ABSTRACT

The process planning activity involves pre-production preparatory work like selection of suitable manufacturing processes, sequencing of operations, selection of datum, selection of tools, selection of machining parameters etc., to manufacture a part in more efficient manner. Process planning helps in improving quality, rate of production and subsequently cost of production and it is of utmost importance to the production system in the present competitive global markets.

The aim of the present work is to develop an optimised generative CAPP system for prismatic components. It consists of a generative CAPP system for prismatic components and feature extraction module. The various modules of the system have been developed using VC++ Version 6.0, Developer 2000 at the front end for processing and displaying information, and Oracle 7.3 at the back end for databases.

A feature extraction module to feed feature data of the components to be produced to CAPP system is developed. It will extract feature data from a CAD package and store it in database prior to passing it to CAPP system. This is to integrate CAPP system with a CAD package, so that manufacturing feature data can be extracted from the given 3D model of the component. An algorithm has been developed for extracting the data related to machining features. The developed feature extraction module is integrated with the CAPP system and is independent of any CAD modeling system. The specialty of the system is that it communicates the machining feature data directly to CAPP system. With the help of a set of case studies, the capability of the feature extraction module is demonstrated. From the above, it was observed that the developed system could extract around 75 to 100 percent of the features present in the selected components. Further, the system has been tested over 50 prismatic components of complex geometry and found to be satisfactory. The various features identified by the proposed approach are also described. The facility to input manually an unidentified feature is also

incorporated in the feature extraction module. It helps in processing totally all the features of the components of a given industry.

Since the selection of an appropriate blank size is an integral part of the process planning activity, in the present work, an attempt is also made to calculate the blank size from the given CAD model. Blank selection module was tested using more than 50 prismatic components. Results were cross-checked with manual calculations and were found to be satisfactory.

The second major module of the present work deals with the development of process parameters of manufacturing processes. Developing the process parameters of the advanced manufacturing processes is one of the major concerns of the aerospace manufacturing industry. A model of the process is required to understand the technology. Development of a proper model is very difficult due to the non-linear behaviour of the manufacturing processes and large number of interrelated parameters.

An attempt has been made to study the process parameters of Wire cut EDM, High Speed Machining and Electron Beam Welding processes which get prominent applications in aerospace industries. Neural network approach has been used for Wire cut EDM process. The experiments have been planned using Taguchi's L_{18} Orthogonal Array and as many as 120 experiments were conducted. The additional experiments were also conducted to test the model developed. The results show that the neural network model can be successfully used to select the required process parameters of the WEDM.

Process parameters of High-speed milling have been studied using multiple regression and fuzzy logic approaches. These approaches are used in an attempt to determine the optimal combinations of control parameters of high-speed milling. Number of experiments were conducted, as the required expertise was not available. Additional experiments were conducted to test the validity of the approach. With statistical analysis, it is concluded that fuzzy logic system gives satisfactory results and can be used for obtaining the output values within reasonable limits.

Process parameters of the Electron Beam Welding Process for Titanium alloy (Ti6Al4V) of 5.50 mm thick plate have been studied using multiple regression

approach. These approaches are used in an attempt to determine the optimal combinations of control parameters like accelerating voltage, beam current, weld speed and distance between gun to work of Electron Beam Welding. It is observed with statistical analysis that generated regression model is a valid model, which can be used for obtaining the output values within reasonable limits. The accuracy of predicted results of regression models for weld penetration levels and weld strength is 97% and 99% respectively. Further research is planned to estimate the effect of focusing current on weld strength and also measure the depth of penetration of the welds.

The third major module of the CAPP system is generation of optimised set-up plan using Genetic Algorithm. The input for an automatic set-up planning system comprises of machine resources, raw stock, features to be machined, dimensional specifications and tolerance requirement. The output is high level machining instruction, which will be further detailed by machinist in shop floor production. An optimisation criterion to generate the optimised process plan is developed. Automatic set-up planning and operation sequencing has been demonstrated successfully by machining industry standard ANC-101 prismatic component using the generated optimised process plan.

Prior to the development of the different modules of the CAPP system, a coding system for machines and tools was developed to suit the generative CAPP system development. The machine coding system is based on nine characters whereas the tool coding system has five characters. The methodology for feature-process-machine-tool correlation and the logic involved was developed. Further, an automatic tool and machine coding methodology was developed to generate the codes for a new machine or tool. An exhaustive tool and machine database comprising of over 1000 tools and 50 machines was created. An exhaustive machining cutting data base for different work materials, cutting tools and various machining operation has been developed. The database structure and information flow for cutting parameters are also developed.

The feature-process correlation and the process rules applicable to machining of job shop type prismatic components have been developed. A feature

coding methodology and feature-process correlation link were developed to facilitate the generative CAPP system in generating process plans automatically. More than two hundred comprehensive process rules related to processing of prismatic components were gathered from industrial practices and consolidated. These process rules were compiled after discussions with shop floor personnel/ process planners. Also some critical prismatic components were studied to derive process rules. These process rules were further supplemented from the literature available in the CAPP area. The process rules address the special needs of prismatic components with special emphasis on complex geometry, clampability of component during machining, fragileness of a feature, non-conventional machining processes and heat treatment. Automatic set-up planning and operation sequencing for typical prismatic components of complex geometry, employing the above process rules were demonstrated with typical industrial case studies. Set-up plans were optimised for minimum cost criteria.

In the present work, an attempt is made to develop an optimised process planning system. The system was demonstrated successfully by machining industry standard ANC-101 prismatic component using the generated optimised process plan. It was also evaluated satisfactorily on complex industrial prismatic component by machining with generated process plan. The system was further tested on more than 50 different prismatic components of complex geometry and the results were found to be satisfactory. The generated process plans were compared with that of manually prepared ones and found to be in good agreement with them. Therefore, the present work lays the foundation for integration of CAD and CAPP, which is a very complex and critical element in successful implementation of paperless manufacturing.