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A CAD-SYSTEM FOR DESIGNING MACHINE TOOL SPINDLES

The paper presents the structure of a computer-aided design system for spindle assemblies. A relevant data base with typical elements (rolling bearings, spindle ends, nuts) is described. New modules and applications in C language are presented. They form new commands in AutoCAD and provide additional operations on graphic objects. The system may be applied in designing and assessing the quality of a spindle with regard to static strength characteristics and enables quick evaluation of various spindle structures.

1. Introduction

At present a machine-tool spindle design can be evaluated no sooner than at the prototype stage. If the product fails to fulfil design requirements then the time span between the original concept and marketing the product lengthens excessively and costs rise. That is the reason why an automated system is needed for performing designing and evaluating activities in a parallel way. The system should be capable of performing design analysis of the spindle assembly based on CAD techniques involving formulation of alternate solutions and evaluation of the alternates. An integrated approach to the spindle design process may result in significant time and cost reductions.

2. Structure of the system

A schematic layout of the system for designing and evaluating spindle assemblies is shown in Fig. 1. The following stages of the design process can be defined:

- definition of product need and conceptual design based on input data available to the system,
- preliminary specification of the spindle assembly geometry with alternate solutions possible,
- final specification of the spindle assembly geometry,
- evaluation of static properties of the model,
- technical documentation (production drawings, material specification, process and equipment selection).

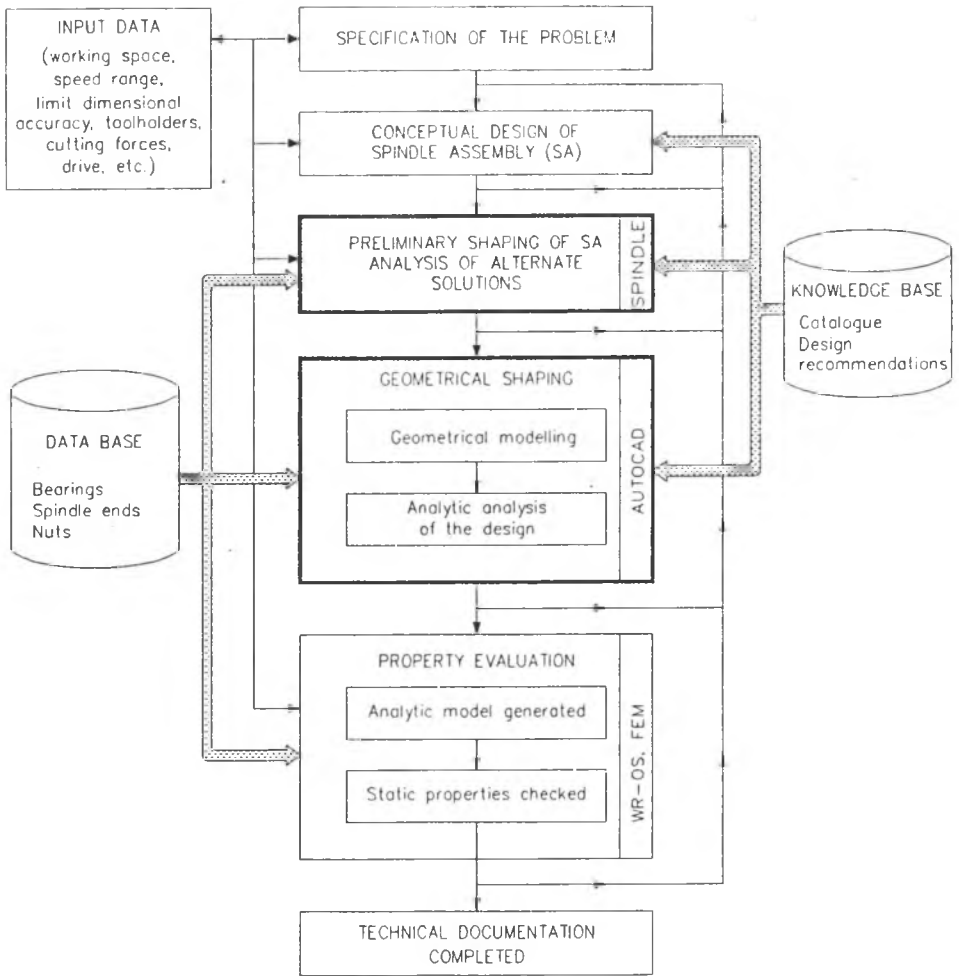


Fig.1. Structure of CAD-system for designing machine tool spindles

The system makes use of various bases comprising numerical ones (bearings, spindle ends) [6], graphic ones as well as a knowledge base containing design drawings, tables, design recommendations [5], etc. The contents of any of these bases can be utilized at any stage of the design process.

