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Structure and Information Provision of a System for Automated Design of Clamping Devices in Fixtures for Workpieces Locating in Machining

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Abstract. In this article a structural schematic diagram of a system for computer aided design of clamping devices in fixtures for locating of the workpieces during machining is developed. A parametric library with solid models of clamping elements and a database for storing information necessary for the design of clamping devices have been developed. The development is part of a system for automated design of devices for locating workpieces during machining.

INTRODUCTION

The advancement of engineering automation systems in recent years, especially in their CAM part, has necessitated the development of automated design systems and in particular fixtures for locating of the workpieces which include newer tools, libraries, functional applications and levels of integration.

There are a number of methods for realizing the tasks related to the automated design of fixtures, including the use of CAD systems [2,3,6].

The analysis of the existing methods for automated design of fixtures shows that insufficient attention is paid to the stage related to the design of clamping devices (CD) (Fig. 1), which is one of the most labor-intensive stages related to multivariate design solutions.

In connection with this there is a need to automate the activities related to the design of the CD, which is *the purpose of this work*.

EXPOSITION

The design of the CD is performed after the design stage of the base elements of the fixtures [2,4,6]. The initial data in the design of the CD consists of the 3D models of the workpiece, the selected setting scheme and the designed base elements.

The automated system must consist of (Fig. 2):

- control module;
- module for calculation of clamping forces;
- module for selection of the parameters of the CD;
- block for calculating the parameters of the CD.

The block for calculating the parameters of the CD includes the modules for calculating: threaded CD (TCD); wedge CD (WCD); eccentric CD (ECD); lever CD (LCD) and combined CD.

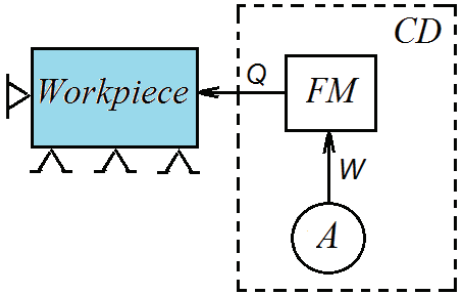

FIGURE. 1. *Schematic diagram of clamping device*
(FM – force mechanism; A – actuator; Q – clamping force; W – output force)

