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COMPUTER AIDED SYSTEM FOR DESIGN & PROCESS PLANNING OF SPUR GEAR

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ABSTRACT

The design and process planning activity of spur gear involves number of iterations before an acceptable solution is arrived at. Doing this manually is error prone and time-consuming process. The present paper describes the development of a system to automate the design and process-planning activity for spur gear. The system is developed using the computer programming language Visual Basic 6.0 and Microsoft Access.

The system is divided into five modules. The module 1 for Material Library form, module 2 for Machine Tool Library form, module 3 for Spur Gear Design form, module 4 for Process Planning form and is sub divided into Variant type Process Plan and Interactive type process plan and module 5 for generation of documented reports.

KEYWORDS: CAD, Module, Spur Gear, CAPP and Reports.

INTRODUCTION

Gearing is one of the oldest and most important critical components in a mechanical power transmission system. Spur Gears have straight teeth parallel to the axes and thus, are not subjected to axial thrust due to tooth load i.e. there tooth traces are straight-line generators of the reference cylinder. The design process of spur gear involves number of iterations before an acceptable design is arrived at. This also takes into account the consultation of various charts and tables for extraction of the required data. Doing this manually is error prone and time-consuming process. The process planning of spur gears involves number of operations including machine tool preparations, routing charts, process-planning parameters, tooling design etc. The preparation of routing charts/process plans if done manually requires lot of time of process planner. The present work is in a direction of automating the design and process planning activity of spur gear so as to reduce the time and error involved in the activity. This automation is done using the computer programming language visual basic 6.0 [1] and Microsoft Access [2]. The same existing traditional approach to design and process planning is followed. The only difference is the use of a computer.

The approach followed is based on the user input, depending on which the required data is extracted from the database within the program. This database consists of the information from the tables and charts stored in database. The design of the gear is tested for various loads and stresses until an acceptable solution is reached. The final dimensions are also stored in the database & can be displayed on the graphic window. In the similar fashion the process plan for the gear can also be generated & display in the graphic window.

The Computer Aided System for the Design and Process Planning of Spur Gears is divided into five modules. The module 1 for Material Library Interface, module 2 for Machine Tool Library Interface, module 3 for Spur Gear Design Interface, module 4 for Computer Aided Process Planning of Spur Gears Interface and is sub divided into Variant type CAPP module and Interactive type CAPP module and module 5 for generation of Documented Reports.

LITERATURE REVIEW

Many researchers are working for developing CAD systems for the manufacturing industries to have automatic and optimal design systems since the last three decades. Prasad D Yalla [3] developed a web-based system for the design of spur gear, which uses SI & English system of units. The input data involves either the horsepower or torque at a particular gear, the materials for the pinion and gear, the operating centre distance, number of teeth on the pinion and gear, the pressure angle, face width, pinion RPM, operating temperature, module or diametral pitch. The outputs from the system are face width,

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clearance, backlash, Tooth deflection, circular pitch, interference and other required parameters. Savage, M., et al [4] worked for the optimal design of compact spur gear reductions. It includes the selection of bearing and shaft proportions in addition to the gear mesh parameters. Shuo et al [5] developed a computer-aided design system for generating bevel gears. Timothy R. Griffin [6] developed computer aided design software for torsional analysis of gear. Dr. Veniamin et al [7] has presented a new approach based on the application of a special type of geometrical objects named blocking contours (BC) & developed computer aided design software for design of spur and helical gears. Božidar Rosić [8] presented the kinematics and computer aided procedure for the design of internal involute spur gears. A computer program was developed to design the gears for the given set of kinematics model. Ferreira B., Joseph [9] worked for the design of a system for cutting rudimentary spur gear on a laser cutter using some basic parameters of spur gear. The Laser Cutter quickly and accurately cut the outline of a gear from wood or plastic.

