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Computer Aided Process Planning using STEP Neutral File for Automotive Parts

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***Abstract*- Automation of production systems for improvement in production efficiency and manufacturing flexibility has become one of the key issues in manufacturing industry and the only way to achieve this, the realization of a computer integrated manufacturing environment in which computer aided systems work together with an integrated approach to support the life cycle of a product leading to enhancement of production efficiency to a greater extent. In this paper we will discuss the important role of the product data exchange standard STEP in the integration, as well as how to apply STEP in the development of our STEP-based CAD/CAPP/CAM integrated system and presents a framework is proposed to support integration of CAPP with CAD system. After analyzing the STEP AP-214 neutral file, a method for extracting the basic features of automotive part from STEP AP-214 of 3D model is proposed.**

Key words: CAPP frame work, CAD, CAM, STEP AP-214, standards, Feature integration.

I. INTRODUCTION

The manufacturing industry is increasingly dependent on digital tools, such as computer-aided design (CAD), computer aided engineering (CAE), computer-aided manufacturing (CAM), and product data management (PDM) systems to design and manufacture products. Collaborative e-engineering requires different digital tools in different phases of the product development process. The use of computer technology for process planning was initiated four decades before. Since then, there has been a large amount of research work carried out in the area of computer-aided process planning (CAPP). One of the reasons for this is the role of CAPP in reducing throughout time and improving quality [1].

Computer Aided Process Planning is the link between Computer Aided Design and manufacturing, A process plan comprises the selection and sequence of operations and associated processes to transform a chosen raw material into a finished product [2].

"STEP, Standard for the Exchange of Product Model Data, provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle including design, manufacture, utilization, maintenance, and disposal. The information generated about a product during these processes is used for many purposes. This use may involve many computer systems, including some that may be located in different organizations. In order to support such uses, organizations must be able to represent their product information in a common computer interpretable form that is required to remain complete and consistent when exchanged among different computer systems.

STandard for the Exchange of Product model data (STEP) is actually a series of standards, known as ISO 10303 developed by experts worldwide [3]. As the area of application of the STEP standard is extremely broad, it is issued in numerous sections, identified as Parts. The Parts known as APs (Application Protocol) define the scope, context and information requirements of applications [4, 5]. The STandard for the Exchange of Product model data (STEP - ISO 10303) provides a neutral computer interpretable representation of product data throughout the life cycle of a product, independent of any particular system.

Almost everyone involved with product design and/or manufacture, whether it is mechanical, electrical/electronic, or electromechanical, agrees on the importance of being able to exchange product data effectively among contractors/customers and subcontractors/suppliers who often use different CAD/CAM/CAE systems. Manufacturing is frequently outsourced. Accurate, complete product data is essential for the production and procurement of quality products. The issue of "standards" usually comes up in discussions about data exchange.

1.1 step fundamentals:

STEP is an International Standard for the computer-interpretable representation and exchange of product data. The objectives are to provide a neutral mechanism capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also a basis for implementing and sharing product data bases, and archiving.

The information generated about a product during its design, manufacture, utilization, maintenance and disposal is used for many purposes during its life cycle. The use may involve many computer systems. The product information should be represented in a common computer- interpretable form that is required to remain complete and consistent when exchanged among different computer systems. STEP is just to meet this requirement.

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STEP is organized as a series of parts, each published separately. The parts fall in to one of the following series:

1. Description methods.
2. Integrated methods,
3. Application methods,
4. Abstract test suites,
5. Implementation forms,
6. Conformance testing.

STEP uses a formal language, EXPRESS, as a description method, to specify the representation of product information. The use of a formal language enables precision and consistency of representation and facilitates development of implementation. STEP separates the representation of product information from the implementation methods used for data exchange. The representation provides a single definition of product information common to many applications. The series of integrated resources is the common definition. It can be tailored to meet the needs of specific applications. An application protocol specifies the representation of product information for one or more applications. The implementation methods used for data exchange support the representation of product information included in application protocols. They describe how to implement product data exchange in various computer systems. STEP also provides a methodology and framework for the conformance testing of implementations. For each application protocol, there is a corresponding abstract test suite which contains the set of abstract test cases for the application protocol to support the conformance requirements.

Although STEP has not been approved as an international standard, the present documents have rich contents that can be a sound support to CAD/CAPP/CAM integration. The integrated resources include fundamentals, geometry, topology, product configuration, material, tolerances; form features etc. aspects of product information throughout the life cycle. Several application protocols have been outlined. Implementation methods of file exchange and application progressing interface are presented.

1.2. Step neutral file:

STEP (Standard for the Exchange of Product data) is a world wide effort to develop mechanisms for the exchange and sharing of engineering data. The requirement is that product features must be transmitted with geometry. ISO-10303 is an international standard for computer interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the lifecycle of a product, independent from any particular system. For mechanical parts, the description of product data has been standardized by ISO-10303. ISO-10303 informally known as STEP, describes an ASCII representation, it does not provide any information about state and it only represents a snapshot in time. The nature of this description makes STEP suitable not only for neutral file exchange, but also as a basis for implementing, sharing product databases. The STEP file is based on the Boundary Representation (B-Rep).

