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INTELLIGENT SYSTEM OF GEARBOXES DESIGN

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Abstract: *In this paper it is proposed an Intelligent Integrated System of gearboxes design as independent products. The CAD activities in correlation with expert system regulations are defined according to a given expertise domain (design of mechanical systems) that supposes taken into account and operating with two information categorie: knowledge and data. Knowledge processing as an expert rule base generally works with qualitative information that involves searching for suitable solutions and their combination into conception variants. Data processing is based on computational models and suppose inter-related with reasoning knowledge process. In order to generate an expert – CAD/CAE/CAM system of gearboxes design in this work it is presented an overall algorithm that integrate knowledge processing activities with solid modeling, analysis of behaviors and manufacture aspects.*

Key words*: Expert systems, Computer aided design, Gearboxes design, Total design, Finit element analysis*

1. INTRODUCTION

On basis of an expert system is an intelligent computer program that uses knowledge and reasoning procedures. Building an expert system, first involves extracting the relevant knowledge of practical problem domain (knowledge acquisition) in a way that its can be introduced in computer as a Knowledge Base.

The traditional generations of CAD/CAE programs that generally are focuses primarily on the aspects associated with representation of form and secondly on simulation the functionality performance capabilities are in contrast with tendencies included in actually design programs that are possibilities to take decisions of weather the solution is acceptable and, if it is not, how to make it adequate.

In order to generate the Knowledge Base for design it is necessary to description the domain knowledge using the following representation: features as a set of quantifiable

attributes [1]; relations as possible correlation between features; rules heuristic learned from experience or derived from generalizations of analytical results, knowledge of analysis methods, knowledge of design problem types, knowledge of design methodologies, knowledge of decision methods etc.

This paper develops an attempt to generate an Intelligent Integrates System that involves linking expert system stages with a CAD/CAE/CAM system for gearboxes design. In order to taken in account the quantitative and the qualitative information about the field of design of gearboxes was generated specific algorithms that allow computerized representation of these as data, knowledge and specific programs modules.

2. OVERALL STRUCTURE OF EXPERT CAD/CAE/CAM SYSTEMS

In figure 1 it is presented the structure of an Expert CAD/CAE/CAM System that incorporates two main subtasks: Knowledge Processing, and Data and Algorithms Processing. Knowledge Processing has purposes to representation the knowledge problem with a resolution according to the terminology and experience in the focused domain and fixes the conditions of execution of data processing subtask by definition what is or is not a good solution. Knowledge processing is grounded on the knowledge model which regroups expertise on explored domain and allows description and evaluation of the problem in terms of the expert. The knowledge modeling involves two stages.

First, knowledge preprocessing with two steps:

- Generate a topology of features as a "semantic group characterized by a set of parameters, used to describe an non-decomposable object useful for reasoning about one or several activities of design" [4]. Features are defined by sets of attributes defining various measures of physical characteristics such as load, speed, size, weight, color, form etc.
- Generate a topology of possible relations between features. A relation is defined by qualitative functions of attributes of the related features.

Secondly, knowledge representation involves two steps, too:

- Generate a set of rules used to create the knowledge problem model that is a translation of the problem data in terms

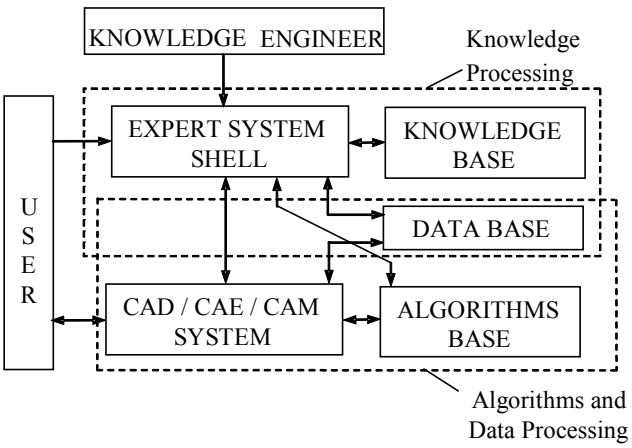

Fig. 1 Expert - CAD/CAE/CAM system chart

of the features and relations. The considered rules are with the general form IF <condition> THEN <consequence>, where the condition is in term of problem data and the consequence define the number and type of features and relations and/or values for feature attributes.

- Generate a set of evaluation criteria rules to quantify, what a good knowledge is, what a good problem model is and what a good solution for examined domain is.

Thus, the knowledge processing is a transformation of the problem input knowledge, using the rule set, in a knowledge model, in terms of features and relations, which is itself processed and evaluate by criteria functions to obtain the Knowledge Base as a computer representation.

Data and Algorithms Processing is the automatic input data which contain implicit alternatives and the systematic exploration of them to obtain the desired output data (it is an application of a given algorithm to the input data). The computational model uses the algorithms and work as quantitative constraints satisfaction and it is defined by:

- a set of problem variables with different possible values for these variable that define a state of problem a possible combination of values of variables,
- a set of problem constraints as a relation between the sets of values that have to be satisfied.