F. Azza, et al [10] worked for the evaluation and derivation of process plans in turning to minimize the total processing time and total number of processing steps. The problem of low efficiency and quality with many of the generative CAPP systems developed during earlier phase of computer-integrated manufacturing systems was studied by Chu et al [11]. Lau et al [12] introduced an intelligent rule-based computer-integrated system for reliable design feature recognition of components. Sadaiah et al [13] has developed CAPP using Visual Basic 6.0 as front end and Oracle 7.3 as back end for prismatic components that extracts the majority of features automatically prior to process planning. Gan, et al [14] has worked for the generation of a process plan for branch and bound algorithm based process-planning system for Plastic Injection Mould Bases with the use of artificial intelligence. Srihari et al [15] designed and developed a prototype CAPP system using artificial intelligence based expert system approach for the PCB assembly domain. Alam et al [16] presented the methodology of a computer-aided process planning system for the manufacture of injection-moulded components (IMOLDFCAPP). Tiwari et al [17] has worked for the development of process-planning system based on case-based reasoning methodology. Srihari et al [18] implemented the dynamic computer aided process planning systems for flexible manufacturing systems. Wu et al [19] had presented an object-oriented and fuzzy-set-based approach for set-up planning. Zhang et al [20] has discussed an automated tolerance based analysis approach of CAPP systems. Cay et al [21] provided perspective view on CAPP research. They have worked in the direction of developing variant, generative and hybrid CAPP systems using expert and artificial intelligence techniques. Liu [22] has proposed the feature based design and process planning through the integration of CAD/CAM.

The researchers were developing CAD & Process Planning systems for various types of components and industries. This motivated the authors to develop CAD system for the design and process planning activity of spur gears.

CONVENTIONAL DESIGN AND PROCESS PLANNING OF SPUR GEAR

Gear tooth design involves primarily the determination of the proper pitch and face width for adequate strength, durability and economy of manufacture. Various approaches for the design of spur gear exist. The design approach used in this section is based on the choice of face width. The size is obtained by using iteration, because both transmitted load and velocity depend, directly on the module. The computation procedure is to select a trial value for the module and then to make the successive computations for pitch diameter, center distance, pitch line velocity, transmitted load, velocity factor, face width, surface strength etc using standard formulae available in various literatures. [23]

The conventional process plan for the manufacturing of any spur gear depends very much on the decision, knowledge, and work experience of the process planner and is varied from person to person and industry. In addition to this variability among planners, there are always chances of difficulties in the conventional process planning procedure. New machine tools many times offer old routings, which is not optimal. During the machine breakdown the shop floor personnel uses temporary routings. This routings are documented and becomes permanent even after the machines are repaired. For this and many other reasons, the numbers of process plans used were not optimal. Figure 1 shows the conventional process route for spur gear.

COMPUTER AIDED DESIGN AND PROCESS PLANNING SYSTEM FRAMEWORK

The developed computer program consists of five basic modules and is accessed through a global interface form. The framework of the forms within the developed system is depicted schematically in

Figure 2. The global interface for the program is a parent form and is the main window for a program within which the other modules operate. Figure 3 is a picture of the global interface of the developed system with the five child forms open within the parent form. The child forms, which include the

Material Library, Machine Library, Spur Gear Design, Process Planning and Reports module, perform the specific tasks for which they are named. The child forms, which include the Material Library, Machine Library, Spur Gear Design, Process Plan and Reports module, perform the specific tasks for which they are named. The Design Module contains one sub-module form of design output, which stores the successful design data. The Machine Library form contains command buttons to access the forms of different machine tools. The process plan module form or feature input form contains sub-module forms of Interactive CAPP and Variant CAPP forms. Both the Interactive CAPP and Variant CAPP module forms contain Tool Sheet forms. The database consist of design data, material properties data and machine database which contains various machine parameters, process plan database i.e. different process plans are stored with complete details of operation descriptions, machine tools used etc. These databases are connected to respective graphic user interfaces. The details of the parent form and the child forms within this program will be provided in the following sections. The whole of the computerized design process and process-planning activity for spur gear is explained in the flowcharts shown in Figure 4 & Figure 5.

Material Library Module

This module deals with the storing of the various materials and their properties of the spur gear. It contains two data-grid controls connected to material properties database. One data- grid control is used for pinion materials and other is for gear materials. The module is updateable, i.e. any new material and its properties can be added very easily by clicking on the add button of the gear or pinion section.

