УДК 621.881

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CREATION OF NEW CLAMPING MECHANISMS USING GENETIC-MORPHOLOGICAL METHOD

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СОЗДАНИЕ НОВЫХ ЗАЖИМНЫХ МЕХАНИЗМОВ С ПРИМЕНЕНИЕМ ГЕНЕТИКО-МОРФОЛОГИЧЕСКОГО ПОДХОДА

Purpose. A new genetic-morphological method using the analogy between the electromechanical system and the mechanical system of rotating the clamping mechanisms. Further the examples of realization of proposed approach in creation of clamping chucks with other forcing (energing) streams.
Design/methodology/approach. The genetic classification of energetic (power) flows in the clamping mechanisms of various versions summarizes the properties of the elastic force structures of these mechanisms and constitutes the systematic basis for understanding of the fundamental principles of the structural organization and natural development of mechanical, electromechanical, hydraulic, pneumatic, electromagnetic, magnetic and other force clamp systems such as bodies of rotation similar to the genetic classification of the electromagnetic field primary sources.
Findings. Main result - in the proposed classification of the interaction of the clamping element with the clamping object (components, work pieces or tool) various principles and laws of mechanics are reflected, including the topological invariance principle of the field sources, the principle of symmetry; the principle of two nets, the principle of conservation of the basic types of mechanical and other energy converters, the law of energy conservation, D'Alembert's principle, Hooke's Law etc.
Keywords: clamping mechanisms, energy (power) flows, collets, wide range chucks, quickset chucks.

Introduction

Providing the required clamping force and strength of the clamping mechanism is now a necessary condition but is not sufficient, due to the increased flexibility of quickset automated production which requires wide-blandness and quick regulating of the clamping mechanisms, in particular, chuck engineering or chucks (CE), while maintaining the accuracy, rigidity, durability and stability characteristics [1, 2, 3, 7].

This article analyses the influence of the CE structure on their wide-blandness and quickset while changing the diametrical size of the object clamp (OC), which may be a cylindrical shank cutting tools (drills, mills, etc.), rod or piece-blank [1, 4].

According to the systematic approach, within a huge variety of the CE construct the quantity of their structures is limited by the direction of the input force from the power source and the drive clamp with the help of the method of energy conversion and transmission of power flow into the CE, the CE power circuit, which can be closed and (or) broken, open, and (or) closed due to the closing of the clamping force, and the connections to the power source and drive clamp [1, 7].

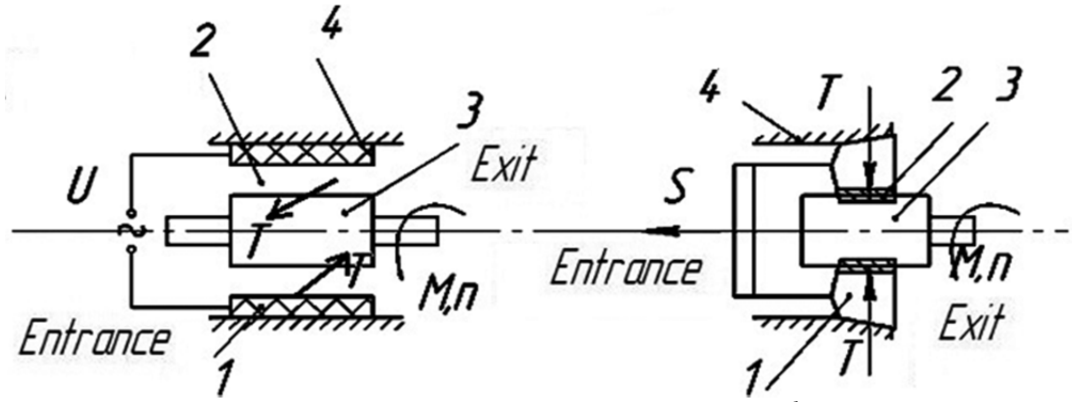
The systematic approach allows combining the structural studies in science and technology successfully because of its interdisciplinary nature, using appropriate philosophical categories and general theory of systems regulations [12].

Exposition

The object lesson of interdisciplinary and community systems approach can be the theory of evolution transfer of electromechanical systems [11] into mechanical and other systems [1, 10]. The analogy between the electromechanical system, for example, an electric motor (Fig. 1,a) and the system of clamping device rotating, such as collect chuck in the latter case (Fig. 1,b) is shown below.