In manufacturing, STEP-10303 has become a widely used standard for product data representation and exchange. STEP includes a series of International standards with the aim of defining data across the full engineering and manufacturing life cycle and the ability to share data across various applications.

1.3. CAD/CAM Integration:

CAD stands for Computer Aided Designing and CAM stands for Computer Aided Manufacturing. The combined CAD/CAM is the technology concerned with the use of computers to perform product designing and manufacturing operations. In the earlier days the CAD and CAM were considered to be two distinct technologies independent of each other, however, now there has been greater integration of CAD and CAM.

Fig 1: CAD, CAM Integration

All the products that have to be then manufactured, have to be designed first and they are sent for manufacturing. Let us see the important processes involved in CAD/CAM integration:

- ***Designing of the product***: First of all the product has to be designed by considering the applications desired from it and carrying out various stress and strain analysis. All these processes are carried out in the computers using appropriate CAD software. At the end of the designing process the product of appropriate shape and size is found designed.
- ***Making the drawings***: After designing the product, the assembly drawings and parts drawings of the product have to be made. These drawings are used for the reference purposes and more importantly for manufacturing the product on production shop floor. The drawings are also made by using CAD software.
- ***Production planning and scheduling***: The production planning and scheduling of the designed product can be carried out in the computers, which helps properly managing the manufacturing resources. There are some special product planning and scheduling software that can be used for this application. This is the CAM part of the product cycle.
- ***Manufacturing the product***: The manufacturing of the product can be carried by using the computers. The machines that are operated by the computers are called Computer Numerically Controlled or CNC machines. Nowadays the use of CNC machines has become very wide spread. In CNC machines the programming instructions for the manufacturing of the product that has been designed using the CAD software are fed. This program can also be fed directly from the CAD software into the computer of CNC machine. The program gives the appropriate instructions to the computer to carry out the manufacturing of the product as per the required dimensions.[6]

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2. PRODUCT DATA EXCHANGE IN STEP:

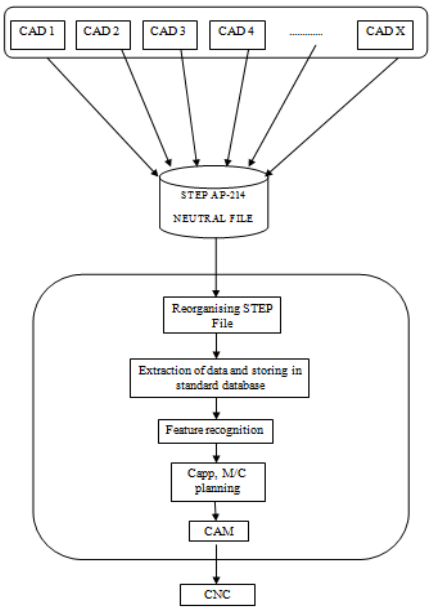

Fig 2: Product flow process flow chart

Figure 1 shows the architecture of the integration CAPP system. The overall system consists of three main subsystems: the CAD system, the process analysis and matching system, and the process-planning system. The first CAD system uses feature-based modeling for part design and generates the raw design data that will be converted to a data file in neutral format (e.g., STEP AP214 file). The second system, which functions during the whole product lifecycle, is to analyze and represent process knowledge according to the collected process information and match the collected process knowledge with existing knowledge for decision support. The third system consists of the following tasks, which are detailed in the following sections:

- Extraction of process features
- Management of features
- Complex feature decomposition
- Features combination and relationship identification
- Feature-extraction-based process planning
- To develop a AP214, STEP based CAPP system for automotive parts concentrating on the automation of feature recognition, machining planning, NC code generation and transfer of process plan to a standard CAM system and CNC machine for the realization of product,
- To provide a system that result in crucial integration between CAD, CAPP, CAM and CNC, also serves as a major step towards achieving CIM, leading to the automation of production systems for improvement in production efficiency and manufacturing flexibility.

Traditionally engineering drawings have been used to convey part specifications and description; however it is found that an engineering drawing is not a suitable mode of input for CAPP systems and as an alternative CAD representation of part model is successfully employed as the input for CAPP system. Hence, it has become common practice to represent a designed part through its CAD model.

The product data stored in the database of CAD systems, generated during the design and modeling process should directly flow to CAPP and from CAPP to CAM for seamless integration of CAD, CAPP and CAM. Therefore in real life manufacturing environment there is always a need to manage data transfer between the CAD platform and other systems for various applications. However, practically such flow of product data encounters considerable difficulties, because each computer aided system has its own internal data model which is a proprietary data format. This makes efficient flow of product data form CAD to CAPP, then to CAM has become a significant research area to be focused and to resolve this, the data exchange issue should be addressed by means of adopting a common file format which the different computer aided system can read and process easily

By using direct translators between CAD and CAPP and between CAPP and CAM the data can be transferred, but the problem with this is, every different computer aided system requires a different translator, so there will be large number of translators required to handle all computer aided systems in the world. Another method is adopting neutral file format , a neutral file can defined as , the file with a format which is independent of any specific system standards and which acts as an 'agent' to connect dissimilar computer systems that cannot normally communicate with each other due to format incompatibility.