3. The system data bases

The system under consideration makes use of data bases for typical spindle unit components such as rolling bearings, spindle ends, rings, nuts and sleeves. The bases contain geometrical characteristics enabling determination of quantities that have an effect on static properties of the whole spindle assembly. Structure of any data base used (Fig.2) has been set-up in such a way as to make its elements accessible at any instant of the design analysis.

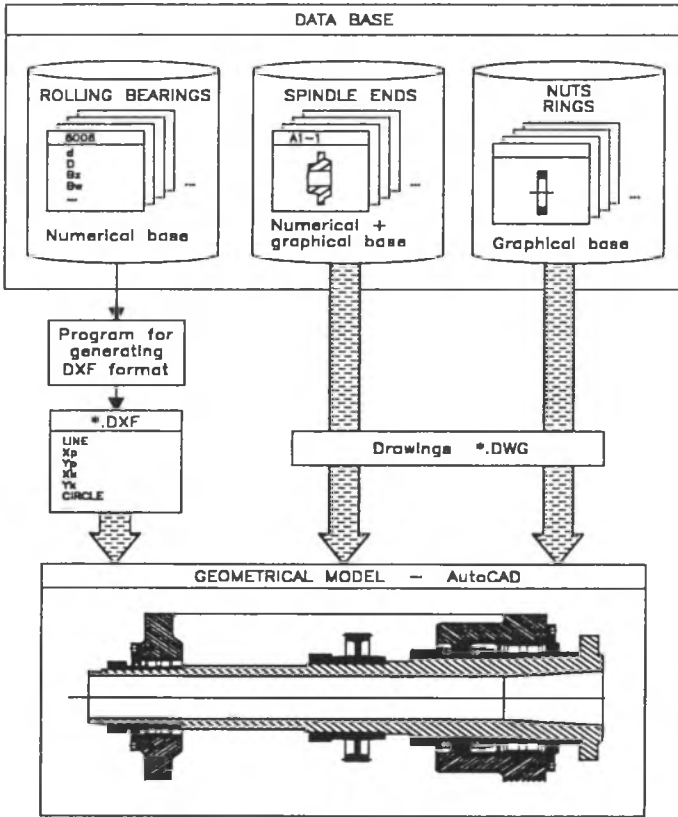


Fig.2. Structure of data base

The rolling bearing base contains standard catalogue data along with other information not to be found in usual reference sources which together are necessary to determine rigidity of each

bearing. The base encompasses a few types of rolling bearings (Fig.3) and currently covers 178 different series, altogether about 2200 bearings are included.

The spindle end base has been set-up in a similar way. Its elements are drawings of spindle shoulder ends in two modifications A1 and A2 as specified by the Polish Standard PN-69/M-55052.

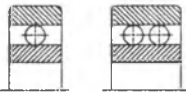







Single- and double-row ball bearings		Axial ball bearings	
Single-row roller bearings	a)  b) 	Angular ball bearings	
Double-row roller bearings (conical hole)	a)  b) 	Conical bearings	

Fig.3.Types of bearings used in the system

Each base has been provided with means of communication and transfer of data from the base to the AutoCAD package. The standard DXF data format [1] has been selected for transferring drawing files. The communicating function is executed by a custom-made program containing a library of procedures which generate text file fragments that represent simple graphic elements such as line, circle, polyline, arc, etc. These simple elements make up more complex objects such as bearings. The DXF files so created contain full definitions of structural elements and are subsequently fed to the AutoCAD program. They are next defined as blocks that can be inserted at any place of a drawing. Other elements from data bases, e.g. spindle ends or nuts are placed within an assembly drawing as complete drawings in the DWG format.

