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Part 2 - Participants’ reports in English

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PHILOSOPHICAL SCIENCES

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钻铣夹头的形态综合
MORPHOLOGICAL SYNTHESIS OF DRILL-MILLING CHUCKS

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摘要：使用了系统形态学的方法，提出了使用圆柱形刀柄的切削工具的工具卡盘（IZP）的新型解决方案，并提出了与已知工具相比较其设计的优于。并以形态矩阵的形式构建了IZP的形态模型。
关键字（中文）：工具夹盘、形态模型、钻头、刀具。

Drilling and milling chucks are a device for mounting and fixing on metal cutting and woodworking machines, as well as in drills of cutting tools with a cylindrical shank - drills, cutters, countersinks, etc[1,4-6].

The problem of reliability of certain types of metal-cutting equipment cannot be fully solved if the question of the correct design and manufacture of chuck chucks is not raised, since it has been proven that characteristics such as accuracy, rigidity, vibration resistance, and others are largely determined by their properties.

Certain difficulties are caused by technological processes of manufacturing parts of tool chucks and, first of all, clamping elements. In many cases, this is clearly underestimated, which leads to a sharp decrease in the quality of machining.

One of the characteristic features of tool chucks is the wide range of sizes of tools to be clamped. The tool centering accuracy depends primarily on the design and manufacturing process of the clamping elements and is one of the main characteristics of tool chucks. Certain technological methods in the manufacture of clamping elements can achieve practically zero runout of the tool.

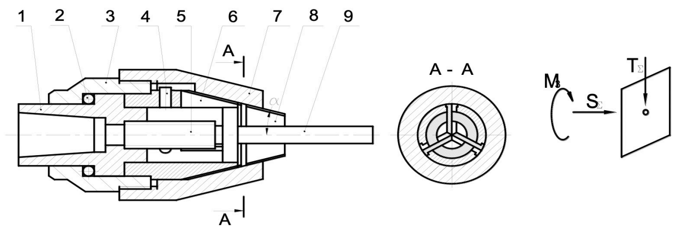
The clamping forces and torques transmitted by tool chucks vary over a very wide range. The automatic chuck is fast acting by simply turning the taper sleeve in a matter of seconds[3]. The stability of automatic chuck chucks fluctuates within extremely wide limits and depends on the design and correctness of technological processes in the manufacture of their parts.

Despite the well-established design forms of automatic drill chucks, the latter continue to be improved. You can outline several main directions in which work should go to improve these cartridges. [1-3].

First, structures must allow for tool clamping with wider tolerances. Secondly, new, high-strength materials must be used that can withstand large fluctuations in clamping forces. At the same time, this will reduce the size. Thirdly, it is necessary to look for new design solutions to increase the range of load changes and improve performance. Fourth, we must look for ways to self-regulate the strength of anchoring. At first, it is important to create a mechanism, adjusting which, the adjuster would be able to precisely set the desired value of the clamping force. Fifth, it is imperative to improve the manufacturing processes of automatic drill chuck parts. For the same clamping elements, different manufacturing and heat treatment processes are not justified at different plants. In practice, this leads to unnecessary waste of metal and excessive workload of tool shops.

On the basis of patent research, it is proposed to search for new solutions using the system-morphological approach[1]. On the basis of patent research, it is proposed to search for new solutions using the system-morphological approach. The morphological model of the schemes of wide-range wedge drilling-milling chucks and new variants of their designs are given. It is known that for clamping cutting tools with a cylindrical shank, tool chucks with a wedge transmission-reinforcing link in the form of wedge cams and collets are widely used. Clamping chucks with a transfer-reinforcing link in the form of an eccentric have so far found greater application for clamping artificial and bar blanks.

Automatic clamping drill chucks (Fig. 1, a) allow clamping the tool in a wide range (wide-range), converting the M_3 torque into the S_Σ axial force due to the screw pair, and then into the T_Σ radial force due to the wedge transmission-reinforcing link, that is the power flow from the drive to the clamping object looks like $M_3 \rightarrow S_\Sigma \rightarrow T_\Sigma$ (Fig. 1, b).



a *b*

Figure: 1. Wedge self-clamping drill chuck without a key (a) and the diagram of the power flow in it (b): 1 - case; 2 - balls; 3 - cylinder bushing; 4 - pin; 5 - screw with left-hand thread; 6 - separator; 7 - conical bushing; 8 - wedge cams; 9 - tool (drill)

Tool chucks (Fig. 2, a) allow you to clamp a tool of the same size (high-range) and, similarly to wedge chucks (Fig. 1, a), convert a steep M_3 moment into an axial force S_Σ due to the thread on the body and a thrust nut, and then into a radial force T_Σ due to conical surfaces on the collet, that is, a similar force flow (Fig. 2, b) $M_3 \rightarrow S_\Sigma \rightarrow T_\Sigma$ is formed, but in the opposite direction.