It should be noted that neutral format is the 'acceptable' and consistent format within an organization or a group of organizations and the format may differ from other organizations which may set their own format standards. A review shows that companies are using neutral format files to achieve integration of manufacturing systems. In this research , ISO standard STEP -10303-21, AP-214 is suggested to be the standard for the neutral file due to the fact that it is a universally accepted standard for conversion programs available for proprietary CAD packages including AutoCAD, CATIA , Unigraphics , Solid-Edge , Pro/Engineer , CADDS etc. Furthermore, Feature data in STEP AP214 format are used to obtain the type of machine features and their attributes presented in the part.

3. LITERATURE SURVEY:

A significant number of research papers are reviewed related to, integration of CAD, CAPP, CAM and CNC, Computer Integrated Manufacturing (CIM), Computer Aided Process Planning (CAPP), Product Data Management (PDM), Product Life cycle Management (PLM), Product Data Exchange between different CAD systems, Neutral file concept, ISO standard 10303 Standard for Exchange of Product model data (STEP) and specifically STEP Application Protocol (AP) – 214, which is designed for Automotive Parts. The benefits of CAPP systems are yet to be realized in industrial applications. Even though a considerable amount of work has been carried out on the development of CAPP systems over the last three decades, the benefits of CAPP systems are yet to be realized in industrial applications. In the past, Alting and Zhang [7], Steudal [8], Eversheim and Schneewind [9], El Maragy et al.

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[10], Ham [11], Weill et al. [12], Kiritsis [13] and Cay and Chassapis [14] have made extensive surveys of the CAPP literature and have given future directions for CAPP. Cay has given a detailed survey of the latest directions of CAPP systems and has stated that the ultimate goal of computer integrated manufacturing (CIM) and concurrent engineering is to integrate design, manufacturing, shop floor activities, and management activities. The following directions were given in his survey.

1. In the future, agent based distributed engineering systems will provide a basis for the integration of concurrent product development activities.
2. There is a need for a universal language for communication among heterogeneous systems of CIM. It is also mentioned that agent-based systems may give solutions for this problem.
3. Most of the present CAPP systems are single domain systems such as for machining, sheet metal working, or assembly, but in real-world industrial applications, there will be interaction among these domains. So it is suggested that, in future, interaction of these domains should be taken into account when developing CAPP systems. Further, it is also suggested that manufacturing domains such as joining processes, casting, metal forming, and fabrication of plastics and composites should be considered for process planning. In a standard process plan, the data related to part inspection and statistical process control should be included.
4. There is a need to develop user-friendly artificial intelligence (AI) software tools in order to solve some of the problems in computer-aided process planning.
5. Optimization techniques should be employed in order to reduce cost during design and manufacturing.

4. OBJECTIVES:

CAE systems involved in every stage of product life cycle mainly uses the product data produced by the CAD systems and integrated manufacturing data produced by CAPP and CAM systems. As the degree of automation and CAD/CAM integration increases, the inclusion of high level information with the product data and its seamless flow in CAD-CAM-CNC chain becomes a necessity.

The objective of this work is to develop a system for automotive part design using STEP AP214 features, enabling the inclusion of high level information about the product besides geometry, and automatic generation of NC-code using this data in neutral format. The developed system aims to incorporate the small and medium sized Automotive manufacturing enterprises into the e-manufacturing chain by adopting the NC-code based CNC machine tools without any modification of the controllers.

5. METHODOLOGY

As mentioned above, most of the CAD systems available in market today have built in facility of representing designed part model in STEP AP 214. Using any of these packages the STEP AP 214 representation of CAD model can be obtained. Using this neutral file it is possible to integrate the CAD, CAPP, CAM and CNC systems. For this first the CAD model of the designed part is represented in neutral file format and then process it to make the CAPP system accept this neutral format for the generation of optimal process plan for the given part and finally the output of CAPP system is transferred to a standard CAM system for automatic generation of CNC codes.

The neutral file defines the CAD data of a designed part in terms of low primitive geometric entities such as vertices, lines, curves and surfaces which cannot be used directly for the automation of process planning activities. It is necessary to process the neutral file and reorganize the data to convert it into manufacturing features. It is because, for a product the manufacturing features are the volumes which are removed by one or a series of operations and it is possible to associate manufacturing information with them. Therefore, features are considered the communication medium between design and manufacture and the automation of process planning begins with the implementation of feature recognition procedures. Accordingly feature recognition is considered as the first and most important activity in the development of a CAPP system which leads to the automation of subsequent activities of manufacturing planning and also shop floor activities such as scheduling.

6. POSSIBLE OUTCOME:

The possible outcome of the research is the integration of CAD, CAPP, CAM and CNC through seamless data flow from CAD to CNC machines for manufacture of Automotive Parts. This will be achieved by developing software which is independent of proprietary data format ISO 10303 AP-214.

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