The aim of data processing is to find the optimized state of the problem and generate The Data Base as sets of input data that are used by Expert System Shell to reach a conclusion and by CAD/CAE/CAM package to reach an optimized solution.

The design activities involves finding various variables of problem and it is necessary to use a lot of calculus modules. The dimensioning and checking algorithms implemented in specific subroutines are stored in an Algorithms Base. The reasoning process supposes adequate algorithms that usually imply considering knowledge from Knowledge Base.

In order to develop efficiently an expert system was created independent structures named Expert System Shell that usually separate specific domain knowledge from more general aspects about knowledge representation and reasoning. The Expert System Shell programs usually contain the following modules: User Interface, Knowledge Base Editor, Inference Engine, Explanation Subsystem. The Inference Engine is used to reason with both the knowledge, typically being in the form of set “IF <condition> THAN <consequence>” rules, and specific data base, provided by the user and partial conclusions based on these knowledge and data, temporally stored in Working Memory, in order to the particular problem being solved. The dimensioning and checking algorithms implemented in specific subroutines are stored in an Algorithms Base. The reasoning process uses adequate algorithms that usually imply considering knowledge from the Knowledge Base.

3. EXPERT CAD/CAE/CAM SISTEM OF GEARBOXES DESIGN

In the figure 2 it is presented the structure of an intelligent system for design gearboxes on basis of chart presented in the Figure 1. In order to considering all quantitative and qualitative data and all algorithms calculus are presented in this diagram working modules based on data, knowledge, parts and scripts. In the first column from Figure 2 are presented data base modules that are attached to specific program modules (column 2). These modules are grouped in main algorithm of gearboxes design and work in correlation with specialized program modules (column 3) and expert system modules (column 4). Furthermore the specific program modules are in correlation with behaviour simulation programs based on finite element analysis and with many scripts for part and assembly modeling. The proposed intelligent system for gearboxes design was developed on bases of the following software environments: expert system shell, PROLOG flex; data base module, Excel and CAD/CAE/CAM system, CATIA. The Input data contain the Product Definition Specification which consists in a set of product attributes (inputs, outputs) and constraints associated with the product and optimization goals [3]. The Product Definition Specification attributes are included in three groups of information: *requirements* e.g. transmission power, input revolute motion, overall speed ratio, orientation of inputs/outputs shafts and distance between centers (Figure 3); *evaluation criteria*: size, manufacture costs, ease of manufacture, life etc.; *environment*: temperature, humidity etc. Using the functional diagram and the function structure, the *embodiment diagrams* are established which contain the first level of subassemblies and elements. In order to determine the unknown parameter values for each type of component (subassembly or elements) and for each type of joint a calculus algorithms or selection algorithms are associated (in the case of specialized components). The calculus tasks which are performed in detail design phase include: gear strength analysis, bearing selection, shaft design, design optimization, parametric design of parts, part and assembly modeling. The algorithms calculus are implemented as programs using CATIA Knowledge Advisor modules. The solid modeling of elements and assembly modeling are carried out using CATIA Part Design and Assembly Design modules. The CAE algorithms are implemented as scripts generated using CATIA Generative Structural