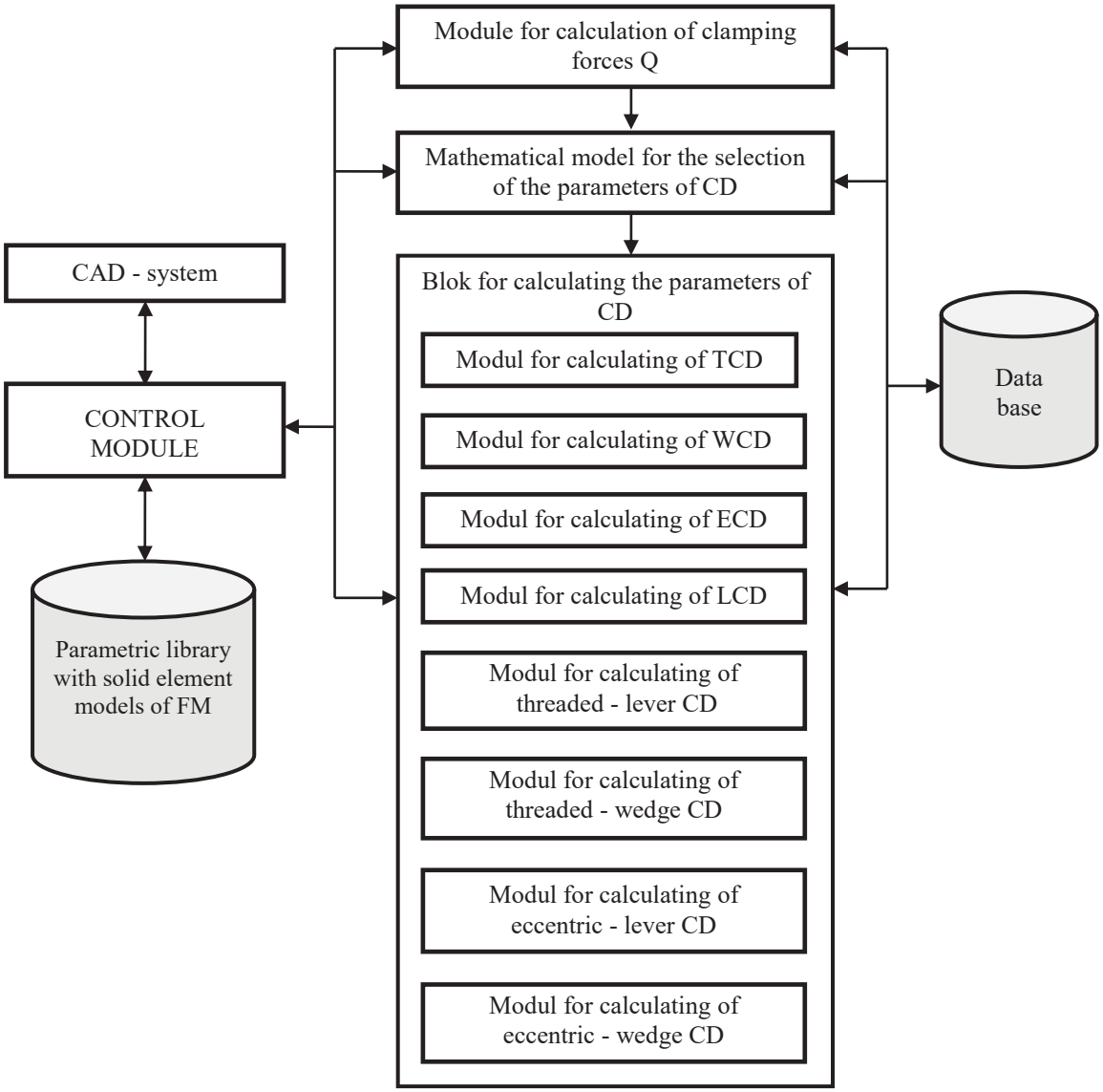

FIGURE. 2. *Structural diagram of a system for computer aided design of clamping devices*

The information provision of the automated product for design of the CD consists of:

1. Parametric library with solid models of elements of force mechanisms (FM);
2. Database for storage of information required for the design of the FM of the CD.

The parametric library with solid models is shown in fig. 3.

