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EMERGING ROLE OF GROUP TECHNOLOGY IN COMPUTER AIDED PROCESS PLANNING

Manish Billore* and Mukesh Pandey**

ABSTRACT

Modern Manufacturing Environment calls for a rapid conversion of ideas in to reality. It takes very less time to get the consumers' demands change drastically, due to increasing Consumer Awareness. Process Planning has been involved quite significantly in the mentioned 'conversion process', and the increasing role of Computer Aided Process Planning (CAPP) has further enhanced its relevance. CAPP basically translates design information into the process steps and instructions to efficiently and effectively manufacture products. This can be ideally achieved in a few 'mouse clicks', as the experts say, if the formulation of the task is perfectly done, with an appropriate methodology of converting it into the actual Process Plan. Group Technology can be very useful in identification and segregation of similar attributes of the process. These attributes allow the system to select a 'baseline Process Plan' for the Part Family*, thereby accomplishing about ninety percent of the planning work.*

Traditional Method of Process Planning

Process planning encompasses the activities and functions to prepare a detailed set of plans and instructions to produce a part. The planning begins with engineering drawings, specifications, parts or material lists and a forecast of demand. The results of the planning are:

- *Routings* which specify operations, operation sequences, work centers, standards, tooling and fixtures. This routing becomes a major input to the manufacturing resource planning system to define operations for production activity control purposes and define required resources for capacity requirements planning purposes.
- *Process Plans* which typically provide more detailed, step-by-step work instructions including dimensions related to individual operations, machining parameters, set-up instructions, and quality assurance checkpoints.
- *Fabrication and Assembly Drawings* to support manufacture (as opposed to engineering drawings to define the part).

Manual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. This is obviously time-consuming and the results vary based on the person doing the planning.

Modern Method of Process Planning

Manufacturers have been pursuing an evolutionary path to improve and computerize process

* Chief Engineer, Machine Tools (India) Ltd, Bhopal (MP) India
manishbillore@hotmail.com; manish@mactool.com

** Registrar, Rajiv Gandhi Technological University, Bhopal (MP) India

planning in the following five stages:

Stage I : Manual classification; standardized process plans

Stage II : Computer maintained process plans

Stage III : Variant CAPP

Stage IV : Generative CAPP

Stage V : Dynamic, generative CAPP

Prior to CAPP, manufacturers attempted to overcome the problems of manual process planning by basic classification of parts into families and developing somewhat standardized process plans for parts families (Stage I). When a new part was introduced, the process plan for that family would be manually retrieved, marked-up and retyped. While this improved productivity, it did not improve the quality of the planning of processes and it did not easily take into account the differences between parts in a family nor improvements in production processes.

Computer-aided process planning initially evolved as a means to electronically store a process plan once it was created, retrieve it, modify it for a new part and print the plan (Stage II). Other capabilities of this stage are table-driven cost and standard estimating systems.

This initial computer-aided approach evolved into what is now known as “variant” CAPP. However, variant CAPP is based on a Group Technology (GT) coding and classification approach to identify a larger number of part attributes or parameters. These attributes allow the system to select a baseline process plan for the part family and accomplish about ninety percent of the planning work. The planner will add the remaining ten percent of the effort modifying or fine-tuning the process plan. The baseline process plans stored in the computer are manually entered using a super planner concept, that is, developing standardized plans based on the accumulated experience and knowledge of multiple planners and manufacturing engineers (Stage III).

The next stage of evolution is toward generative CAPP (Stage IV). At this stage, process planning decision rules are built into the system. These decision rules will operate based on a part’s group technology or features technology coding to produce a process plan that will require minimal manual interaction and modification (e.g., entry of dimensions).

While CAPP systems are moving more and more towards being generative, a pure generative system that can produce a complete process plan from part classification and other design data is a goal of the future. This type of purely generative system (in Stage V) will involve the use of artificial intelligence type capabilities to produce process plans as well as be fully integrated in a CIM environment. A further step in this stage is dynamic, generative CAPP which would consider plant and machine capacities, tooling availability, work center and equipment loads, and equipment status (e.g., maintenance downtime) in developing process plans.