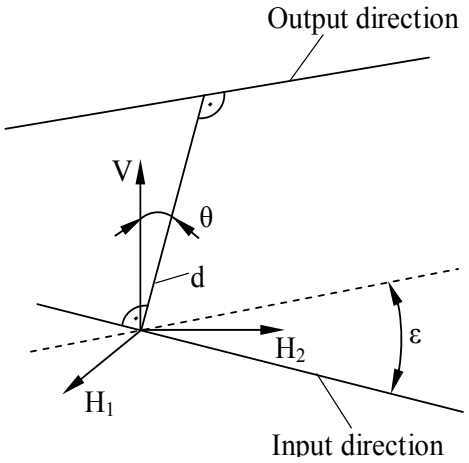

Fig 3. Layout of input/output position

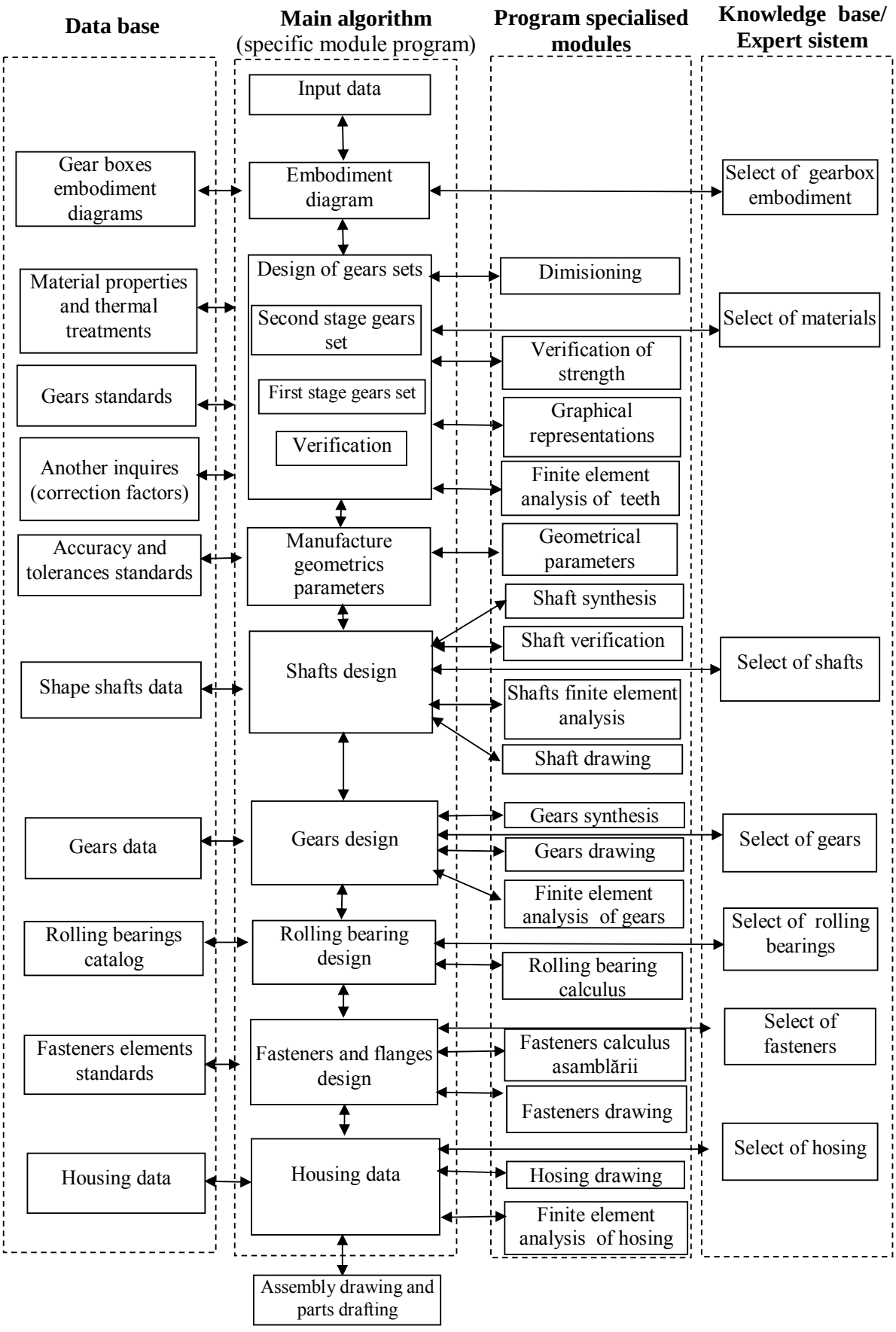

Fig. 2 *Chart of intelligent system of gearboxes design*

Analysis module that allows to finite element modeling assembles with considering virtual finite elements and various kinds of constraints and loading. For instance, in Figure 4 it is presented a finite element analysis model associated with the subassembly input shaft [2].

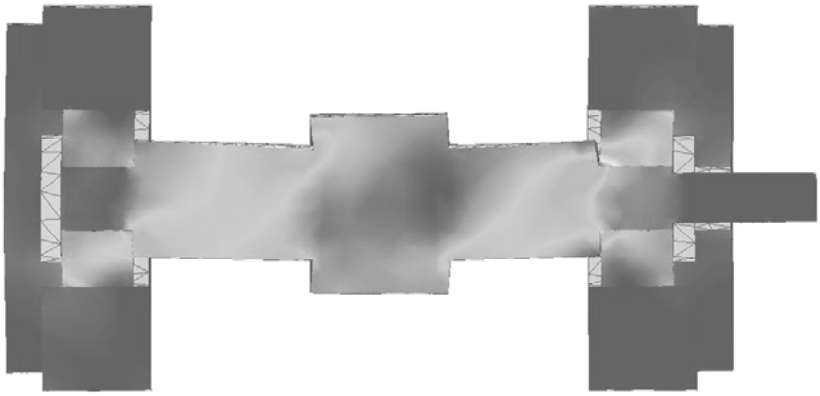

Fig. 4. Finite element analysis of an input shaft subassembly

4. CONCLUSION

The Intelligent System approach of gearboxes design has been developed to integrate various stages in the total design process (conceptual design, embodiment design, detail design and manufacture) with expert system module in order to reduce time to market and to decrease product costs. Structural composition of gearboxes as an independent formal method allows computer implementation of an intelligent system that integrates multiple cooperative knowledge, algorithms and data. Thus, during the design process it is possible to ask and receive information and details about the adopted solutions. A further benefit of this approach is that the design model can be permanently modified taken into account changed supplier or different component specification. On the other hand the proposed intelligent design system can be used in education: teaching students how to design is a difficult task; enabling them to clearly distinguish and work with elemental functions, conceptual design, embodiment design and detailed design becomes much easier.

5. REFERENCES

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