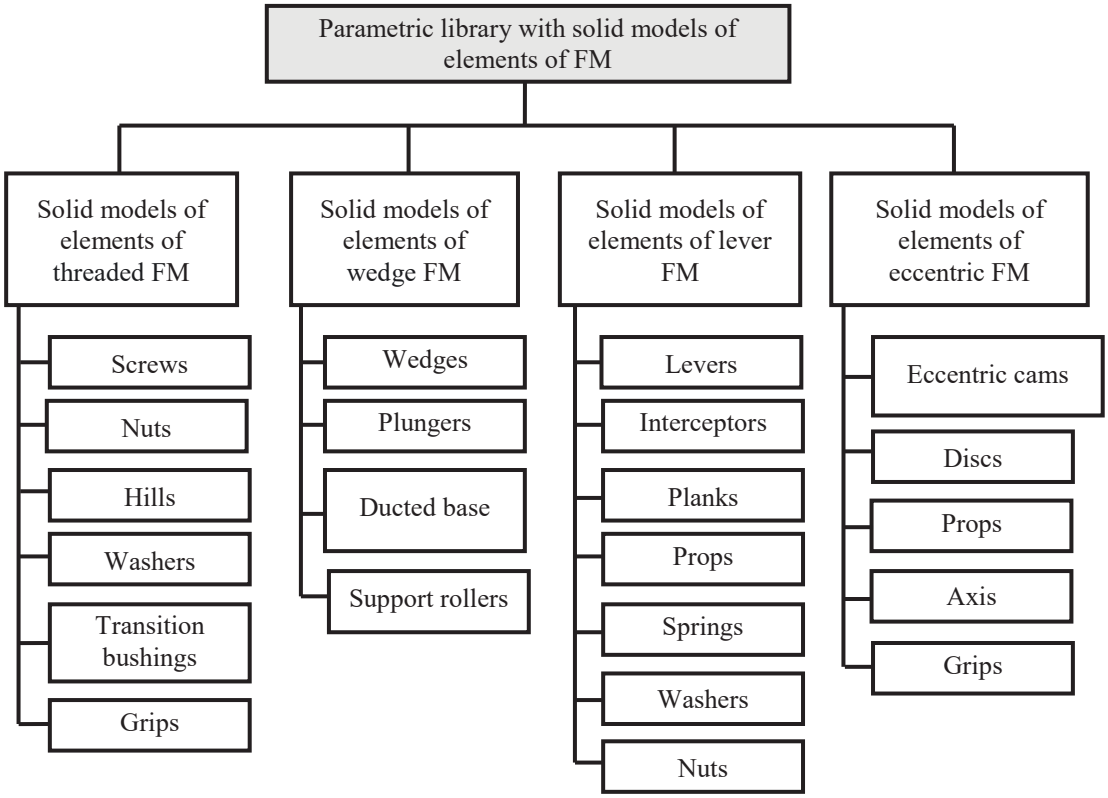

FIGURE. 3. *Structure of the parametric library with solid models of force mechanisms elements*

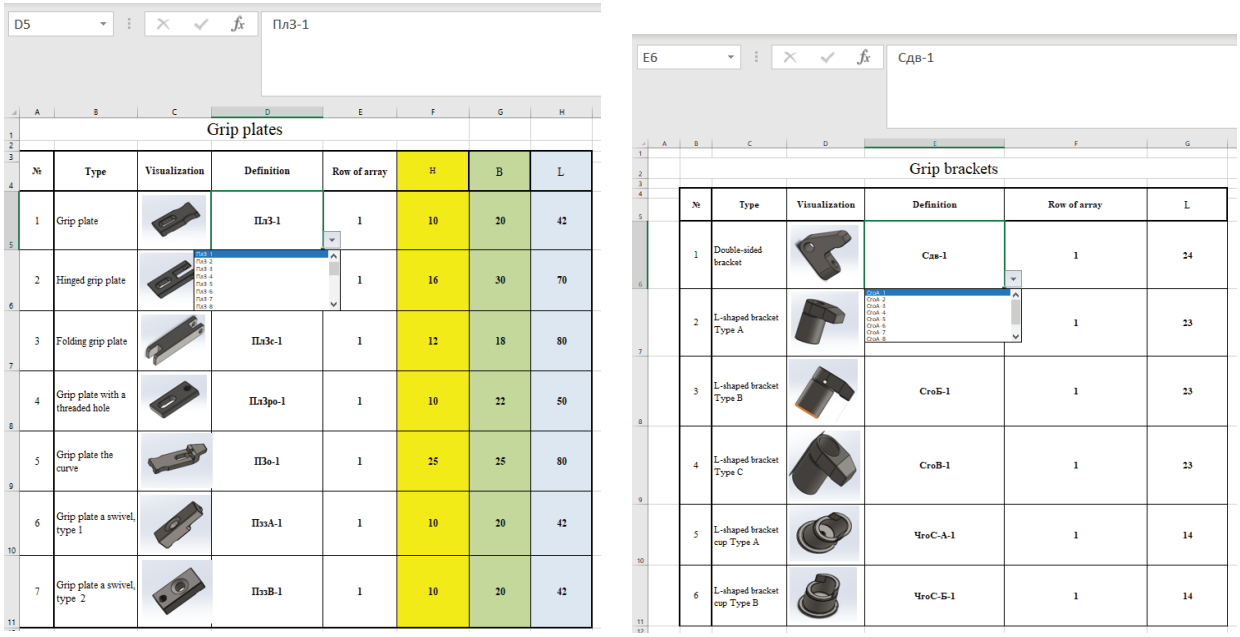

FIGURE. 4. *Exemplary solid models of force mechanisms elements*

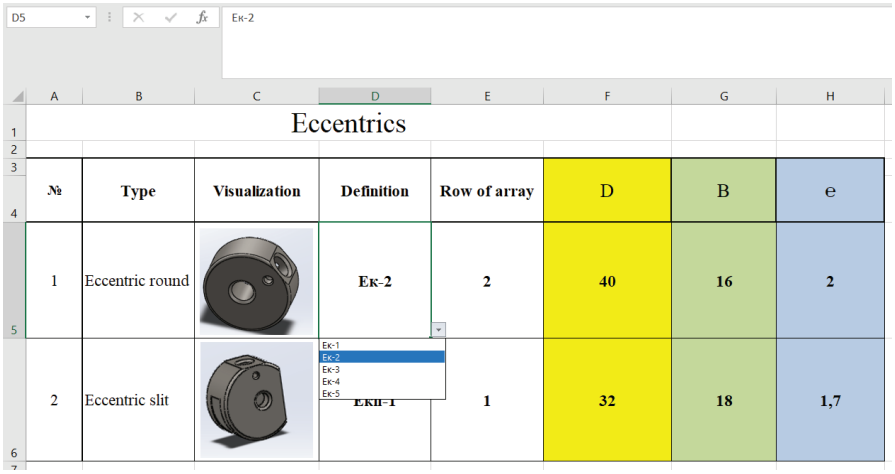

FIGURE. 4. *Exemplary solid models of force mechanisms elements (continued)*

The choice of clamping elements is made depending on the selected fastening scheme, and for this purpose tables for automated selection of [3] are made: grip plates; eccentrics; grips with flat jaws; grip clamps. Some of the developed tables are shown in fig. 4.

The database used in computer-aided design is an interactive database, the structure of which consists of linked tables, each containing information about attributes (characteristics) of parts and elements of force mechanisms and actuators (A) (Fig. 5).

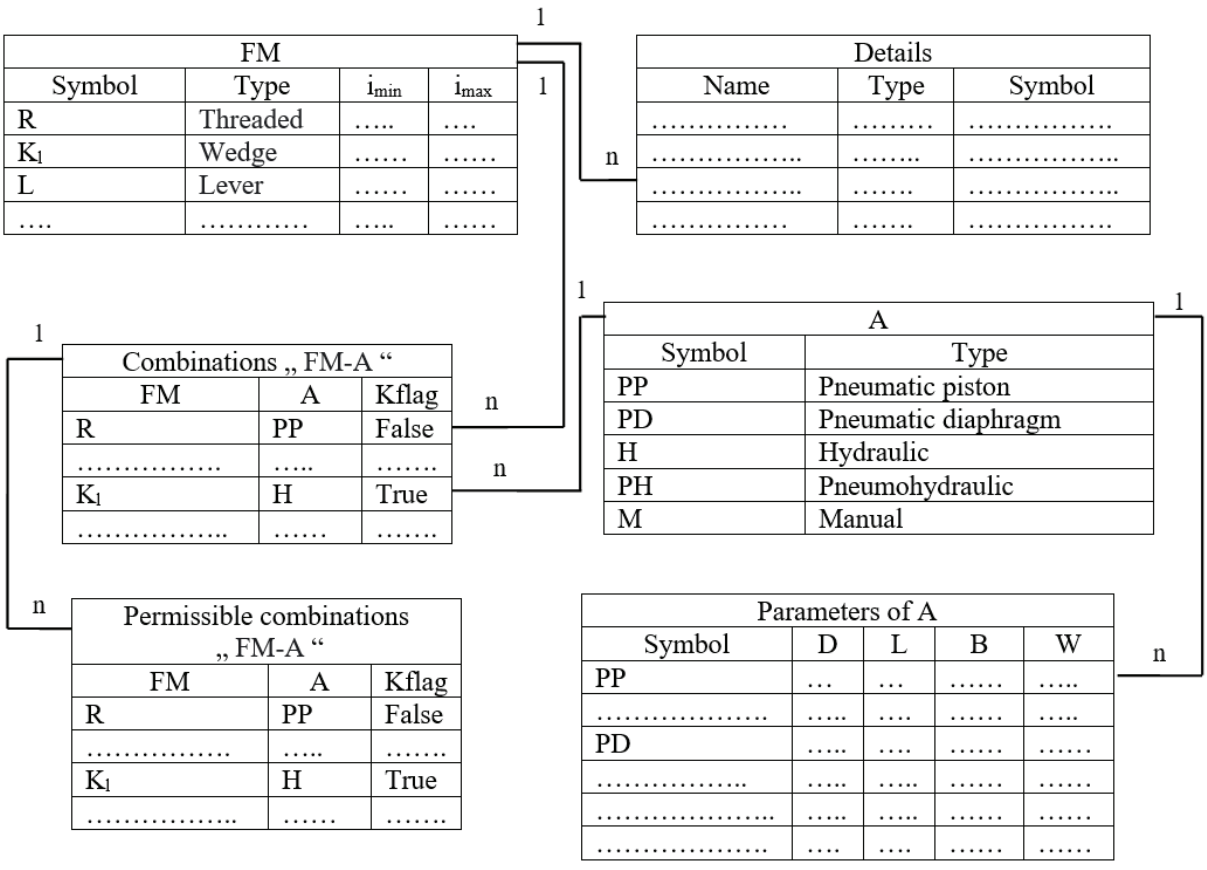

FIGURE. 5. *Database structure*

The module which implements the mathematical model for selection of the parameters of the CD allows to obtain a list of permissible combinations "FM-A", using the main criteria for the selection of FM - the amplification factor *i* [5].

The next steps of the modeling are related to the ranking of the admissible alternatives in accordance with the level of preference for the conditions under which the CD is selected according to the criteria: speed; self-restraint; dimensions and cost. In this case, it is convenient to use the method of analysis of hierarchies [5] or the method of allocation of priorities [1]. It is also possible to change the permissible for the specific conditions combinations "FM-A" (for example, the lack of a hydraulic system in the workshop excludes options with hydraulic actuators from consideration).

The module for calculation of threaded clamps (TCD) allows to determine the parameters of TCD.

According to the calculated clamping force Q and the clamping conditions (type and condition of the workpiece surface) the type of contact surface of the screw or nut face is determined.

The thread diameter of the screw (nut), the lift angle and the friction angle of the thread are calculated, then a standard screw (nut) is selected. A reliability test against self-unscrewing is performed, determining the *coefficient of efficiency* of the screw pair. In case of non-compliance with the condition for reliability against self-unscrewing, another screw with a smaller thread is selected. The last stage is calculation of the required tightening torque and the length of the grip.

The module for calculation of the wedge clamping devices (WCD) allows determining the parameters of the wedge and wedge-plunger FM. At the first stage, depending on the required amplification factor *i*, the schematic diagram of the wedge FM and the wedge angle α is selected. The following recommendations should be taken into account: $\alpha < 5°30'$ is recommended for mechanisms without rollers to ensure reliable self-restraint, and $\alpha > 10^{\circ}$ for non-self-restraining mechanisms with rollers. The stock of the plunger stroke, which records the inaccuracy of wear of the mechanism and the stability of the FM the stroke of the plunger (hump) and the wedge stroke are determined at the next stage, depending on the required minimum clearance for locating the workpiece.

The module for calculation of eccentric clamps (ECD) allows determining the parameters of the EFM. The constructor selects the type of eccentric (round, curvilinear in Archimedean or logarithmic spiral) and enters the necessary input data, determining the parameters of the EFM (eccentricity, diameter, width of the eccentric, moment and length of the grip).

The module for calculation of lever clamping devices (LCD) allows determining the parameters of LFM. The scheme of the LFM and the arms of the lever are selected, the necessary input data is entered and the following parameters are calculated: the movement of the lever at the place of application of the clamping force Q and the output force W; the diameter of the lever axis and the width of the lever.

The modules for calculating the combined clamping devices are developed in accordance to the modules for calculating the simple CD. At the first stage, the amplification coefficients of the simple FMs that are part of the combined CD are determined, and then these FMs are calculated sequentially.

CONCLUSION

- A structural diagram of a system for computer aided design of clamping devices in fixtures for locating the workpieces during machining has been developed;
- The parametric library with solid models of elements of force mechanisms and tables for computer aided selection has been developed, allowing the inclusion of new constructions of elements;
- A structure of an interactive database of related tables has been developed, each of which contains information on attributes of parts and elements of force mechanisms and actuators;
- This development is part of a system for computer aided design of fixtures for locating of workpieces during machining.

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