Software System of Integrated and Simultaneous Engineering

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Abstract: - This paper presents an integrated software system that allows simultaneous and integrated approach of design (CAD), process planning (CAPP) and manufacturing (CAM) of the products. The whole system, named SIIRoD, is developed on the basis of constructive-technological entity concept and is designated for developing parts of the spur gears family in accordance with the simultaneous engineering principles.

Key-Words: - Simultaneous/concurrent engineering, Constructive-technological entity, CAD, CAPP, CAM

1 Introduction

The essential idea of concurrent engineering (CE) is to put the majority of effort in the product design stage to analyze the factors which might affect subsequent production processes, and hence save overall product development time[9], [6].

Even though the CAD/CAM systems have been significantly developed they required a fully defined of product from geometrically point of view in order to pass to the stages of downstream design as process planning and manufacturing [1]. They do not allow establish the technological sequences of the entities or for a certain side of workpiece before it to be finished.

Great savings in machining times and costs can be achieved if designers can solve machining problems of the products at the design stage. This can be obtained only through making the manufacturability analysis of entities simultaneously with their definition, thus integrating technological and manufacturing information since phase CAD.

CAD/CAM integration [2] is a technology that realizes automatic transmission and conversion of information among CAD, CAPP, and CAM. Currently, features are widely used for product modelling [5]. They play an important role for integrating CAD and CAM.

Moreover, the constructive-technological entity is the medium of information transmission in CAD/CAPP/CAM integration because besides the geometrical design information it carry non-geometrical design information too (like tolerance, roughness etc.). Since the CAD phase, they allow taking into account the technological and manufacturing aspects thus facilitating Concurrent Engineering [3], [5].This information are very useful for process planning and manufacturing at the conceptual or early design stage is the key for designers to evaluate manufacturability.

Even if some systems integrate design and process planning to allow simultaneous design with process planning [8] however, design process planning and manufacturing are sequential activities, and integration is limited to sharing of a common data model.

This paper introduces an integrated software system based on the constructive-technological entities. The integrated system, named SIIRoD, is developed in Visual LISP environment using AutoLISP programming language and Dialog Control Language and allows simultaneous approach of design, process planning and manufacturing for the parts of spur gear family.

2 Integrated Software System - SIIRoD

SIIRoD system is a software that enables simultaneous and integrated approach to the processes of design, process planning and manufacturing and is the result of the integration of three software systems: PRoDi-CAD, PRoDi-CAPP and PRoDi-CAM [3], [4], [5]. The system integrates the activities above mentioned by integrating the databases of the three software products (Fig.1).

2.1 PRoDi-CAD Software System

PRoDi-CAD software product was created as a development in AutoCAD, VisualLISP and DCL (Dialog Control Language) and is designated three-dimensional design of spur gears by means of 3D constructive-technological entities using synthesis by entities/features method [3], [5]. As structure, PRoDi-CAD system consists of several modules. Each module, in his turn, is made up of other modules/sub-modules having a corresponding to a certain constructive-technological entity.
This structure allows developing of system by integrating new modules, hence by integrating new constructive-technological entities. In this way, the system can ensure constructive design of all revolution parts in whose geometry can be identified the entities contained in the system library. The system, also, enables the generation of work drawings of the parts as well as the technological sketches of process plan generated by PRoDi-CAPP system.

An essential aspect, both for CAD system and the activities of the downstream design, is the manner in which the data associated of each type of entity, both geometrical and non-geometrical (roughness and dimensional deviations) are saved. These data, for accessing and using in all programs of developed systems are stored in the CAD database by using the extended data technique associated to the entities. In this manner, the extended data are accessed, extracted and used in all systems of the software tool SIIRoD such as in the process planning (PRoDi-CAPP system) and machining (PRoDi-CAM system).

2.2 PRoDi-CAPP Software System

Computer Aided Process Planning – CAPP is recognized as the interface between the design (CAD) and manufacturing (CAM). Solving the technological problems depends on the manner in which the data, both geometrical and non-geometrical, are taken over by the specialized software for technological analysis.

From this point of view there are two possibilities used in processing planning: on the one hand, the individual approach of the process planning phase, on the other hand the integrated approach of the technological phase when the characteristic part data are taken directly from CAD.