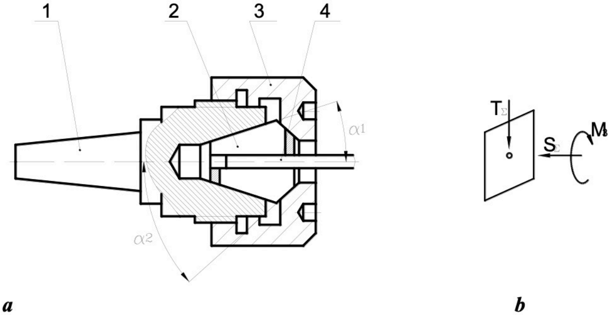


Fig. 2. Collet drill-milling chuck (a) and power flow diagram in it (b): 1 - case; 2 - double cone collet; 3 - persistent nut; 4 - tool

Band chucks for piece workpieces (Fig. 3, a) are used in lathes and grinding machines, in which the previous clamp is protected by a spring, and the final self-jamming from the cutting forces (moments) due to jamming. The radial dimensions of the conventional eccentric chucks for workpieces do not allow them to be used as tool chucks.

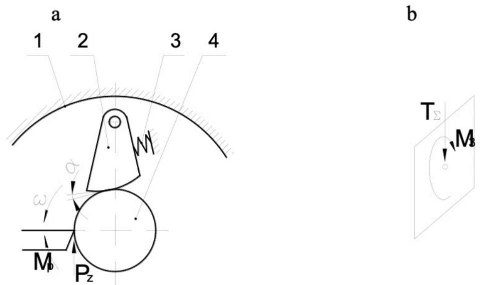


Fig. 3. Schemes of a self-clamping eccentric lathe chuck (a) and the power flow in it (b)

Therefore, it is necessary to look for new technical solutions that combine the advantages of wedge and eccentric chucks, this is what this work is devoted to, as a result of research and development work, carried out at the Department of Machine Design using the system-morphological approach.

To do this, in the chuck-tool drive system, we select the main features:

- input (drive): 1- type of energy source; 2 - number of inputs; 3 - transmission-amplifying link I input; 4 - transmission-reinforcing link II input;
- cartridge 5 - Connecting part of the body; 6 - the location of the axis of the eccentric clamping element; 7 - the outer surface of the eccentric clamping element; 8 - the number of clamping elements;
- exit (fixing object): 9 - tool type; 10 -Loading.

We build a morphological model (the table is not given for confidential reasons) with various alternatives of its main features, according to which the total number of possible and not possible schemes of tool chucks:

$N_{ІЗП}=3\cdot3\cdot5\cdot5\cdot6\cdot3\cdot4\cdot2\cdot6\cdot4=777600$

Let us represent the morphological model in the form of a morphological matrix in a collapsed and expanded form:

$M_{ІЗП}=M_{ВХ} \wedge M_{СТ} \wedge M_{ВИХ}$

$$\text{ì ¡3П} = \begin{vmatrix} 1.1 & 2.1 & 3.1 & 4.1 \\ 1.2 & 2.2 & 3.2 & 4.2 \\ 1.3 & 2.3 & 3.3 & 4.3 \\ & & 3.4 & \\ & & 3.5 & \end{vmatrix} \wedge \begin{vmatrix} 5.1 & 6.1 & 7.1 & 8.1 \\ 5.2 & 6.2 & 7.2 & 8.2 \\ 5.3 & 6.3 & 7.3 & \\ 5.4 & & 7.4 & \\ 5.5 & & & \\ 5.6 & & & \end{vmatrix} \wedge \begin{vmatrix} 9.1 & 10.1 \\ 9.2 & 10.2 \\ 9.3 & 10.3 \\ 9.4 & \\ 9.5 & \end{vmatrix}$$