The process plan developed with a CAPP system at Stage V would vary over time depending on the resources and workload in the factory. For example, if a primary work center for an operation(s) was overloaded, the generative planning process would evaluate work to be released involving that work center, alternate processes and the related routings. The decision rules would result in process plans that would reduce the overloading on the primary work center by using an alternate routing that would have the least cost impact. Since finite scheduling systems are still in their infancy, this additional dimension to production scheduling is still a long way off.

Dynamic, generative CAPP also implies the need for online display of the process plan on a work order oriented basis to insure that the appropriate process plan was provided to the floor. Tight integration with a manufacturing resource planning system is needed to track shop floor status and load data and assess alternate routings vis-a-vis the schedule. Finally, this stage of CAPP would directly feed shop floor equipment controllers or, in a less automated environment, display assembly drawings online in conjunction with process plans.

Methodology of CAPP

The system logic involved in establishing a variant process planning system is relatively straight forward - it is one of matching a code with a pre-established process plan maintained in the system. The initial challenge is in developing the GT classification and coding structure for the part families and in manually developing a standard baseline process plan for each part family.

The first key to implementing a generative system is the development of decision rules appropriate for the items to be processed. These decision rules are specified using decision trees, computer languages involving logical "if-then" type statements, or artificial intelligence approaches with object-oriented programming.

The nature of the parts will affect the complexity of the decision rules for generative planning and ultimately the degree of success in implementing the generative CAPP system. The majority of generative CAPP systems implemented to date have focused on process planning for fabrication of sheet metal parts and less complex machined parts. In addition, there has been significant recent effort with generative process planning for assembly operations, including PCB assembly.

A second key to generative process planning is the available data related to the part to drive the planning. Simple forms of generative planning systems may be driven by GT codes. Group technology or features technology (FT) type classification without a numeric code may be used to drive CAPP. This approach would involve a user responding to a series of questions about a part that in essence capture the same information as in a GT or FT code. Eventually when features-oriented data is captured in a CAD system during the design process, this data can directly drive CAPP.

The 'Missing Interface' : CAD/CAM Integration With CAPP

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 operation sequence need to be made. This is the function of CAPP. Without some element of CAPP, there would not be such a thing as CAD/CAM integration. Thus CAD/CAM systems that generate tool paths and NC programs include limited CAPP capabilities or imply a certain approach to processing. CAD systems also provide graphically-oriented data to CAPP systems to use to produce assembly drawings, etc. Further, this graphically-oriented data can then be provided to manufacturing in the form of hardcopy drawings or work instruction displays. This type of system uses work instruction displays at factory workstations to display process plans graphically and guide employees through assembly step by step. The assembly is shown on the screen and as a employee steps through the assembly process with a footswitch, the components to be inserted or assembled are shown on the CRT graphically along with text instructions and warnings for each step.

If NC machining processes are involved, CAPP software exists which will select tools, feeds, and speeds, and prepare NC programs.

The 'Real' Advanteges of CAPP

Significant benefits can result from the implementation of CAPP. In a detailed survey of twenty-two large and small companies using generative-type CAPP systems, the following estimated cost savings were achieved:

- 58% reduction in process planning effort
- 10% saving in direct labor
- 4% saving in material
- 10% saving in scrap
- 12% saving in tooling
- 6% reduction in work-in-process

In addition, there are intangible benefits as follows:

- Reduced process planning and production lead time; faster response to engineering changes
- Greater process plan consistency; access to up-to-date information in a central database
- Improved cost estimating procedures and fewer calculation errors
- More complete and detailed process plans
- Improved production scheduling and capacity utilization
- Improved ability to introduce new manufacturing technology and rapidly update process plans to utilize the improved technology

Conclusion

CAPP 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 minimal cost and risk. Effective use of these tools can improve a manufacturer's competitive advantage.

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