative process plan generation is based on recognized manufacturing features and various production rules. After generating multiple process plans, each process plan is allocated the possible manufacturing scheduling time and the candidate process plans are retrieved based on the required due day. An example problem is presented to illustrate the functionality of the prototype system. This research presents an alternative method that provides useful information to the factory planner and controller to facilitate production.

Keywords: Process planning; Scheduling verification; Manufacturing information integration

1. Introduction

Undoubtedly, the process planning and scheduling are the most important tasks in flexible manufacturing systems. These tasks strongly influence the profitability of manufacturing a product, resource utilization, and product delivery time. Because the stream of traditional production activities, from design to manufacturing, is sequential and interdependent, the downstream activities cannot be done before the upstream activities are finished. For example, it is impractical to select a manufacturing process without the engineering design that describes the part. Without process planning, it is difficult to schedule manufacturing activities. Meanwhile, manufacturing processes and schedules are normally

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determined by the available facilities (Geiger & Dilts, 1996). From a "decision making" point of view, the design phase, process planning phase, and scheduling phase are the sequential actions of reducing the solution space for production. The number of available alternatives is reduced at each step and the result can be based on all the boundary limitations. Unfortunately, this traditional logical stream is usually broken in real-world situations, e.g. a product design without concern for the facilities' capacity will increase the manufacturing difficulty and manufacturing cost, and a process plan usually needs to be modified because of the due date or unavailable machine tools (Yang, Parsaei, Leep & Wong, 1998).

The shortcomings of the sequential manufacturing design, process planning, and scheduling phases are due mainly to a lack of downstream knowledge and information, or develop because the procedure involves a large amount of data. Also, the dynamic environment does not make it cost effective to incorporate all the data from the past. Because a computer is integrated into the enterprise, the sequential phase problem becomes solvable. With large storage capabilities, direct data transformation, and accurate machine controllability, the computer becomes the core of the entire system. The designer can modify the design via a CAD tool, the process planner can use a schedule module to adjust the process plan, the operator can control the machine tools by numerical control, and the sales representative is able to respond to the customer's demands of price and delivery time in a short time (Parsaei & Sullivan, 1993). The integration of manufacturing activities and information management systems is the objective of the computer-integrated manufacturing philosophy. The integration functions are of utmost concern now and more attention is needed in this area because they are not automatically achieved. Each of the functions in the manufacturing system has developed immensely but with an absolute lack of integration (Burkett & Yang, 1995).

Process planning is the systematic determination of methods by which a product is to be manufactured. Scheduling is defined as the allocation of resources over time to perform a collection of tasks. In current manufacturing practice, scheduling usually is performed after process planning. The scheduling function is bounded by the sequencing restrictions dictated in the process plan. Performing process planning and scheduling separately results in a situation in which neither the process plan nor the planned schedule are truly followed on the shop floor. Owing to the changing conditions, the resource availability changes. This change affects the previous assignments, rendering most plans unfeasible. Most of the shop floor supervisors make temporary changes in the schedule, trying to optimize the present conditions on the shop floor. But from a global perspective, the whole performance of the shop floor does not see the optimization in the same way. Investigations have shown that in some companies, 20–30% of the total load of a period has to be redirected to other machines to reach the desired output of the period and only a small part of the job shop orders actually comply with the production plan (Liao, Coates, Aghazadeh, Mann & Guha, 1993). The main problem with the process planning function is that it assumes an unlimited availability of resources on the shop floor and the desired machines are always ready as selected in the process plan.

In order to overcome the turnover in scheduling, intuitively, two methods can be used. One method is to ensure that the scheduling function works well in the real world, such as Kurbel and Ruppel (1996). Kurbel and Ruppel's idea of real-world scheduling is to reschedule all the jobs online in a short time span by using simulated annealing and only local changes will be made in order to keep the schedules valid. Besides, Blazewicz, Dror and Weglarz (1991) studied several mathematical programming formulations for the scheduling task and Randhawa and Zeng (1996) presented the performance comparison for several scheduling rules. However, this method can only help the symptom but fails to correct the global imbalance if some preferred machines exist.