Computer Aided Process Planning (CAPP) for Production Process-A Review

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Abstract – Computer aided process planning (CAPP) has attracted lot of research interest. A huge volume of literature has been published on this subject. In last four decades, a tremendous amount of effort has been made in developing CAPP system. CAPP is a link between design and manufacturing. It is the system which develops process planning with the help of computer. Process planning is an important activity as it involves deciding materials, processes selection, process sequencing, machining parameter selection tool path planning, machine selection, fixture selection, etc. It affects product cost and quality. Many CAPP systems have so far been developed. Different researchers adopted different advanced techniques and approaches. Nowadays, due to fluctuating market and business globalization, CAPP faces new challenges. Thus, there is a great need to come to the current status and detecting future trends of CAPP. In this paper, overview of literature CAPP and development of CAPP has been discussed. Two methods of CAPP which are Variant CAPP and Generative CAPP also discussed in this paper.

Keywords— Process Planning, Machining Process, CAPP, Variant CAPP, Generative CAPP.

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1. INTRODUCTION

Process planning can be defined as systematic determination of sequence of the manufacturing process by the conversion of design data to work instructions economically. The process plan incorporates process description, the process parameters, machine tool selection with available resources. Process planning has always been the most important interface between the product design and manufacturing. In general, there are two approaches to process planning, i.e., first one is manual process planning and second one is computer aided process planning. Selection of machining process is an important component of process planning whether it is manual process planning (MPP) or computer aided process planning (CAPP). It affects the production time, rate of production, cost and quality of components Process planning is dependent on the experience and judgment of the process planner in case of manual process planning. Due to this, operation sequences developed by various planners are also different. The process planning decisions may vary from industry to industry and person to person. The process planner spends his most of time on non-decisional and repetitive activities. This non decisional time spent by process planner is reduced by development of CAPP *[1, 2].*

An attempt has been made in recent years to make use of computer for developing an expert system to generate process plan. However, CAPP is not implemented effectively in industries. It is revealed from the industries that process plans are prepared by manual approach, i.e., manual process planning (MPP). The selection of machining process will depend upon number of factors such as material, size, weight, complexity of the geometry, labour, tooling, quantity, size tolerances, geometrical tolerances, surface roughness, etc. No two process planners are likely to come up with the same machining process within same times. It shows the inconsistency in the selection of machining process. Besides that intangible benefits of CAPP are reduced lead time, process plan consistency, to use of improved technology, etc. Thus, industry felt the importance and need of CAPP. Therefore, for the purpose of taking benefits of CAPP in manufacturing industries and to overcome limitation of the present method of manual process planning (MPP), there is a significant need for CAPP system development. Therefore, it is decided to undertake the research study to facilitate the CAPP for production process *[2, 3].*

Out of the various CAPP methods, variant process planning is the easiest to implement. However, in order to implement variant process planning, products must first be grouped into part families based on feature commonality. If a new part cannot be easily placed into an existing family, then a feasible process plan cannot be generated. Also as the complexity of feature classification increase, the number of part families also increases, causing excessive search times during process plan generation. For that purpose, need arises for an approach to manufacturing in which similar parts are identified and grouped together in order to take advantage of their similarities in design and production, called as Group Technology (GT). When there are only a few part families with little feature deviation for new designs, variant process planning can be a fast and efficient method for generating new process plans. Variant process planning explores the similarities among the parts and then grouping them into a family. A standard process plan is developed for that part family which is the process plan that applies to an entire part family when a standard plan is retrieved; a certain degree of modification follows in order to accommodate the details of the design. In general, variant process planning has two operational stages, a preparatory stage and a production stage *[4].*

This paper includes a brief review of the current CAPP, discussion and conclusions.

2. LITERATURE REVIEW

Even though researchers have carried out considerable amount of work on the development of CAPP, benefits of CAPP systems are still to be realized in industries. Several researchers have attempted to survey the various CAPP systems and the research in CAPP, and have identified areas that need further research. The reviews present the overview of methodologies and approaches being pursued, the current trends and future recommendations in a particular CAPP research area. Accurate decision about the selection of a production process is very critical issue. It influences the product cost to a great extent because the process selection determines the type of tooling, equipment, labour skill and lead time required. Various authors have explored different approaches to the problem of process selection.

CAPP is very old technique and the idea was first presented by Niebel in 1965 using the speed and consistency of the computer to assist in the determination of process plans. Despite of this, till 1970s CAPP system was not addressed broadly. Two CAPP were developed in 1976 namely CAPP and MIPLAN. Up to 1990, integrated system of MRP and CAPP utilized by 20% of manufacturing industries and 50% of the process plans generated by computer to produce parts or assemblies *[1].*

Venkataraman *[5]* presented a graph based frame work for feature recognition. The feature recognition step involved finding similar sub graphs in the part graph. The novelty of this framework laid in the usage of a rich set of attributes to recognise a wide range of features efficiently.

Ajmal and Dale *[6]* developed a simple computer aided process planning and cost estimating system from technical drawing for jobbing foundry application which focuses estimating casting and core weight, manufacturing time and cost which is then tested for more than 200 ferrous and non-ferrous castings. The system is comprised of six modules and has a feedback loop for comparing the actual and estimated weights and times. It is observed that closeness of fit between estimated and actual weights and times decreases as the casting and core shapes becomes more complex. To compensate this variation, a correction factor could be developed depending on manufacturing strategy and company business.

Gupta et al. *[7]* developed CAPP system for prismatic parts using feature based design concept. Input module has been developed as a layer in AutoCAD which allows user to define geometry. There is central database which contains six sections which contains present information and storing actual data of component. Other database facilities machine tool selection, set-up planning, tool selection, operation sequencing. For the purpose selection of all these parameters software set some rules and logic and Developed model support limited features for typical prismatic parts and set-up planning is done for parallel-piped shaped jobs.

Sirilertworakul et al. *[8]* developed computer aided structure of knowledge base such that inputs of alloys are given which selects alloy depending on engineering, mechanical, casting chemical, general properties following the casting selection of casting process based on selected alloy.

Darwish and Tamimi *[9]* developed the preliminary casting processes selection expert system (PCPSES) with the help of rule master, a software package for building expert systems in which knowledge can be entered directly as rules. The processes stored in the knowledge base are those used for the production of a cast component. Expert system is structured by developing four modules which further contains sub-modules. Each sub-module characteristic is related to design; production and manufacturing are coded in knowledge base and offered to the user at the time of selection process. After entering all the characteristics of component to be cast based on that system suggest casting process for that particular component.

Tiwari et al. *[10]* developed computer aided process planning system for machining prismatic components with the help of case based reasoning, typically consist of three modules, i.e., part input and representation, case retrieval and case adaptation. In first module faces of the parts allotted numerical values, on the basis of that preliminary sequencing developed. In case of retrieval module methodology used is multi-parametric and absolute. First stage matches the features of new part then process parameters to the cases in case base. Second stage of case of retrieval deals with checking of operation sequence feasibility and matching of capabilities of the machining processes. Flow chart is developed for each of these matches. On the basis of that most similar case is retrieved from case base for the new part. Thus, developed computer aided process planning is effective and time reducing but as the size of case base increases time required increases.

Sadaiah et al. *[11]* attempted to design and develop a generative CAPP system for prismatic components. This CAPP system has been divided into three modules. The first module is concerned with feature extraction. The second and third modules deal with planning the set-up, machine selection, cutting tool selection, cutting parameter selection, and generation of process plan sheet. The developed CAPP system is linked with CAD module and it extracts the majority of features automatically prior to process planning. The developed CAPP system has been tested with aerospace components. Features recognition module of the CAPP system must be further developed in order to recognize complex features.

Chougule and Ravi *[12]* developed innovative approach to casting process planning based on case based reasoning for both generative and variant process planning and has been implemented in a web-based virtual foundry environment. The work focused on the preliminary process planning of the cast components. For generating casting process plan, case based reasoning methodology which uses nearest neighbour algorithm in that analytical hierarchy process has been employed in which weight of the attributes is evaluated by using analytical hierarchical process (AHP). Attributes are grouping according to their similarity and comparability for getting nearest neighbour. Similarity coefficient is calculated on the basis of weighted value of attributes after that nearest three cases have been identified and them similarity index calculating for those three cases in which 1 indicates best match.

Chougule and Ravi *[13]* used Case Based reasoning approach in conjunction with the nearest neighbour algorithm and analytical hierarchy processes used for retrieval of a previous case closest to problem. Attribute weights, relative attribute weights and attribute values are calculated to express importance of each attribute relative to other. Similarity is determined using Euclidean distance function for getting nearest neighbour. This methodology is implemented on body cap casting which gives feasible processes and the nearest neighbours.

Daws et al. *[14]* developed Computer Aided Casting Process Selection (CACPS) with help of fuzzy logic in which compatibility rating between product requirements and the alternatives stored in database for each decision criteria. In screening phase casting process are eliminated on the basis of attributes like materials, shape, quantity where as in Rating phase attributes like geometric, quality, economic, production are set in four limits which are used for mapping process capability. Input of twelve casting process and seventy alloys of aluminium and steel with their all mechanical properties are given as database using visual basic language version which links with Microsoft Access system. Entering required specifications system select casting processes according to computability.

Khan et al. *[15]* applied object oriented approach to prepare the part geometric database and translates this information to manufacturing knowledge. The part design was introduced and represented via CAD software and the CAD software generates and provides the geometrical information of the part design in the form of a STEP file (the standard format). This provides ability for the proposed methodology to communicate with the various CAD/CAM systems. The object oriented approach is implemented using Visual C++ provides an efficient and automatic link between the geometric data, the generated process and the setup plan.