Design Module

This module is used for the design of the spur gear. The controls on this form are material selection, input / output parameters etc of spur gear. The user has to enter the gear material, type and some of the given known parameters as input to the module. The other unknown parameters are than calculated. To choose the quality of the spur gear a graph between module vs permissible error and permissible error vs pitch line velocity is also given in the form. This form has one child form for storing the design data in the database. This is used for storage of various designs data. The design output form is connected to the design data table of the database and is opened by clicking on the “Show Design Data” command button.

Machine Library Module

This module is developed for storing the machine tool specifications, such as types, working and tool attachment parameters etc. This form contains text box and command buttons to add, edit and view the machine tool details.

Process Planning Module

The Process Planning module deals with the generation of computer aided process plans for the manufacturing of spur gears. This module offers speedy development of process plans for new gears with ability to accommodate variety of spur gears. The process plan includes machines, tooling, process cutting parameters, heat treatment and finishing and packaging for various gear manufacturing operations. When the user clicks on the Process Plan button of global interface form’s toolbar this form is opened. The various manufacturing features / attributes text controls of spur gear are placed on the form. These features are used as input for the generation of process plans. Two types of computer aided process plans are generated based on these features, variant type of process plan and interactive type of process plans.

When a new gear is to be manufactured, various features/attributes are entered in the database through process planning module form or feature input interface, the system searches process plan database for the process plan containing manufacturing operations related to these features. This is action is performed by clicking on the variant process plan button in the form. If the system finds the process plan, which contains similar manufacturing operations as required for, the given feature is displayed in the variant CAPP Interface. The process plan is then edited in the variant CAPP Interface to suit the new spur gear and is saved in the database. This documented process plan is printed and sent to the manufacturing department to manufacture the gear. If the system does not find the existing plan in the database, the user then clicks on the interactive process plan button to generate the process plan from scratch using manual aid i.e. entering the various

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manufacturing operations, machine tool parameters etc from the text and combo controls of the form.

Report Module
This module form deals with the printing of the reports (documentation) of material and their properties, machine tool data, design data and process planning data. This form has four sections- Material, Design, Machine and Process Plan. Each section contains text box controls and command buttons to print the required type of document.

RESULTS AND DISCUSSION

A CAD system for design and process planning of spur gear has been developed. The design module of the developed system successfully designs the spur gear for a given set of inputs as per the general procedure of design given in the various literatures. The material library module provides simple and easy access of viewing and updating of material properties data with the database. The machine library interface also provides a flexibility of storing of machine tool specifications as and when a new machine tool is introduced in the manufacturing shop. The process planning module of the system is capable of generation of computer aided process plan of variant type as well as generative type with manual aid. The feature input interface is easy to use. The report module interface is capable of generating any type of report needed in the design and process planning face of the spur gear. Many research have worked for the development of computer aided tools for design of spur gears or generation of spur gear process plans hence there is a gap of system having both the design as well as process planning activity to be included in the system. The developed computer aided system tries to fill this gap and is successful in implementing this. The system developed can be applied to gear manufacturing industries. The system is powerful and user friendly as it gives wider flexibility of using and updating knowledge.

CONCLUSION

.This paper has presented the development of computer aided system for the design and process planning of spur gear using programming language visual basic 6.0 and Microsoft access. The system developed can be applied to gear industries. The system is powerful and user friendly as it gives wider flexibility of using and updating knowledge. The system can be further developed to include automatic generation of 3D CAD model for analysis, NC part program generation, feature recognition technique, expert system and artificial intelligence. We are working in this direction so as to improve the whole design and process planning activity.