This possibility is greater than the first and in accordance with the CAD/CAM technology and principles of simultaneous and integrated engineering. Therefore, the representation of parts by constructive-technological entities becomes a crucial element within the medium of information transmission in CAD/CAPP/CAM integration because besides the geometrical design information it carry non-geometrical design information too (like tolerance and roughness), thus facilitating concurrent engineering (CE).

Software system PRoDi-CAPP, as way of solving technological problems, falls within the category of systems that work in integrated manner with CAD hence the data for each entity/group of entities are taken directly from the PRoDi-CAD system.

The software product PRoDi-CAPP allows generating the variants of micro-process/technological process for each simple or complex constructive-
technological entity. The system also calculates the machining allowances, cutting parameters, the machining time and the estimated cost for each processing phase/procedures, work time and the estimated cost at the operation level etc. manages all sub-programmes from retrieving geometrical and non-geometrical data associated to the entities to generation whole technological process and technological documentation (process plan and/or CNC files) [3], [4]. PRoDi-CAPP system assures generation of technological sequences (optimal technological procedures of machining) relating to each simple or complex entity since CAD phase before the workpiece to be completely define from geometrically point of view.

As structure, it consists of three main modules, namely:
1. Identification Processor - it has the role to identify the simple constructive-technological entities that must be grouped (obtaining complex entities) in order to be manufacture of the same clamping (an operation) and hence can be generated a micro-process of machining;
2. Technological Processor - it has the role to solve, by means of several modules/subprograms, all technological problems from getting geometric data and precision parameters from the CAD to generate optimal technological sequences of entities.
3. Editing Processor/Postprocessor - it sorts the processing procedures within an operation as well as establish the sequence of operations and finally completes the process plan and generates/writes NC files.

2.3 PRoDi-CAM Software System
PRoDi-CAM system enables automatically generation of CNC files for turning machining [3], [5]. CNC files can be obtained both for workpiece partially defined from geometrical point of view, for which was established technological sequences of machining, thus allowing taking into account the technological (CAPP) and manufacturing (CAM) aspects from the beginning (CAD phase).

The complexity of algorithms that underlie the system derives from two aspects. On the one hand, the PRoDi-CAM system will always generate CNC files only for the processing procedures which are selected of those technically possible by the PRoDi-CAPP system. On the other hand, in order to generate the CNC files, the PRoDi-CAM system, by means of the specialized algorithms, extracts all data directly from the databases of the PRoDi-CAD and PRoDi-CAPP systems (Fig.2).

In this manner the designer can evaluate the manufacturability of the design so that some potential manufacturing problems can be exposed and eliminated at the early design stages.

2.4 Operation of Integrated System SIIRoD
Integrated system SIIRoD was developed for simultaneous approaching of activities regarding design, process planning and manufacturing of products in accordance with the sequence of the simplified algorithm from figure 2.

Fig. 2 Sequence of simplified algorithm of integrated system-SIIRoD
From this point of view, the system allows operating in two variants, as following:

1. For each simple entity or significant part of the workpiece, the system allows established since CAD phase, when the part is not finished from constructive view point, of machining procedures, machining time and cost as well as the simulation of CNC files. This way of approaching allows to the user to analyze time and cost of machining for different alternative of procedures, materials, machines-tools or cutting tools so that, since this stage, to be taken the best decisions concerning process planning and manufacturing of product.

When the workpiece is geometrically finished, after a simple reordering of optimal procedures (already established) can be generated the final process plan and CNC files.

2. The workpiece is geometrically completed and for each simple entity or significant part are established the machining procedures.

Whether is chosen the first or the second variant of operation, after completing the workpiece geometry, the system allows the following actions:

- obtaining the work drawing of workpiece current modelled;
- generating the final technology of workpiece. In this stage takes place the grouping and reordering of the procedures related to technological sequences previously established for each simple entity or significant part of workpiece, establish the machining operations and their sequence, elaboration of technological sketches, completing the files of process plan as well as generation of CNC files for finished workpiece.

### 3 Conclusion

Integrated software system, SIIRoD, can be considered as a system of simultaneous and integrated engineering that aims approaching of design and manufacturing activities by view of simultaneous engineering method known as design for manufacturing (Design For Manufacturing - DFM).

From this point of view, the developed system integrates the processes of product design with the processes of machining and manufacturing. It allows reducing development time and launching of the products by removing discontinuities between phases of product life cycle as a result of parallel approaching of activities as well as avoiding reiteration of some activities.

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### References:


