

DESIGN OF THE MODULAR DEVICE FOR THE MULTIPLE DRILLING OF HOLES FOR THE AUTOMOTIVE PIECES

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Abstract: *Modular Devices for the Multiple Drilling of Holes allow the multiple drilling of holes vertically, achieving simultaneously such types of work as drilling, enlargement, reaming, countersinking. In recent years, the design of the modular device using more and more the numerical modeling which has several advantages and allow its utilization within simultaneous engineering. This study presents the stages of the numerical modeling of the Modular Devices for the Multiple Drilling of Holes used to work the piece “Pump Cap”, using the CATIA software.*

Keywords: modular device, multiple drilling, numerical modeling, FEM

INTRODUCTION

Within the context of the appearance and development of the flexible production systems, the achievement of the modular elements devices constituted a major preoccupation of technological equipment producers [1, 2]. These devices have a flexible structure which allows their adaptation to different processing types and ensuring of high degree of universality, within increased efficiency.

Modular Devices for the Multiple Drilling of Holes (MDMDH) allow the multiple drilling of holes vertically with the help of a column type drilling machine or of a beam drill, achieving simultaneously such types of work as drilling, enlargement, reaming, countersinking. Drilling devices obtained from modular elements can be successfully used in the automotive industry in order to process different components (block engines, brake disks, water pump caps, brake drums etc.).

In recent years, a large number of studies have been devoted to the analysis and modeling of the modular device. Generally, the stages of the numerical modeling of an assembly type of product are: the geometrical modeling (3D) of the piece type elements; the assembling of the pieces in subsystems; the assembling of the subsystems; the analysis with the help of the finite element method of the behavior of the subsystems and / or of the product while operating; the simulation of the product operating.

This study presents the stages of the numerical modeling of the modular device for the multiple drilling of holes used to work five holes in the piece “Pump Cap”, figure 1.

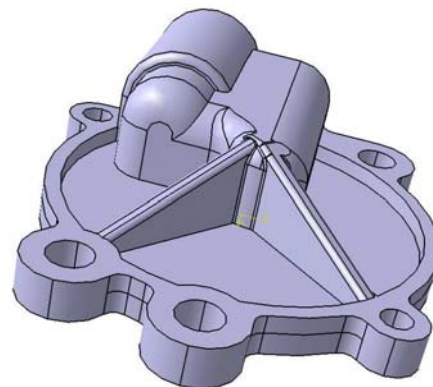


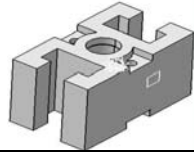
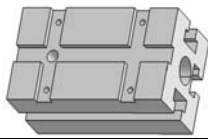
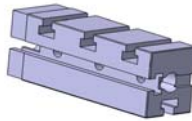
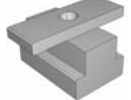
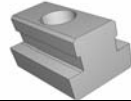
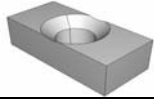
Fig. 1. The piece to be worked on

NUMERICAL MODELING OF MODULAR ELEMENTS AND THEIR ASSEMBLY

After having established the functional structure of the device the designer draws up different constructive solutions which follow the demands of the device. As part of the methodical design, even from the beginning, there is a close relation between the identification of the solutions, the use and the application of the existent pieces of information. The existence of this connection is facilitated by the use of software products which produce new models, take over information, combine and structure them. One of the most frequently used software in designing fabrication equipment is CATIA.

A first step in modeling modular devices is to create a data base with the modular elements of the set. The modeling of these elements was done in the CATIA Part Design modulus and they were structured according to their functional role. Thus, for the modular boring device a “Database of modular elements” was created. In table 1 a part of the structure of this database is given as an example.

Table 1. The database of the modular elements geometrically modeled

No.	The name of the element	Variants of the constructive form	Dimensional variants	Graphical example
1	Intermediate body	Intermediate body I	38X48X64 38X64X64	
2		Intermediate body II	64x76x140	
3		Intermediate body III	64x76x192	
4	Feather key	Double “T” key	Length: 26, 32, 40mm	
5		“T” key	Length: 16, 20, 24, 26mm	
6		Simple key	Length: 14, 9mm	

Drilling modular devices are obtained by assembling some elements of the modular set, following certain steps which are presented in table 2.

The structure of every subsystem of the device is established according to the specific methodologies of their functional role. For example, in order to establish the structure of the S5 subsystem (orientation and hold of the piece) we followed the next steps:

- Establishing the quota to be worked on the piece and the system of the quota bases;
- Establishing the system of the technological bases;
- Establishing the systems of the alignment bases and the alignment parts which can be used;
- Calculating the errors of the quota which can be admitted when working on the piece;
- Calculating the alignment errors for every variant of alignment;
- Establishing the optimal alignment variant;
- Establishing the hold mechanism and calculating the necessary holding force;
- Establishing the hold mechanism and calculating the used holding force.

The constitutive modular parts of the subsystem were established after a constructive optimizing [3].

When using the computer assisted design the process of taking all the steps in conceiving the subsystems and the device is facilitated by the use of the geometrical models (3D) of the modular parts. The subsystems S1 - S5 were achieved in the CATIA Assembly Design modulus by assembling all the modular parts according to mechanical rules in order to align them and to establish the contact surfaces. The geometrical models (3D) of the S3, S4 and S5 subsystems are presented in figure 2.

Table 2. Steps for assembling the drilling modular devices

No.	The name of the step	General description
1	Establishing the main structure of the modular device for the multiple drilling of holes	<p>The constitutive systems are established and they have the following main functions [5, 7]:</p> <ul style="list-style-type: none"> • S_1 – the joining modular system with the bench of the drill machine: makes the connections between the bench of the drill machine, the central guiding modular system (S_3) and the orientation and hold of the piece system (S_5) • S_2 – the joining modular system with the main shaft: makes the connection between the main shaft, the working tools and the guiding modular system (S_3) • S_3 – sets the subsystems S_1, S_5, S_4 and S_3 reciprocally, so that it provides the given precision of the holes. • S_4 – the adjustable guiding modular system for the tools: provides the position of the tools in connection with the piece to be worked on. • S_5 – aligns and holds the piece the piece to be worked on.
2	Establishing the optimal System of the Orientation and Setting Basis (S.O.S.B.)	The optimal orientation and hold of the blank (piece) is established on account of the execution drawing and of the operating scheme.
3	Making the S_1 subsystem – a joining modular system with the bench of the drill machine.	The dimensions of the base slab of the device are established taking into account the type of the equipment used for the manufacturing.
4	Making the S_5 subsystem – a modular system of orientation and hold of the blank (piece).	The constitutive parts are established and the base slab of the device is assembled.
5	Making the S_3 subsystem – a guiding central modular system.	The constitutive parts are established and the connections between the base slab of the device and the modular system of alignment and hold of the blank are made.
6	Making the S_4 subsystem – an adjustable guiding modular system for the tools (bridge frame - bushing)	The constitutive parts are established and the connections between the subsystem and the base slab are made.
7	Making the S_2 subsystem – a joining modular system with the main shaft	The parts of the multiple head are established and the connection to the main shaft of the machine-tool is made.

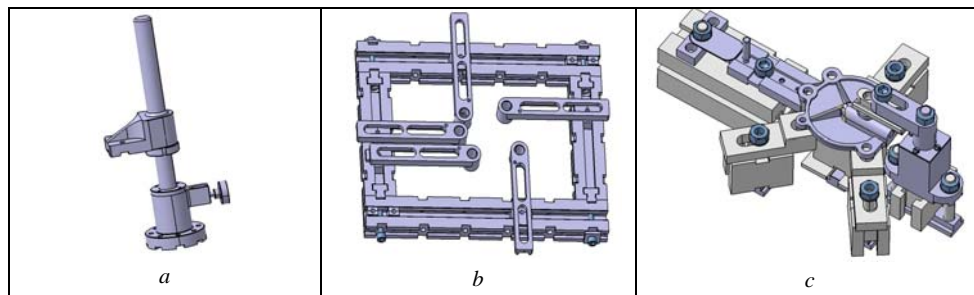
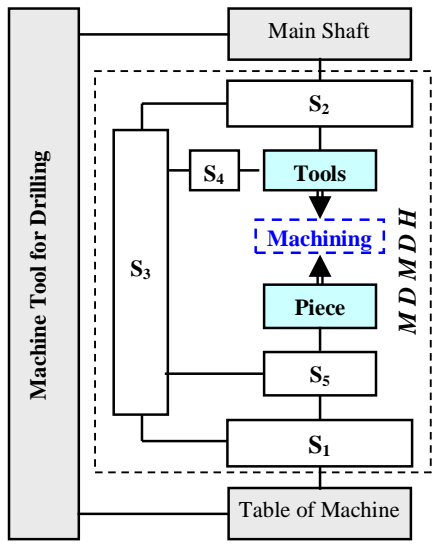


