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A system based on machined volumes to reduce the number of route sheets in process planning

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Abstract

The paper focuses on the problem of choosing the manufacturing route in metal removal processes, which is very important for the Computer Aided Process Planning (CAPP) systems.

A method consisting in establishing groups of precedence between machine operations has been proposed, in order to reduce the number of possible routes. This reduction is based on the elimination of the routes which are not technologically possible, despite being mathematically computable.

A wide range of parts has been evaluated, using group technology for choosing the representative cases. For the different parts, the mathematically possible routes have been generated. Graph Theory has been used to determine the precedence between operations.

The application of this method permits to reduce considerably the number of possibilities that must be computed, and therefore, the route sheet is obtained more quickly and the computational resources are used more efficiently.

Keywords: Process planning; Computer Aided Process Planning; Features in process planning; Sequencing in process planning; Computer integrated manufacturing; Production scheduling

1. Introduction: process planning

The planning process is the act of preparing detailed operating instructions for turning an engineering design into an end-product, i.e. the part [1]. This implies the need to translate the design specifications of a part into the required manufacturing operating instructions, to convert it from the raw material to the part in its final state [2].

There is a great deal of manufacturing data in process planning, such as the identification of machines, tools, flanging, parameter selections for machining, operations, etc. [3,4]. All of this data has to be evaluated in order to select the sequence of operations that will make up what is known as the route sheet. The sequence is generally obtained to conform with particular objectives, such as, for example, the shortest time and/or the minimum cost.

Process planning requires many kinds of human abilities, which are to be found in the figure of the process planner [2,4,5].

The traditional approach to resolving the process planning task is the one found in a manufacturing company, when the plans are handed over to the manufacturing process experts who then specify the procedures to make the product. The process planners, using their experience and knowledge, generate instructions for the manufacture of the products based

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on the design specifications and the available installations and operators. The fact that there are few experienced process planners and that, when faced with the same problem, different process planners would probably come up with different plans is an indication of the heterogeneity that exists in process planning [2]. But, in short, consistent and correct planning requires two things: knowledge of manufacturing processes and experience.

This has led to the development of Computer Aided Process Planning (CAPP) systems, which are becoming more and more important in this field.

2. The CAPP systems

CAPP systems are beginning to be developed as a link between design and manufacturing, filling the existing gap between Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) [6,7], along with the need for Material Requirement Planning (MRP) to work with standard and optimised routes which can be used in Schedule Production [3]. Based on the CIM strategy, CAPP allows the user to develop an integrated structure that deals with the flow of information between CAD, CAPP, MRP and Numeric Control (NC) activities within the company [8], as shown in Fig. 1.

CAPP systems have evolved from the traditional/manual approach to two recognised approaches: the variant and the generative.

The traditional or manual approach means examining the drawing of the engineering part and developing plans for the manufacturing processes and instructions based on a knowledge of the machines, the tools, the materials, the related costs and the working practices of the company.

The variant approach is based on getting the plan of a similar previous process and modifying it. In these kinds of CAPP systems, the parts are sorted into groups for which process plans are made which are then stored in the computer to be recovered as required for new parts or for modifications. In this way, the Group Technology helps to identify a suitable group to which the new part can belong. The main disadvantage of this is that the quality of the process plan still depends on the prior knowledge of a process planner [2,7].

The systems using the generative approach are designed to draw up, automatically, an individual plan for each part, using the appropriate algorithms that process the information in the manner required by the decisions that need to be taken. The first versions of these generative systems used tables and decision trees to capture the logic of manufacturing [5].

The result, i.e. the output of a CAPP system, is a route sheet. The route sheet is the sequence of manufacturing operations which contains the details of the depth of pass, the speeds, the dimensions, the assembly steps, the tools, etc. This sequence has to be the optimal sequence obtained as a result of defined objectives, but, even so, the optimum process plan may not guarantee the best way of manufacturing the part in the plant at a

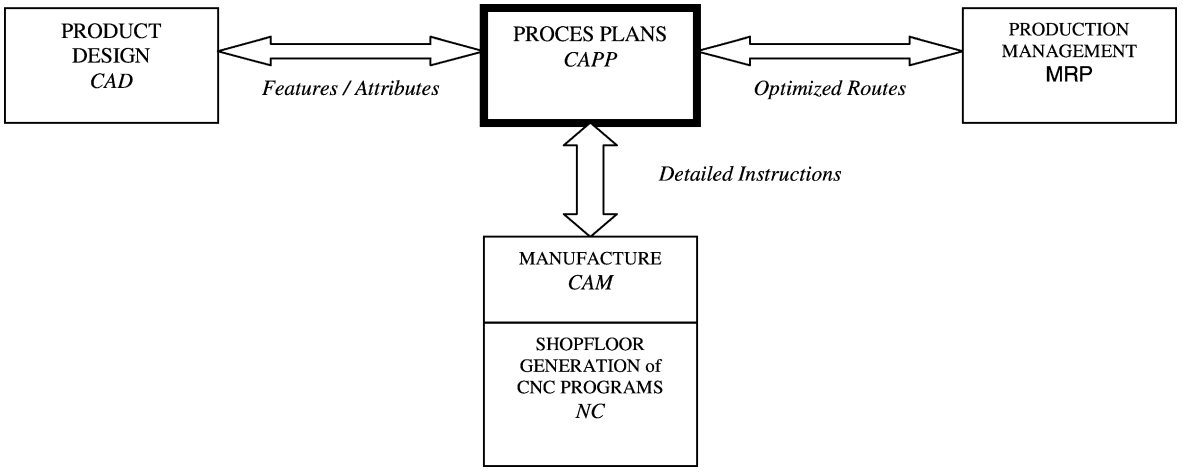

Fig. 1. The integration of the CAPP systems in the production environment.