4. Geometrical design of the spindle

Once the conceptual design stage has been completed the system can be used for preliminary definition of the spindle unit allowing for alternate solutions. As a result a preliminary spindle design evolves [2,3].

The next step consists in finding a final shape of the spindle and involves the following two modules:

- geometrical modelling of the spindle assembly
- analytical modelling of the design.

The system user arrives at successive modifications of the spindle geometry while working in the AutoCAD environment. The package is known to have an open architecture, i.e. it can be easily adapted to individual needs. This feature has been fully utilized in the system being described (Fig.4). Separate customized menus have been prepared which make interactive operation smooth and easy. Additionally, a library of new application functions in C language have been created which act as new commands of AutoCAD and are used for performing operations on graphic elements. A method has also been worked out for shaping successive steps of a stepped spindle, the current design alternate being immediately seen on a display.

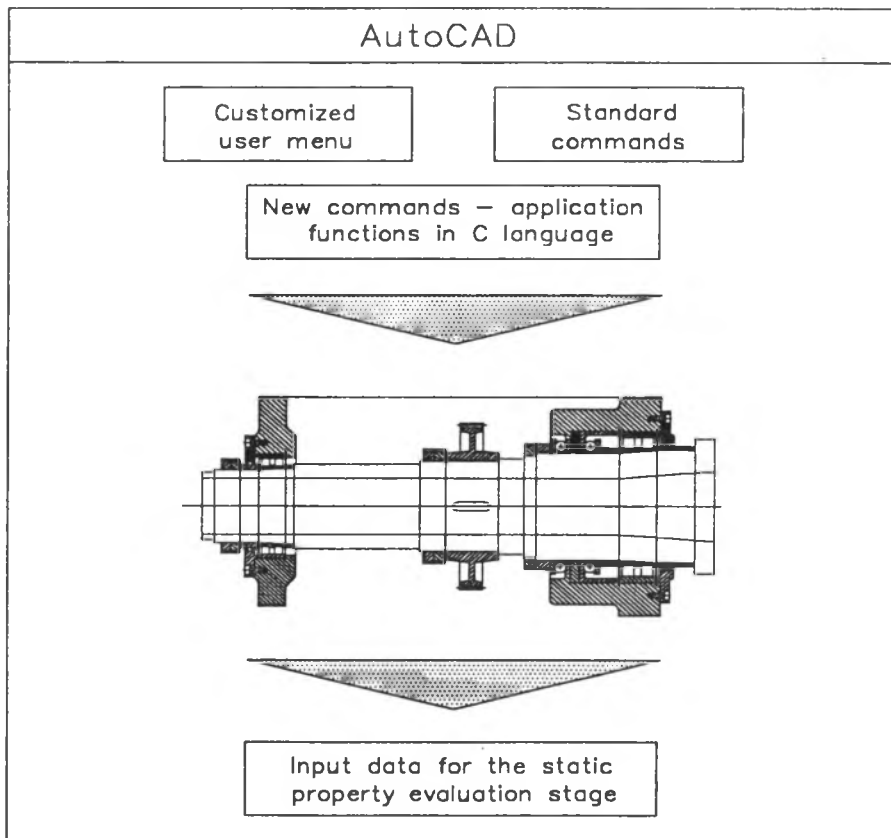


Fig.4. Customizing AutoCAD for designing spindle assemblies

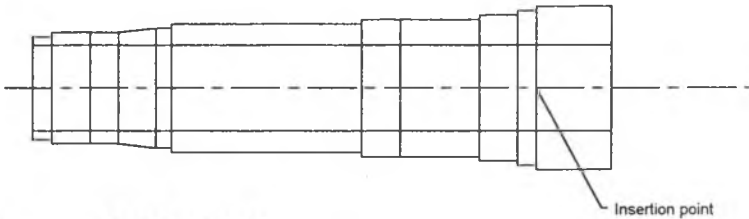
Other commands cause complete structural elements from a data base to be inserted in a drawing, perform operations on blocks, change and create new layers, etc. For example, in order to insert a bearing everything that is needed is to type its catalogue designation and

choose a point of insertion and the corresponding bearing drawing will be placed within the assembly drawing of the complete spindle unit. Examples of these new commands are shown in Fig.5.