3. VARIANT CAPP

This method of CAPP is comparable with the traditional manual method where a process plan for a new part is created by identifying and retrieving an existing plan for a similar part and making the necessary modifications for the new part. This is generally based on the concept of Group Technology (GT). Group Technology can be defined as the identification of similar product within the population at large for the purpose of design and manufacturing efficiencies through the consistent application of best practice technology to the characteristic attributes of the family. A Standard plan consisting of a process plan to manufacture the entire family is created and stored for each part. The development of a variant process planning system is shown in figure 1.

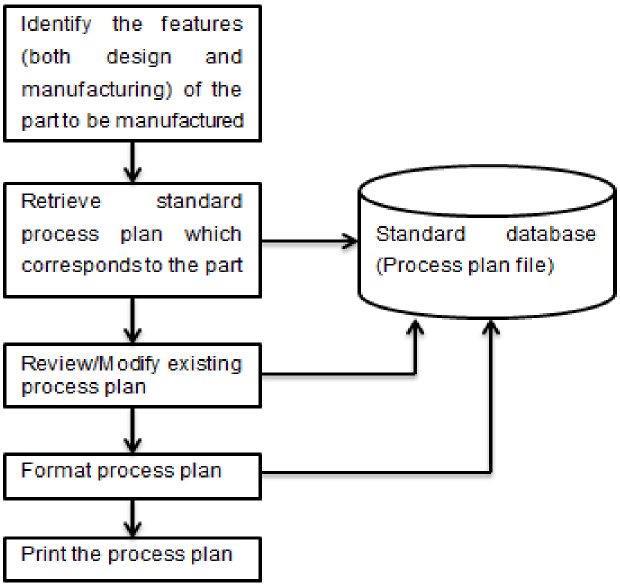

Fig.1 Variant CAPP system

The preparatory stage: During the preparatory stage, existing components are coded, classified, and later grouped in to families. Families can be formed based on geometric shapes or on process similarities. Families can often be described by a set of family matrices. Since the processes of all family members are similar, a standard plan can be assigned to the family. The standard plan is structured and stored in a coded manner.

The process planning stage: New components can be planned in this stage. An incoming component is first coded. The code is then sent to a part family search routine to find the family to which it belongs. Since family number indexes the standard plan, the standard plan can be easily retrieved from the database. The standard plan is designed for the entire family rather than for a specific component, thus editing the plan is unavoidable.

4. GENERATIVE CAPP

In this approach, process plan is generated by means of scratch without human intervention. The system is designed such that process information is synthesized automatically to develop a process plan for a particular part. This system uses decision logics, technology algorithms and geometry based data to perform many processing decisions. System contains rules of manufacturing and the equipment capabilities stored in computer, which generate process plan for a specific part without any involvement of process planner. It develops new plan for each part based on input about the part's features and attributes. Due to the complexity of this approach a generative CAPP system is more difficult to design and implement than a system based on the variant approach. But a generative CAPP system does not require the aid of a human planner, and can produce plans not belonging to an existing part family. It stores the rules of manufacturing and the equipment capabilities in a computer system. The generative approach is complex and a generative system is difficult to develop. In comparison, the variant systems are better developed and mature than generative systems; they are suitable for planning processes in mass or large production volumes. For planning discrete processes of manufacturing products of great diversity, generative systems are much more suitable than variant systems. However true generative systems are still to come although the earlier optimistic speculation made by researchers. Most CAPP systems in use now are either variant systems or semi-generative systems (with some planning functions developed with variant approach, others with generative approach). Proper combination of the two approaches can make an efficient CAPP system. First the system will check whether the process planning is possible for a new part by variant approach. If variant system is unable to identify the part to be of a previous group or family it will use generative technique for process planning. So both the variant and generative process planning approaches need further development in parallel.

5. CONCLUSIONS

In industry, CAPP plays an important role which reduces time and cost. Many CAPP systems have been developed which adopt many advanced techniques and approaches such as feature-based modelling, object oriented programming, database and utilize new computing methods. But the rate of development of systems and introduction to new ideas in the field is greater than that of the rate of implementation of CAPP systems in industry. Effectiveness of these systems in industry is not truly satisfied. The Speed of development of CAPP with CAD and CAM has not kept pace though CAPP is the main element in the integration of design and production. This situation has made process planning as a bottleneck in the manufacturing process. There are so many a benefit promised by various CAPP systems still adaptation by industry is slow. Today, most of the companies use CAPP systems which are integration of product design and production planning and control activities. Due to this it is necessary to create link between CAD and CAPP such that two way interactions will be possible between design and process planning. It has also become essential to get feedback from process planning to assist the designer in early design stage. So CAPP is one of the key areas for research and development, it will integrate design and manufacturing which reduces total product development time and lately cost.

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