Chapter (1)
Theoretical background and literature survey

1.1 Introduction:

It is well recognized that the computer aided process planning (CAPP) plays an important role in the development of computer integrated manufacturing systems (CIM). The Capp system provides a vital link between computer aided design (CAD) and computer aided manufacturing (CAM).

The significance of CAD/CAPP integration arises from the fact that the CAPP relies on the data which is provided by CAD to perform precise and consistence process plans. However CAD and CAPP tend to have different databases i.e. CAD databases are usually geometry based, consisting of geometry primitive (points, lines, circles,…) whilst CAPP systems tend to be feature based (grooves, pockets, holes, …) [1]

The integration of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) has received significant attention in the recent years according to the development of faster computing power tools. However, the actual integration between CAD and CAM, for the downstream applications such as process planning, can be achieved only when the manufacturing information can be obtained directly from 3D solid model and hence automate the process planning functions. This automatic extraction of manufacturing information from CAD systems play an important role to facilitate the concurrent engineering concept in order to achieve the link between the design and manufacturing activities. This successful link can be considered as fundamental step to automate the product development from the design stage all the way to manufacturing and shipping stages. Hence, the total life cycle of the product can be reduces dramatically. [2]

CAD-CAM integration requires that design and manufacturing features can be extracted and interpreted automatically from a CAD model without human intervention. Thereby, feature recognition is essential to apprehension and extraction of the design and manufacturing characteristics of a part. The approach of design-by-features is, whereas, inconsistent with the way that was traditionally followed by most designers; it may force a designer to work on the low levels of details and specifications at the early design stage'. Most feature recognition research applied to CSG or B-Rep solid models uses the method of syntactic pattern recognition to find machinable features without addressing the issues of features relationships or no geometric information existing on 2D engineering drawings. This

information, however, is important to designing and planning the manufacturing processes.
It has been pointed out that only 15% of process planners time is spent on technical decision making, while the remaining time is spent equally gathering or calculating data, and preparation of documentation. Also the investigation shows that efficient CAPP systems could result in a total reduction in manufacturing cost of about 30%. The manufacturing cycle and the total engineering time could also be reduced by about 50%. [20]

1.2. Literature survey:

In this section the important criteria of CAPP and computer aided part programming systems will be discussed. Feature recognition, process planning, part programming and general review of previous works in computer aided process planning and part programming systems are presented.

1.2.1. Feature recognition and design by feature:

The word ‘‘feature’’ signifies different meaning in different contexts depending on the specific domain. For example, in design it refers to a web or a notch section, etc., while in manufacturing it refers to slots, holes, and pockets, while in inspection it is used as a datum or reference on a part. Classification of features is totally application dependent. It is very difficult to make an application-independent classification of features. There are many definitions in the literature for the term ‘‘feature’’, some of which are as follows:

- ‘‘A feature is any entity used in reasoning about the design, engineering, or manufacturing of a product’’.
- ‘‘a geometric form or entity whose presence or dimensions are required to perform at least one CIM function and whose availability as a primitive permits the design process to occur’’.
- ‘‘A region of interest on the surface of a part’’.

Although many different definitions have been given, the basic of these definitions is that features represent the engineering meaning of the geometry of a part, assembly, or other manufacturing activity.(2)
In recent years, various researchers have come up with different ways and means to integrate CAD and CAM. Automatic feature recognition from CAD solid systems highly impacts the level of integration. CAD files contain detailed geometric information of a part, which are not suitable for using in the downstream applications such as process planning.

Different CAD or geometric modeling packages store the information related to the design in their own databases. Structures of these databases are different from each other.(2)
One of the foundation tasks in a Computer Integrated Manufacturing (CIM) environment is to extract and identify the information in the CAD model file. The conventional approach to feature extraction is accomplished by the human planner examining the part and recognizing the features designed into the part. Automated feature recognition can best be facilitated by CAD systems capable of generating the product geometry based on features, thereby making it possible to capture information about tolerance, surface finish, etc. However, such CAD systems are not yet mature and their wide usage in different application domains remains to be seen. It is therefore necessary to consider developing an intelligent feature recognition system to extract features from part geometry.