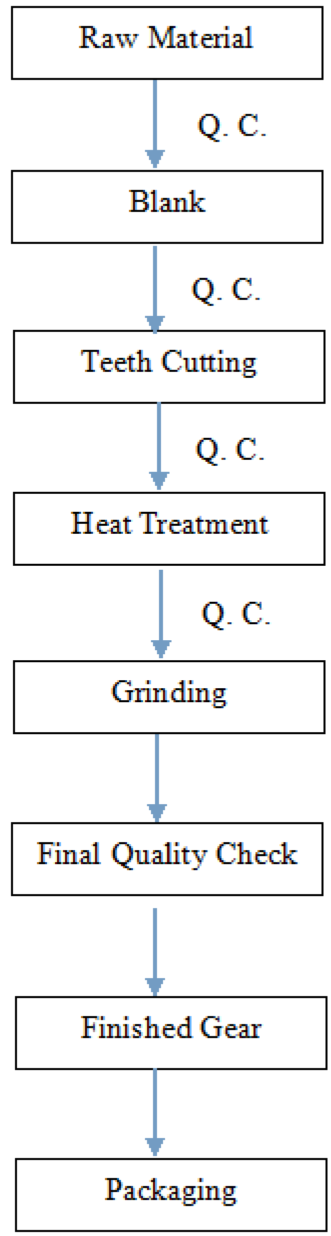

Figure 1: Conventional Routing for Spur Gear

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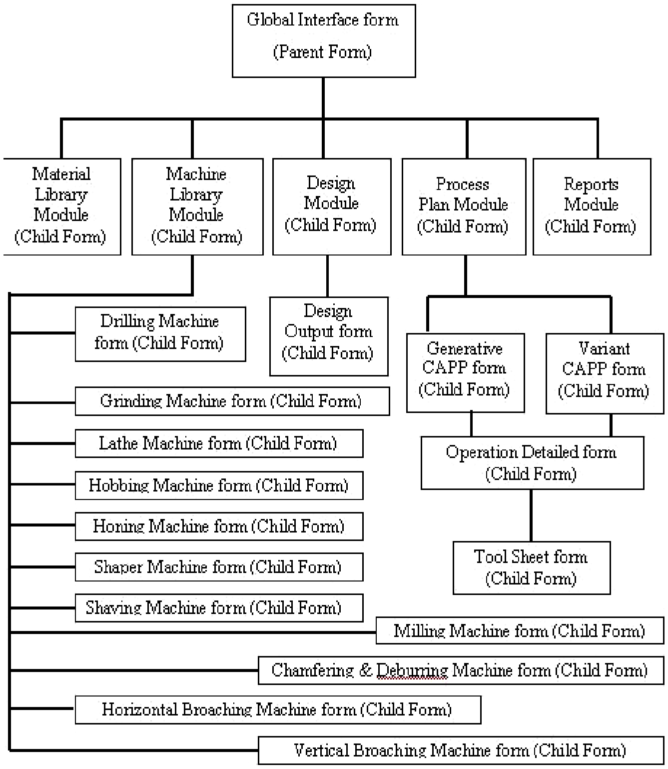

