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Improvement of Product and Process Planning by Generative Method

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ABSTRACT

*This paper examines the current status of, and suggests some future directions for, research efforts in an area important for computer-integrated manufacturing: computer-aided process planning (CAPP). Rather than discuss a specific aspect of the subject or present details of a particular prototype system, the major emphasis is on the global perspectives of fundamental issues involved in developing computer-based planning systems for various manufacturing tasks. In reviewing the current research, references are made to technical papers presented at the 19th CIRP (*International Institution for Production Engineering Research*) International Seminar on Manufacturing Systems held at the Pennsylvania State University, June 1-2, 1987, with the major theme of Computer Aided Process Planning. In suggesting future directions, an integrated planning framework as a logical extension of current CAPP activities is proposed. The need for, and challenges of, such an integrated planning approach to manufacturing problems are summarized, and, specifically the potential role of artificial intelligence (AI) based techniques within this framework are explained.*

Keywords**- Computer-aided process planning (CAPP), Artificial Intelligence (AI) in Engineering, Knowledge-Based expert systems, Manufacturing automation, Computer-Integrated manufacturing, Simultaneous Engineering, Production scheduling, Factories of the future.

I. INTRODUCTION

Process planning translates design information into the process steps and Instructions to efficiently and effectively manufacture products. As the design process is Supported by many computer aided tools, computer aided process planning has evolved to simplify and improve process planning and achieve more effective use of Manufacturing resources.

CAD/CAM Integration and CAPP features

A frequently overlooked step in the integration of CAD/CAM is the process planning that must occur. CAD systems generate graphically oriented data and may go so far as graphically identifying metal etc. to be removed during processing. In order to produce such things as NC instructions for CAM equipment, basic decisions regarding equipment to be used, tooling and operating sequence need to be made. This is the function of Computer aided process planning. Without some elements of CAPP there would be no such thing as CAD/CAM integration. The CAD/CAM systems that generate tool paths and NC programs include limited CAPP capabilities or imply a certain approach to processing.

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II. GENERATIVE CAPP SYSTEM OR GENERATIVE APPROACH

The generative method of developing process plans involves starting from scratch every time a different part is to be processed; no plans are available as the baseline. The basic requirement for a generative process planning system is that the given component model/drawing is to be interpreted in terms of manufacturability. Here Instead of retrieving and editing an existing plan contained in the computer database, generative system creates the process plan based on logical procedures. In a fully generative CAPP system the process sequence is planned without human assistance and without a step of predefined plans.

A generative CAPP system is usually considered part of the field of expert systems, a branch of artificial intelligence. An expert system is a computer program that is capable of solving complex problems that normally require a human with years of education and experience. Process planning fits within the scope of this definition.

There are several ingredients required in a fully generative process planning system

First the technical knowledge of manufacturing and the logic used by successful process planners' must be captured and coded into a computer program. In expert systems applied to process planning, the knowledge and logic of human process planners' is incorporated into a so called "knowledge base". The generative CAPP system then uses that knowledge base to solve process planning problems (i.e. create route sheets)

1. Second ingredient in process planning is a computer compatible description of the part to be produced. This description contains all the pertinent data and information needed plan the process sequence. Two possible means of providing this description are:

2. The third ingredient in a generative CAPP system is the capability to apply the process knowledge and planning logic contained in the knowledge base to a given part description. In other words, the CAPP system uses its knowledge base to solve a specific problem planning the process for a new part. This problem solving procedure is referred to as the "inference engine" in the terminology of expert systems. By using its knowledge base and inference engine, the CAPP system synthesizes a new process plan from scratch for each new part it is presented.

III. GENERATIVE PROCESS PLAN

Generative process planning is the second type of computer aided process planning. It can be concisely defined as a system, which automatically synthesizes a process plan for a new component. The generative approach envisions the creation of a process plan from information available in a manufacturing database without human intervention. Upon receiving the design model, the system is able to generate the required operations and operation sequence for manufacturing the component.

Knowledge of manufacturing has to be captured and encoded into computer programs. By applying decision logic, a process planner's decision-making process can be imitated. Other planning functions such as machine selection, tool selection, process optimization, etc. can also be automated using generative planning techniques.

A generative process planning system comprises three main components.