The final result of this phase of the design process is an assembly drawing of the spindle unit. The construction so defined is then subjected to numerical analysis and prescribed an analytic model. The corresponding program modules create now a set of input data for the design evaluation stage. A computational check [4] is performed with respect to the criterion of the maximum rigidity of the spindle unit. The computations yield a distribution of linear and angular displacements of arbitrarily selected points belonging to the spindle central axis. Both tabular and graphic representation of the displacement results is possible (Fig.6).

Command INSCYL

Cylinder outer diameter $D[\text{mm}]$: 95
Hole ? None/Cylindrical/Taper : C
Hole diameter $d[\text{mm}]$: 50
Cylinder length $l[\text{mm}]$: 40
Insertion point :



Command READBEAR

Catalogue bearing designation : 6013
Insertion point :

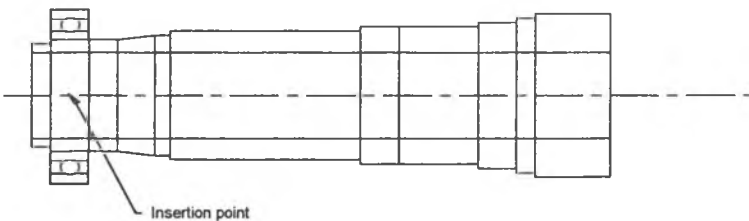


Fig. 5. Example of new commands in AutoCAD

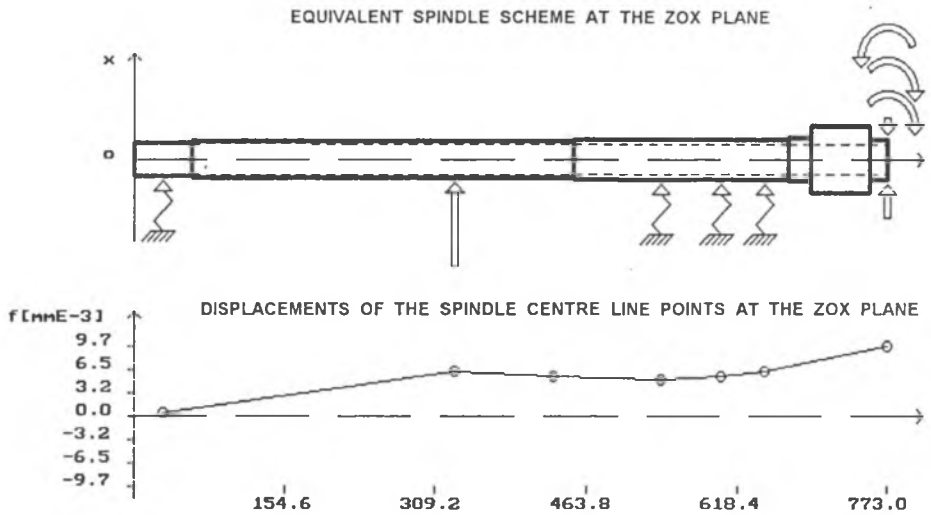


Fig. 6. Displacements of spindle axis

5. Conclusions

The system presented above is capable of computer-aided designing machine-tool spindle assemblies. The AutoCAD package (version 11) used as an interactive part of the system enables alternate design solutions to be readily selected, all the changes being immediately seen on a monitor.

The system makes use of data bases comprising standard elements of spindle units such as bearings, spindle ends, nuts, etc. The data bases have been provided with means of communication with the AutoCAD package. Additionally, new functions and program modules in C language have been worked out that supplement the AutoCAD command library. The new commands enable additional operations on graphic elements transferred from a data base to be performed.

The final geometrical shape of the spindle assembly is then automatically analysed to produce input data for strength evaluation. The programs enable the best spindle shape to be selected according to an assumed criterion - here the rigidity one.

The system allows the design process to be substantially simplified and shortened with many alternate design solutions of the spindle unit quickly assessed.

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