Fig. 2. Geometrical models of the subsystems of the modular device for the multiple drilling of holes
 a) the main guiding modular system S_3 ; b) the adjustable guiding modular system of the tools S_4 ; c) the modular system of aligning and holding the piece S_5

THE FINITE ELEMENT METHOD ANALYSIS

In the case of the design of the modular device for the multiple drilling of holes the finite element method was used in order to constructively optimize the S4 subsystem. The optimizing consisted in establishing the best position of the bushing holder clips on the frame according to the worst stress that may occur during the working process, so that we can provide the precision imposed to the working process [4, 6].

The analysis took place in the CATIA Generative Structural Analysis modulus in conditions of statically stress. The optimal configuration of the clip holder frame is given as an example in figure 3. The figure points out the most stressed areas of the system and the areas where maximum strains appear.

After having defined the constructive solution of the S4 subsystem all the subsystems were assembled in order to obtain the geometrical model of the device. This model is presented in figure 4.

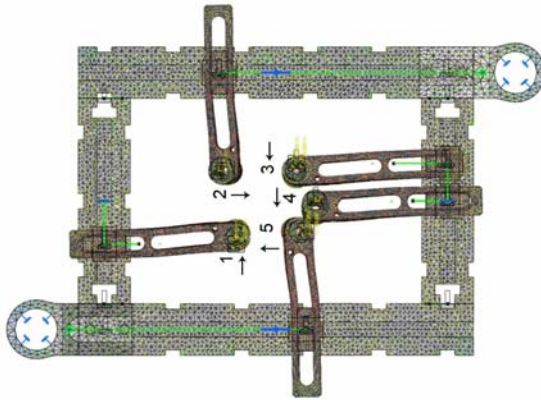


Fig. 3. The straining modulus of the S4 subsystem (optimal configuration)

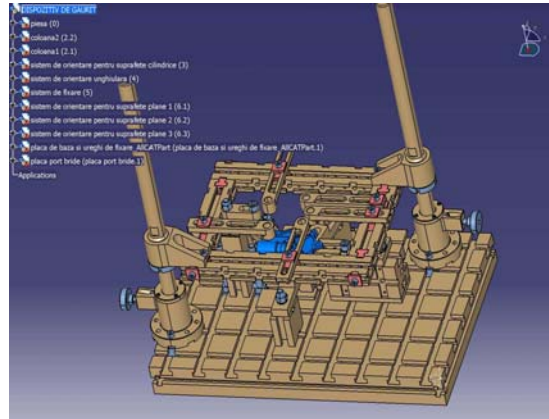


Fig. 4. The geometrical model of the modular device for the multiple drilling of holes

THE SIMULATION OF THE DEVICE OPERATING PROCESS

In order to verify the operating modulus of the device its operating process was simulated using the CATIA DMU Kinematics modulus. The main stages of the simulation are presented in figure 5.

CONCLUSIONS

The use of the numerical modeling when designing modular parts for devices has several advantages, such as:

- designing some model subsystems of the modular devices (alignment subsystem for flat surfaces, alignment subsystem for inner cylindrical surfaces, holding subsystem);
- structuring the model subsystems in data bases in order to be used again;
- the possibility of conceiving more constructive solutions of the subsystems or / and of the device;
- the possibility of analyzing the behavior of the subsystems in stress conditions through the finite element method and based on these results their constructive optimizing;
- the analysis of the operating mode and the use of the device by simulating the operating process.