- Part description
- Manufacturing databases

- Decision making logic and algorithms

The definition of generative process planning used in industry today is somewhat relaxed. Thus systems which contain some decision-making capability on process selection are called generative systems. Some of the so-called generative systems use a decision tree to retrieve a standard plan. Generative process planning is regarded as more advanced than variant process planning. Ideally, a generative process planning system is a turnkey system with all the decision logic built in. Since this is still far from being realized, generative systems developed currently provide a wide range of capabilities and can at best be only described as semi-generative.

IV.GENERATIVE WORK AND ANALYSIS

In order to perform manufacturability analysis, a product design must be interpreted in terms of manufacturing features. Automated feature recognition has become the preferred technique for producing such feature-based representations, having been successfully employed for a variety of applications including process planning and part code generation for group technology. These feature technologies are rely heavily on the geometric and topological manipulation capabilities of solid modeling systems and deal predominantly with form or machining features. Presented the first effort to use a grammatical approach to parse solid models of parts for group coding presented a grammar based method for extracting non-intersecting features for a class of 2 dimensional parts Methods based on graph-grammars have been used to both recognize features and translate between differing features. Peters analyzes the combinatorial complexity of graph and grammatical approaches to feature recognition and presents heuristics to reduce these costs. In another effort to address combinatorial problems and handle realistic industrial designs, describe techniques for abstracting an approximation of the geometric and topological information in a solid model and finding features in the approximation. More recently, have outlined methods to utilize multiple distributed processors. Their initial results show that multi-processor techniques can be effectively employed to significantly expand the class of mechanical designs that are feasible and produce large improvements in system response times.

Generative methodology: The developed CAPP system consists of feature recognition module and other modules for selecting machines, tools, machining parameters and optimization modules. The feature recognition module has been developed by solid Works as modeling software and features are interpreted using a programmed written in Visual Basic 3.0. The Oracle 4.3 has been used for database management. The highlight of the system is that it has got excellent user interface by which user can interact with the system at different levels while generating a process plan.

V. FORGING PROCESS

Bulk deformation processes involve shaping of materials to finished products which have small surface area to thickness or surface area to volume ratio. Sheet metal forming produces parts having large surface area to thickness ratio. In sheet metal forming thickness variations are not desirable. Examples for sheet metal forming are: beverage cans, automobile body etc. Bulk forming processes may be primary processes such as rolling of ingot to blooms or billets, in which the cast metal is formed into semi-finished raw material. In secondary forming, the raw materials, such as blooms, billets are converted into finished parts such as gears, wheels, spanners etc.

Figure 4.1 open die forging

Forging is a deformation processing of materials through compressive stress. It is carried out either hot or cold. Hot forging is done at temperatures above recrystallization temperatures, typically 0.6 Tm, or above, where Tm is melting temperature. Warm forging is done in the temperature range: 0.3 Tm to 0.5 Tm. Cold forging has advantages such as good surface finish, high strength and greater accuracy. Hot forging requires lower loads, because flow stress gets reduced at higher temperatures. Strain rates in hot working may be high – 0.5 to 500 s-1. Strains in hot forging are also high – true strains of 2 to 4. Are common typical applications of forging include bolts, disks, gears, turbine disk, crank shaft, connecting rod, valve bodies, small components for hydraulic circuits etc.

Forging has several advantages. Closer dimensional accuracies achieved require very little machining after forging. Material saving is the result. Higher strength, greater productivity, favorable grain orientation, high degree of surface finish are other merits. However, complex die making is costly.

Table 3.1 Comparison of traditional and generative method

Traditional Method	Generative Method
1. Need to extra time for process planning	1. 58% reduction in process planning effort
2. labor cost is high	2. 10% savings in direct labor
3. Unnecessary create scrap	3. 10% savings in scrap
4. Extra tooling used	4. 12% savings in tooling
5. work process rough is long	5. 6% reduction in work in process
6. Non standard process used	6. Process rationalization and standardization
7. Create fluctuate productivity	7. Increased productivity of process planners
8. Cost and estimation is high	8. Improved cost estimating procedures and fewer calculation errors

VI. CONCLUSION AND FUTURE SCOPE

Generative method is a highly effective technology for discrete manufacturers with a significant number of products and process steps. Rapid strides are being made to develop generative planning capabilities and incorporate CAPP into a computer integrated manufacturing architecture. The first step is the implementation of GT or FT classification and coding. Commercially available software tools currently exist to support both GT and CAPP. As a result, many companies can achieve the benefits of GT and CAPP with minimum cost and risks. Effective use of these tools can improve a manufacturer's competitive advantage too.

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