1.2.1.1 Feature recognition techniques and applied models:

Automatic feature recognition (AFR) is the first and the most important step in the process of translation of CAD information into some instructions appropriate for manufacturing. To eliminate a need for human engagement in feature recognition process is essential for a fully automated CAPP system development. The advantages of AFR compared to feature based design are significant time and human resources saving, as well as insurance of desired part functionality without being limited in design creativity by the possibilities of the predefined form feature library. However, in spite of large research efforts, contemporary AFR systems still suffer from many disadvantages: (i) complexity of the recognition algorithms, especially in the case of intersecting features—there is an immense problem in determination of the set of features for which production must be explicitly planned and which features may be collaterally produced by producing certain others; (ii) the domain of recognized features is quite limited—the most of contemporary recognition systems mainly deal with orthogonal features, but with little attention paid to no orthogonal and arbitrary features; (iii) the manufacturing Information attached to the recognized feature is not rich enough to facilitate the determination of the subsequent production plan, etc.[21]

1-IFRM system:

(IFRM) system is developed as a feature recognition system which has the ability to communicate with various CAD/CAM systems. The proposed methodology is developed for 3D prismatic parts that are created by using solid modeling package

by using CSG technique as a drawing tool. The system takes a neutral file in Initial Graphics Exchange Specification (IGES) format as input and translates the information in the file to manufacturing information. The boundary (B-rep) geometrical information of the part design is then analyzed by a feature recognition program that is created specifically to extract the features from the geometrical information based on a geometric reasoning approach by using object oriented design software which is included in C++ language. A feature recognition algorithm is used to recognize different features of the part such as step, holes, etc. Finally, a sample application description for a workpiece is presented for demonstration purposes.(2)

2- STEP-based feature extraction from STEP geometry for Agile manufacturing

This work is aimed at addressing the data exchange and sharing needs of Agile Manufacturing.

The developed feature extraction system takes a STEP file as input and produces a form-feature STEP file.

This STEP file can be exchanged between various companies and can serve as input to further downstream activities such as process planning, scheduling and material requirement planning MRP.. The primary objective of this system that the ability of storing the feature data in a computer interpretable format. The features are extracted from the design data for the particular product and this would force the designer to seek input from the manufacturing engineering and the manufacturing engineering to provide input to the design engineer, so that the product developed can be directly manufactured and the number of design changes made as a result of manufacturing constraints is restricted to a minimum. The feature extraction system developed is aimed at overcoming the shortcomings of the design by feature approach which is limited by the number of features in the pre-defined library of features. The extracted form features are saved in the STEP Part 21 file format which can be read by some of the currently available CAD systems and exchanged between various systems over the Internet or by electronic mail. The output file generated by the feature extraction system contains all the geometry and topology information required to completely define the solid and also form feature information. The form feature information gives higher level meaning to the group the faces forming the solid and can be used for CAPP and CAM. The feature extraction mechanism has currently been developed for solids which can be

manufactured by milling process. AP224 covers products that can be manufactured by milling and turning [19].

3- A feature recognition system using STEP for interfacing design to process planning:

This system is considered as one of modules of an in-house process planning systems the input of the system is the STEP file created for a part which is modeled on any commercially solid modeling environment. The part model is then translated from STEP format into an equivalent format based on boundary representation(B-rep)scheme that is accessible and manipulable in the application environment. Orientation of each face of the part is determined. Relationships between adjacent faces of the part are found based on "concavity" and these relationships are stored in a "relation matrix". By tracing the elements of this matrix, part features are extracted. Then they are identified and recognized by using a variable coding scheme based on the number of the faces, edges, etc. on the part feature [22].

4- IF^2 System:

The developed system uses the neutral product data standard STEP as input and output formats, which include all relevant information such as machining features, surface roughness, and dimensional and geometric tolerances. The system can be ported to arbitrary CAD and planning systems.

The developed system has been completely implemented. Originally IF^2 was written in a combination of C# and LISP, and operated in Unix. However, we changed its base platform into Windows NT on PC, and rewrote the LISP portion of IF^2 in C# primarily for speedup. All extensions of IF^2 have been coded in Microsoft Visual C#. Graphical user interface is coded mainly using OpenGL, and the tool database is accessed through Microsoft ODBC APIs which are functions to access various DBMSs.

IF^2 obtains geometric services from the Para solid modeler [24].

5-ANN system:

A prototype system for the proposed work has been implemented in C with ACIS. This system can be considered as a novel feature recognition method, which incorporates design by features, ANN techniques and a heuristic algorithm. The research can effectively handle feature interactions and overcome limitations of current ANN-based feature recognition methods. It is distinctive in three main aspects.