Figure 2: Schematic Diagram of Developed System

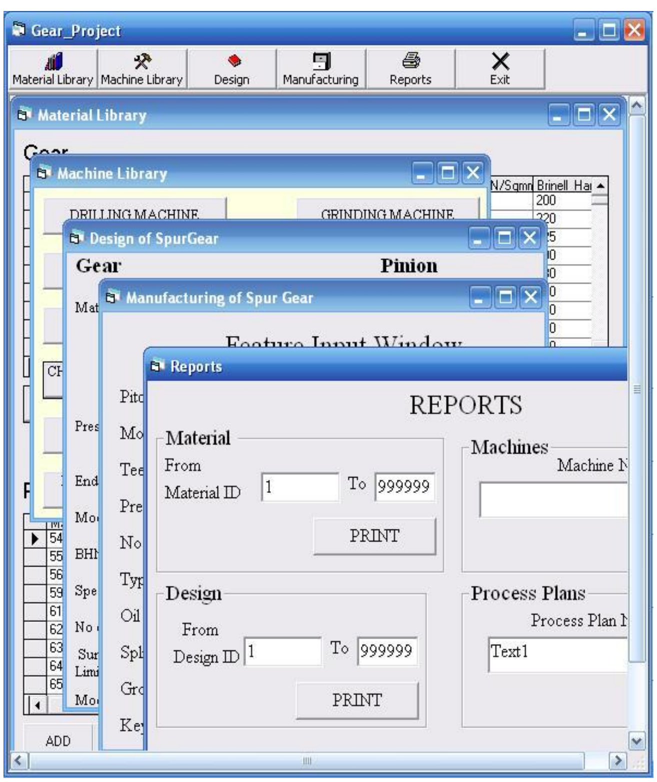

Figure 3: Parent Form/Child Form Hierarchy

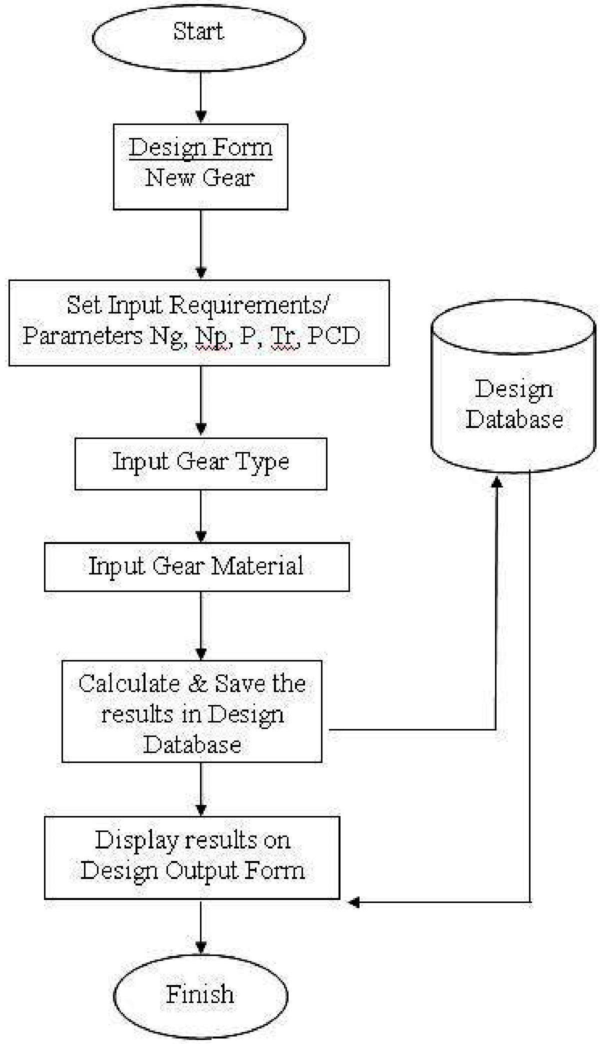

Figure 4: CAD Process Flow Chart

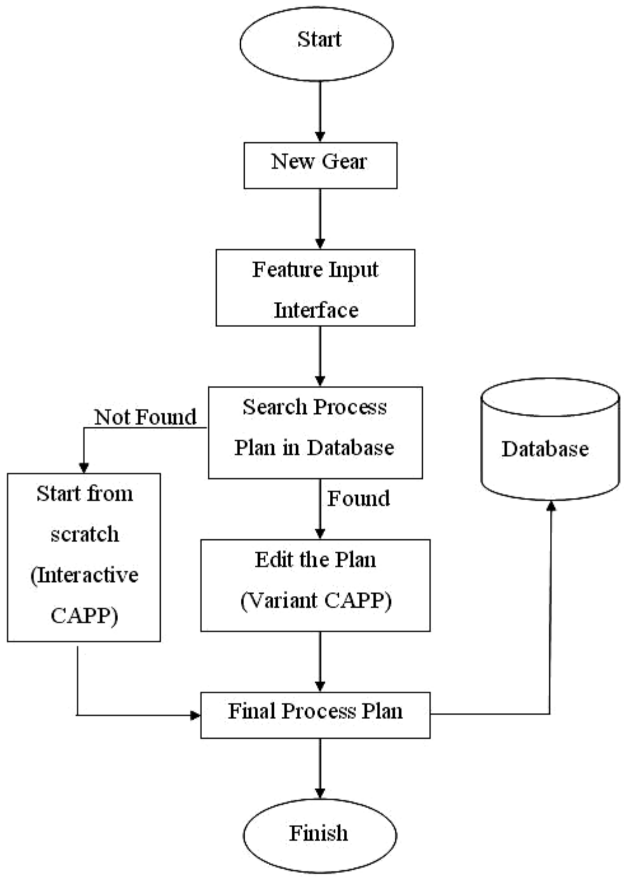

Figure 5: CAPP Process Flow Chart

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