The results of the comparison (Table 1) show the equality of the power flow in both cases.

If in electromechanical system the elementary source of the electromagnetic field at the genetic level is electric charge [11], then in mechanical system of the rotating jig the elementary source of elastic force field in the contact clamping element (Cl.E) and OC at the genetic level is elementary force dT, normally applied to the surface of the contact material point [1].



a *b*

Fig. 1. The analogy between the electromechanical system (*a*) and the system of rotating the clamping device of the execution (*b*)

Table 1

Comparison characteristics of systems

№ position	Electromechanical system (teg.3a)	The system of rotating chuck (teg.3,b)
Entrance	Electric current to the voltage U	Axial force S from the drive terminal
1	Stator	Clamping element (CE)
2	Electromagnetic field	Elastic-power field
3	Rotor	Object clamp(OC)
4	Framework	Spindle
Exit	Electromotive force T, torque M and the rotor speed n	Radial (normal) T clamping force and speed of the object fixing n

In the latter case with the given size of the contact surface (or line) we will get normal voltage $\frac{dT}{dF}$ or specific force $\frac{dT}{dL}$ (where dF - elementary area of the contact surface between the Cl.E and OC, dL - elementary line along the interface between Cl.E and OC).

According to the analogy with the genetic classification of the primary sources of the electromagnetic field [11] there can be offered a genetic classification of elastic force field sources, which is based on the spatial forms of contact interaction between Cl.E and OC, generalized by the geometric classes of elastic force fields: cylindrical, conical, flat, toroidal flat, spherical, toroidal cylinder. The spatial forms of contact interaction are determined by the spatial forms of Cl.E and OC.

These are combinations of different forms of the surfaces or their conversions at the expense of discrepancy between the axes of rotation of geometric figures, which gives additional classes of geometric surfaces: eccentric-cylinder, eccentric-conical, flat-conical or wedge etc.

However, from the technical and economic considerations, technical constraints and the level of technology, the existence region of the field primary sources, which determines the gene pool of any class of mechanical systems rotating chuck at a certain stage of its evolution, may be limited to a reasonable level.

The selection of the principle and structure of the clamping device can be made even at the chromosomal level by type of energy (power) flow from the drive to clamp of the rotating Cl.E, which we will trace in monadic (single) clamp in two mutually perpendicular planes (Fig. 2); one – along the line (axis) of Cl.E rotation, another – in a plane perpendicular to the Cl.E rotation axis [7].

Given that Cl.E rotates, the direction of the power flow along the axes Y and Z, perpendicular to the axis of rotation, can be denoted by one coordinate, for example, Y.

The Input into the energy (power) flow can be a force S (Sx, Sy), the moment M (Mx, My), and the only force T (Tx, Ty), normal to the clamp surface can be its output. The direction of the output force Ty to the axis of Cl.E rotation defines the outer clamp and from the axis – the internal clamp ($\underline{Ty}$, underlining at the bottom). The direction of the output force $\underline{Tx}$ is defined by the front clamp to the spindle, and Tx – from it.