The accomplishment of the geometrical models of the modular parts and of the model subsystems allows designers to use them. Altogether with the above mentioned advantages this fact leads to reducing the designing time which allows the use of this designing method within simultaneous engineering.

The difficulty of using the numerical modeling occur in the early stages at the creation of the geometrical models of the modular parts of the set due to their big number and to the constructive complexity of some of them. This disadvantage is eliminated when defining the data base of the geometrical models of the modular parts.

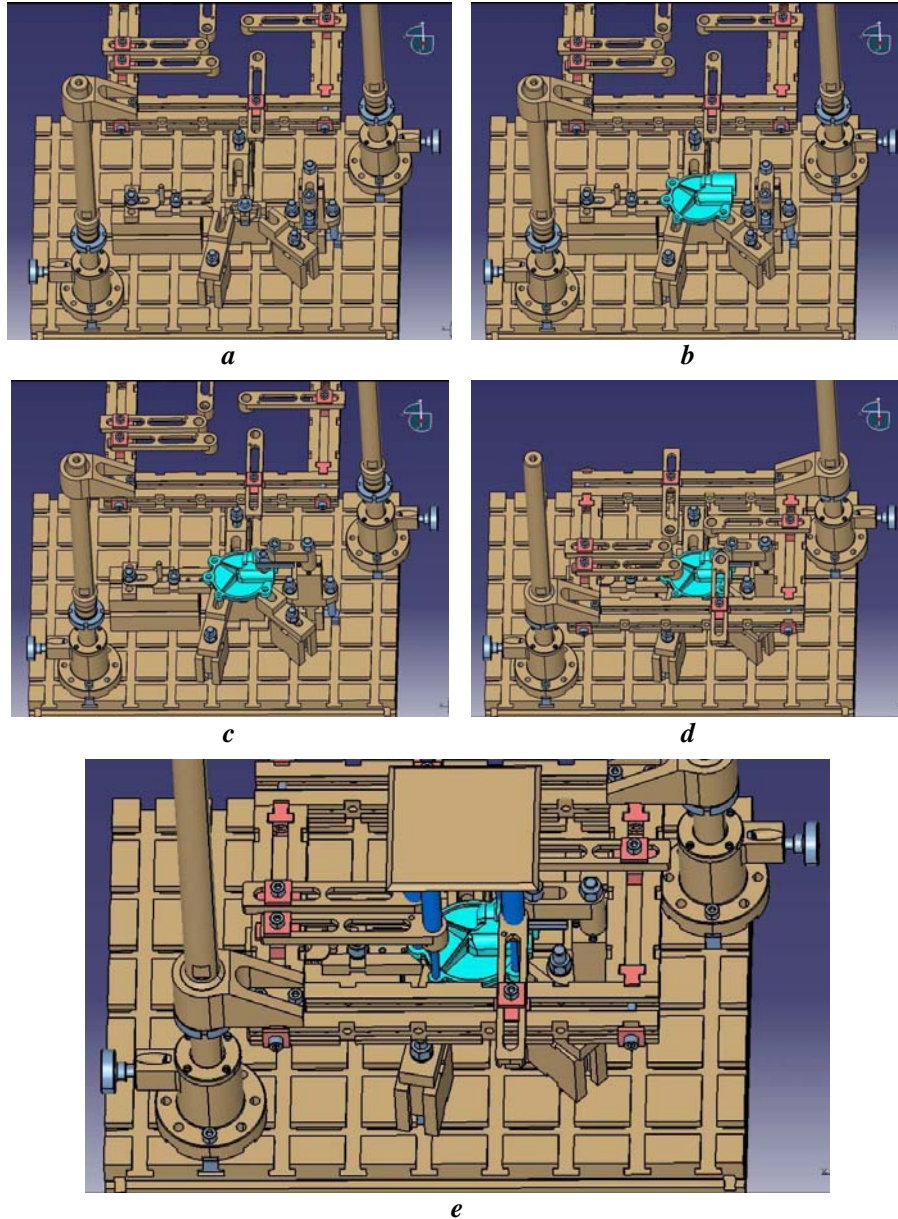


Fig. 5. The main stages of the device operating
 a) Before starting the working process; b) The alignment of the piece;
 c) Holding the piece; d) Descending the clip holder frame; e) Making the hole

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