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 integrated generative CAPP system for prismatic components. It consists of a generative CAPP system for prismatic components, feature extraction module and Machine Monitoring System (MMS). The various modules of the system have been developed using Visual Basic 6.0 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 (SolidWorks98Plus) 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. The speciality 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 80 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. It works on the principle of minimising the blank volume based on the finished work piece volume and machining allowances and clamping feasibility. Testing of the blank selection module was carried out using more than 50 prismatic components. Results were crosschecked with manual calculations and were found to be satisfactory. A library of blanks was created using Oracle 7.3.

The second major module of the present work deals with design and development of a Machine Monitoring System (MMS) to obtain machine availability information from shop floor in an 'on-line' basis to enable the CAPP system to consider only the available machines for process planning. The development of a modular shop floor control unit primarily aims at monitoring the status of conventional as well as CNC machines. For the above purpose, a conventional and a CNC machine were selected. Keyence Programmable Logic Controller (PLC) was used to monitor the status of the conventional and CNC machines. In the present work, the data collection for the purpose of obtaining machine status has been carried out in two phases (i) Manual mode and (ii) Auto mode. Four signals like power 'ON', spindle 'ON', control 'ON' etc., are taken automatically and the remaining signals are obtained manually. As a part of the MMS, the necessary hardware and interfacing modules were developed and integrated with the CAPP system. Later, the status of the machines was monitored and machine availability of the same was fed as an input to the machine selection module of the CAPP system. The response time of the system is of the order of 0.5 seconds for conventional as well as CNC machines. It helps in generating realistic process plans that can be implemented on the shop floor with minimal deviations as against the master plan. Further, the proposed system gives an overall status of the shop floor machines viz. machine availability. The system also helps the user to analyse machine utilisation and machine down time etc. The above approach can be expected to have a comprehensive approach to computer-aided process planning activity.

The third major module, CAPP system, is developed based on the principles of generative process planning approach. The system is built to respond to the shop floor disturbances like machine non-availability, tool non-availability, operator non-availability etc. Further, the system is developed in modular format and integrated with the different modules to address the issues of the CAPP system. The various steps involved in process planning activity are:

(i) Feature extraction

(ii) Unidentified feature input

(iii) Blank selection

(iv) Set-up planning

(v) Process routing

(vi) Machine selection

(vii) Tool selection

(viii) Cutting parameter selection

(ix) Process sheet generation.

Modular algorithmic procedures were developed to perform the above activities. The system was tested with more than 50 prismatic components of complex geometry and the results were found to be satisfactory.

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 eight 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 25 machines was created. Finally, the above database was integrated with the machine availability module of the CAPP system. The tooling information was collected from sources like SANDVIK and WIDIA catalogues to prepare tool and cutting parameters database.

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. Well over sixty comprehensive process rules related to processing of prismatic components were gathered from industrial practices and consolidated. 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.

In the present work, an attempt is made to integrate a modelling package, machine status availability module and a generative CAPP system. The integration of the various modules is carried out to have a comprehensive approach for shop floor resources and process planning activity. The above approach can be expected to generate close-to-realistic process plans. The system was tested by simulating the different shop floor conditions using 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, CAPP and shop floor resources, which is a very complex and critical element in successful implementation of Computer Integrated Manufacturing (CIM).