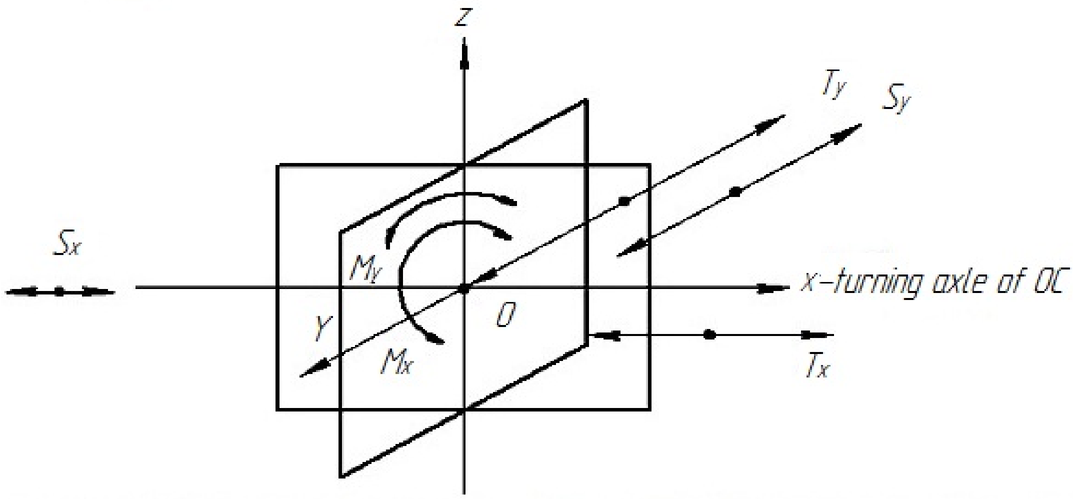


Fig. 2. Graphic interpretation schemes of the energy (power) flow in a rotating chuck out the principles of the clamp

Morphological model of energetic (power) flows can be shown as in Table 2 [5, 13].

The combination of chromosomes entry and exit in the CE, the symmetry and topology applied [8, 9, 11], the power structures of mechanical systems of the clamping mechanisms determines the structure and principle and structure of CE.

The total number of combinations $N_{пз} = 8 \times 4 = 32$, i.e. a total of 32 pairs of chromosomes. From the all given structures or principle soft the clamp as power flows, the widespread practice for external clamping circuits were 1–4 schemes (Table 3). For high-speed and precision processing for clamping tools with cylindrical shank (drills, milling cutters) the schemes 1, 2 have started to be applied [4, 15, 16].

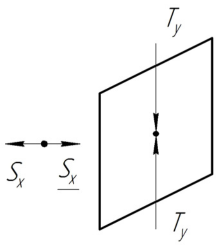
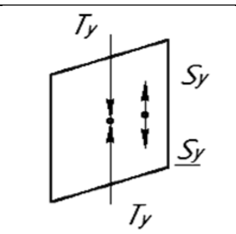
Table 2

Morphological model of energy (power) flows in a mechanical system rotating chuck

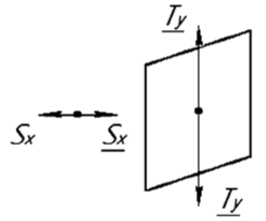
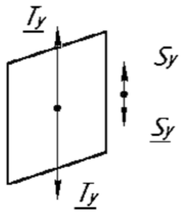
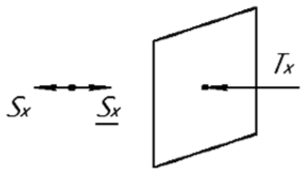
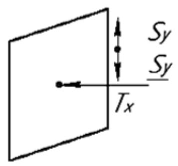
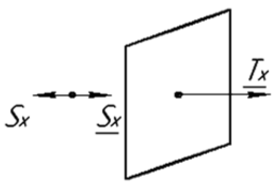
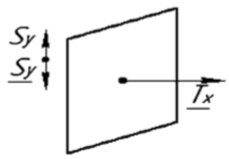
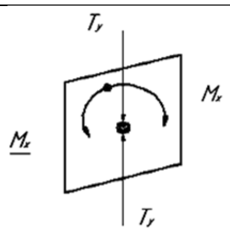
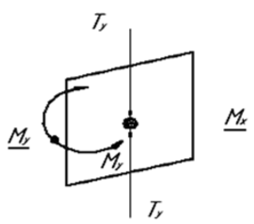
1.Entrance	2. Exit
1.1 S_x	2.1 T_y
1.2 $\underline{S_x}$	2.2 $\underline{T_x}$
1.3 S_y	2.3
1.4	2.4 $\underline{T_x}$
1.5 M_x	
1.6 $\underline{M_x}$	
1.7 M_y	
1.8	