To reduce the number of options for solving the problem of synthesizing tool chucks with an odd number of clamping elements, weed the matrix for a milling machine using a manual clamping at the initial setting for a given machining program with a limited number of connecting part and options for the location of the clamping element axis. Then we get the truncated matrix.

$$\text{ì ¡3П} = \begin{vmatrix} 1.1 & 2.1 & 3.1 & 4.1 \\ & 2.2 & 3.2 & 4.2 \\ & 2.3 & 3.3 & 4.3 \\ & & 3.4 & \\ & & 3.5 & \end{vmatrix} \wedge \begin{vmatrix} 5.1 & 6.1 & 7.1 & 8.1 \\ 5.2 & & 7.2 & \\ 5.5 & & 7.3 & \\ & & 7.4 & \end{vmatrix} \wedge \begin{vmatrix} 9.6 & 10.3 \end{vmatrix}$$

In this case, the total number of IPU circuits will significantly decrease and amount to:

$N'_{ІЗП}=1\cdot3\cdot5\cdot4\cdot3\cdot1\cdot4\cdot1\cdot1\cdot1=720.$

Let us illustrate the formation of tool chucks with two manual clamping inputs (Fig. 5), where in all subsequent combinations (variants$X_2 - X_4$), starting with variant X1, new solutions are emphasized.

Tape drilling and milling chucks, developed by ZMOK LLC, are designed for fast and reliable clamping of tools with a cylindrical shank (drills, countersinks, reamers, cutters, etc.) of right and left rotation in a given range.

With the help of these chucks, it is possible to mill many grooves, drill and cut an unlimited number of holes, unscrew and tighten an unlimited number of screws and nuts, provide various sets of locksmith, machine and assembly tools (manual, electrical, mechanical).

Chucks are efficient and convenient to use in surgical operations - for opening holes in bones, where light weight and dimensions are required, as well as reliable fixation of a drill or other instrument with the possibility of quick changeover to a different clamping diameter. Personality convenience is created by these designs of cartridges when working with a pneumatic or power tool with a fast set of revolutions - there is no self-loosening from inertial forces at the time of starting the cartridge. Additional advantages are low weight and diametrical dimensions, convenience of processing hard-to-reach places.

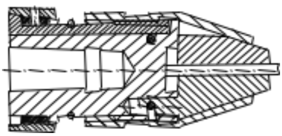
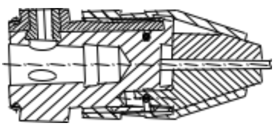
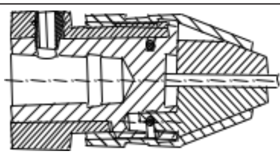
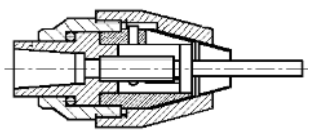
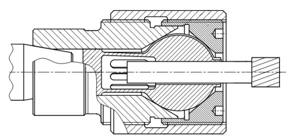
No	Type of ISP	Constructive scheme	Morphological formula
X_1	Without key and two entrances		$\|1.2-2.2-3.1-4.1\| \wedge$ $\wedge \|5.1-6.1-7.1-8.1\| \wedge$ $\wedge \|9.6-10.3\|$
X_2	With a key and several cylindrical eccentrics on the entrance 2		$\|\underline{1.3}-\underline{2.3}-3.1-\underline{4.2}\| \wedge$ $\wedge \|5.1-6.1-7.1-8.1\| \wedge$ $\wedge \|9.6-10.3\|$
X_3	With key, shirt and one cylindrical eccentric at the entrance 2		$\|\underline{1.3}-2.2-3.1-\underline{4.2}\| \wedge$ $\wedge \|5.1-6.1-7.1-8.1\| \wedge$ $\wedge \|9.6-10.3\|$
X_4	Wedge self-clamping		$\|1.2-2.1-3.3-4.5 \wedge$ $\wedge \|5.1-6.2-7.2-8.1\| \wedge$ $\wedge \|9.6-10.3\|$
X_5	Collet wide-range spherical		|1.2-2.1-3.3-4.5|^|5.1-6.2-7.2-8.1|^|9.6-10.4|

Fig.4. Variants of synthesized tool clamping chucks according to the morphological model

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