1. INTRODUCTION

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Creation of primary, real, tangible wealth is the basis and source of all other wealth in a nation. It increases the quality of life, employment, and general economic well being of a country. In industrialized countries, manufacturing accounts for two thirds of the wealth creation and therefore improvement of manufacturing technology is of primary importance. Major objective of modern manufacturing enterprise is to substantially reduce the lead time for the development of a product, from concept stage to realization of the product, called product life cycle. Its effective implementation has become one of the major preconditions for the survival of a company, in this changing global market. These requirements, the growing complexity of running factories in an increasing competitive environment with tight production schedules and sharply increasing costs has forced industry to search for alternatives to the traditional approach of manufacturing. Of all various kinds of manufacturing technology being developed, researched, and implemented today, Computer Integrated Manufacturing (CIM) has demonstrated far greater productivity than anything has that has appeared on the scene since the onset of industrial Revolution. CIM centers around a manufacturing database consists of four primary manufacturing functions. They are Engineering design, Manufacturing engineering, Factory production and Information management. All the sub functions and primary functions are illustrated in Fig 1.1. The goal of such a system is complete integration of the entire concept-to-market process. The rapid improvement in computer hardware and software have made possible, a dramatic shift towards Computer Integrated Manufacturing (CIM). CIM can be achieving full-fledged automation with minimum possible human intervention, to enhance productivity, with the help of computers. The Concept of CIM has lead to various islands of automation, though complete integration of these areas of automation is yet to be realized.

Though conceptually CIM offers many advantages, the major obstacle in achieving CIM has been the integration of CAD and CAM. Researchers have long ago identified planning as a prospective methodology to bridge the gap between CAD and CAM. This resulted in the development of Computer Aided Process Planning (CAPP)
Systems. Out of the different approaches proposed for a vital link in CIM, integration of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) through feature based Computer Aided Process Planning (CAPP) seems to be most promising.

Fig. 1.1 Functions of CIM

DBMS – Database Management System
MIS – Management Information System
AMH – Automated Material Handling
CAM – Computer Aided Manufacturing
CAD – Computer Aided Design
PPC – Production Planning and Control
DSS – Decision Support System
QA – Quality Assurance
GT – Group Technology
1.2 Computer Aided Design and Manufacturing

Computer Aided Design (CAD) is the use of computer to assist the design of an individual part or a system. The CAD system supports the design process at all levels - conceptual, preliminary and final design. The design process usually involves solid modeling. The model of the object displayed on the CRT screen, can be stored, and retrieved for modification, if necessary. Part drawing can also be created using automatic drafting machines. Computer Aided Manufacturing (CAM) is the use of a computer to assist in manufacturing of a part. It can be divided into two main classes.

i. On-line applications, namely, the use of computer systems to control the manufacturing systems

ii. Off-line applications, namely, the use of computer in production planning and non-real time assistance in manufacturing of parts.

CAD and CAM, though effective in their respective areas of application, generally operate in isolation of each other. Thus, to realise CIM, integration between CAD and CAM is necessary. Process planning is the essential link between computer-aided design and manufacturing. This resulted in the development of computer automated process planning.

1.3 Process Planning

Briefly defined, process planning is that function which determines the sequence of individual manufacturing operations needed to produce a given part or product as well as associated machining conditions (feed, speed, etc.). In effect it is the subsystem responsible for the conversion of design data into work instructions. The resulting operation sequence is documented on a form, along with the required machine tools, cutting tools and operation times. Such a form is known as process plan. When a new part is to be produced at the shop, the manufacturing engineer prepares a process plan. The process plan is dependent on the experience and judgement of the planner. It is his responsibility to determine optimum process plans.

Following are the different phases of process planning.

i. Selection of operations.

ii. Sequencing the operations.

iii. Selection of the machine tools.

iv. Selection of the workpiece holding devices and datum surfaces.

v. Selection of cutting tools.
vi. Determination of proper cutting conditions.
vii. Determination of cutting times and non-machining times.
viii. Editing the process sheet.

1.4 Computer Aided Process Planning (CAPP)

Process planning is one of the basic components of the manufacturing system. As the automated manufacturing system tends to replace human operators by more efficient automated equipment in production, the bottleneck stage is transferred to the preparation departments. Therefore, process planning, which represents about 40% of the preparation time, has assumed much more importance. It is an experienced based activity traditionally carried out by highly skilled engineers who have an intimate knowledge of a wide range of manufacturing processes and are themselves experienced manufacturing engineers. There is a shortage of such persons. It is also found that there is generally a lack of consistency among process plans prepared by different individuals with varying manufacturing backgrounds and levels of skill.

1.4.1 Need for Automated Process Planning

Process Planning is the key element in manufacturing cycle, from design stage to actual production. Process planning is "The function within a manufacturing system that establishes the processes to be used in order to convert a piece-part from its initial form to a final form which is predetermined on a detailed engineering drawing".

In recent years, Automated Process Planning has received much attention in the industry. This is attributed to the following:

➤ Each of the operation has to be determined based on the surface finish, tolerance to be achieved, size and material of the part. This requires highly skilled personnel with years of experience in the field of process planning.

➤ The quality of process sheets heavily depends on the intelligence and experience of the process planner. There is a high probability of loosing all the knowledge along with the expert unless some means are found to preserve the much needed knowledge and expertise.

➤ Even for an expert formation of a good and efficient process plan is time consuming job. In today’s market condition it is necessary to develop a process plan in short span of time.

➤ Industries are moving from stand-alone installations to integration of systems, which makes computer integrated manufacturing a necessity. With the emergence
of CIM, process planning has received significant attention and has become a vital objective of CIM systems.

Development of an Knowledge Based Process Planning system helps process planning in a manner that it is possible to add, delete and modify facts and rules in the knowledge base without modifying the program, i.e., it learns new things according to embedded learning procedures.

Good progress is being made in the automation of the actual production process and also the product design elements. CAPP has the potential to achieve the integration between design and production.

1.4.2 Knowledge Based Systems

With the advent of Artificial Intelligence, computers can be made to simulate human intelligence to perform complex tasks which only skilled personnel, having expertise gained over years of experience, can perform. This project deals with the development of an expert system based on generative approach to perform the task of a process planner in a manufacturing industry.

In the past, traditional computer programs have been used to solve formalized problems, where the statements and problems are well understood. The problems that were ill formalized and less understood led to the development of Artificial Intelligence (AI), particularly in the form of knowledge-based systems (KBS).

Knowledge based systems are developed from the field of artificial intelligence, which in turn is a branch of computer science. AI attempts to adapt, learn, invent and accumulate the combined wisdom of profession. With the advancement in microcomputers, new doors have opened into knowledge based system.

In an AI system there are two principal methods in problem solving: weak methods and strong methods. Early AI methods tried to emulate human process of information processing and learning. These general problem solvers were determined to be weak formulations at best. Because they were domain independent, they tended to" blow-up" due to a lack of focus. The domain independent knowledge was learned as tasks were solved. These were soon realized to be insufficient. As a result strong formulations emerged from the weak ones.

Knowledge based system uses one of the two types of solution techniques in arriving at a solution. There are two approaches
- Formation approach: using deductive logic uses facts from a known state to arrive at a known solution. Control strategies used are forward chaining, backward chaining and mixed initiative.

- Derivation approach: This approach uses information about the present state to propagate more information to form higher level solutions from eligible solution components in the knowledge base.

1.4.2.1 Architecture of Knowledge Based Systems

Knowledge based systems incorporate If-Then production rules, certainty factors and an inference mechanism.

![Fig 1.2 Architecture of a Knowledge Based system](image)

The various components of knowledge-based system are illustrated in Fig 1.2 and are discussed here:

- Knowledge base: The knowledge base contains facts and heuristics associated with the domain of knowledge-based system. The knowledge -base should be transparent enough for easy modification. This allows updating the knowledge without changing the program.

- Inference Engine: The inference mechanism contains the control strategy to arrive at a conclusion from the facts of the knowledge base. It retraces the knowledge base in a specific order and arrives at a particular solution.
• Explanation facility: The explanation facility is used to trace the reasoning order and to answer the questions about the reasoning behind the solution procedure. The knowledge-based systems will then respond as to why the particular question asked be of importance.

• User interface: This is the part for the user to communicate with the knowledge-based system. The interface should be highly interactive and should include such things as help and explanation facilities.

Today there is an urgent need of automated process planning due to the rapidly diminishing number of experienced process planners. Productive CAPP system must contain tremendous amount of knowledge facts about machine shops and rules about machining operations. Further more the system must be flexible to suit today’s manufacturing environment.

1.5 Problem Identification

In the present context, the need for developing a bridge between CAD and CAM has been identified. The work has been carried out keeping in view of the requirements of Defense Research and Development Laboratories (DRDL), Hyderabad. DRDL, one of the leading research institutions in the country, is involved in the development and fabrication of defense components. The process planning section of DRDL prepares the process plans for the manufacturing of a large variety of components. A generative type of process planning system for axisymmetric components is already available with that section. Most of the components encountered in DRDL are prismatic; thus the need for development of software for prismatic components process planning has been felt. As the 3-D CAD modeling package used at DRDL is CADDS 5, a CAPP package, which uses the CAD models from the CADDS 5 as input, has been planned. The various problems associated with the development of an automated process planning system are investigated in this work.

1.6 Present Work

This CAPP system is to be designed in a modular fashion, each module responsible for performing a specific task starting from, feature extraction from the solid model to process plan generation.
The following distinct tasks were, therefore, identified and analyzed.

☞ Feature Extraction & grouping: This task will extract the manufacturing features from the CAD models.

☞ Part classification & coding: Features of a part are grouped and classified and codes are assigned to them for archival and retrieval purpose.

☞ Database management: Information about CAD model, raw materials, machines, tooling, cutting parameters, inspection gauges, process plans etc. are to be maintained efficiently. This aspect is studied in this module.

☞ Process generation: The raw material selection, the operations to be performed to realize each part feature, and the sequences of these operations, depending upon the part geometry, feature geometry, dimensions and tolerances, etc form the core activity in process planning. This problem is investigated in detail in this module.