Table 3

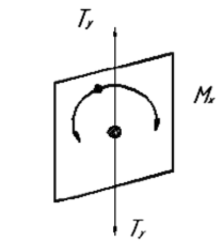
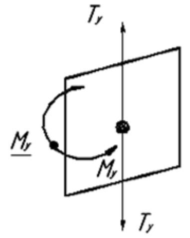
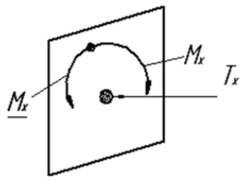
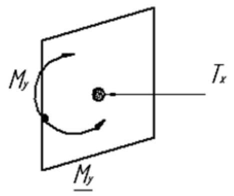
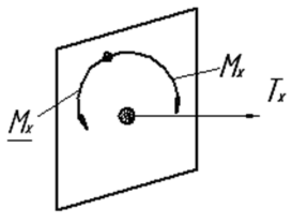
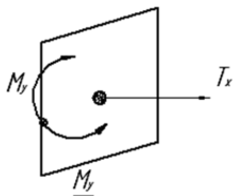
Energy (power) flows in a mechanical system of rotating chuck single clip on the outer surface of the cylindrical parts

№ pos.	Scheme	Code			
		Alphabetic		Digital	
		Entrance	Exit	Entrance	Exit
1	2	3	4	5	6
1		S_x	T_y	1	3
2		$\underline{S_x}$	$\underline{T_y}$	$\underline{1}$	3
3		S_y	T_y	2	3
4		$\underline{S_y}$	T_y	$\underline{2}$	3

Continuation of table 3

1	2	3	4	5	6
5		S_x	$\underline{T_y}$	1	$\underline{3}$
6		$\underline{S_x}$	$\underline{T_y}$	$\underline{1}$	$\underline{3}$
7		S_y	$\underline{T_y}$	2	$\underline{3}$
8		$\underline{S_y}$	$\underline{T_y}$	$\underline{2}$	$\underline{3}$
9		S_x	T_x	1	4
10		$\underline{S_x}$	T_x	$\underline{1}$	4
11		S_y	T_x	2	4
12		$\underline{S_y}$	T_x	$\underline{2}$	4
13		S_x	$\underline{T_x}$	1	$\underline{4}$
14		$\underline{S_x}$	$\underline{T_x}$	$\underline{1}$	$\underline{4}$
15		S_y	$\underline{T_x}$	2	$\underline{4}$
16		$\underline{S_y}$	$\underline{T_x}$	$\underline{2}$	$\underline{4}$
17		M_x	T_y	5	3
18		$\underline{M_x}$	T_y	$\underline{5}$	3
19		M_y	T_y	6	3
20		$\underline{M_y}$	T_y	$\underline{6}$	3

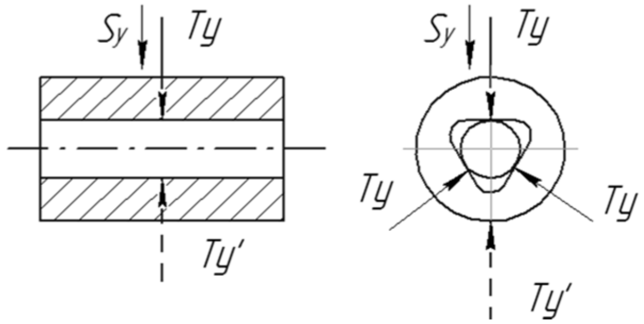
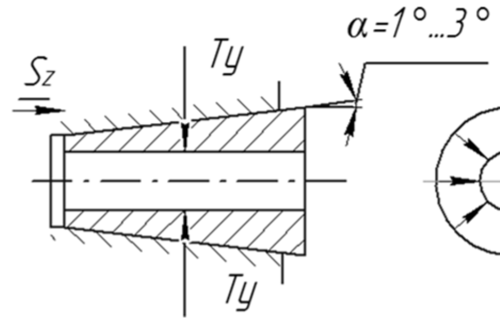
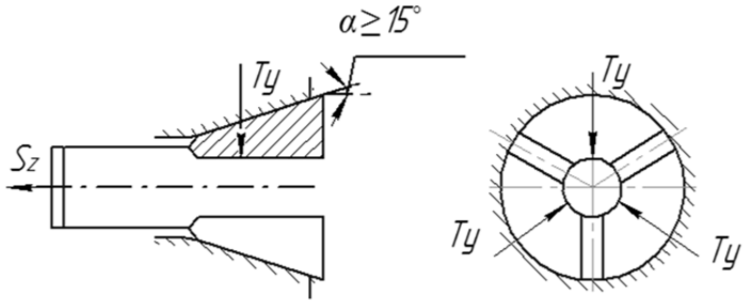
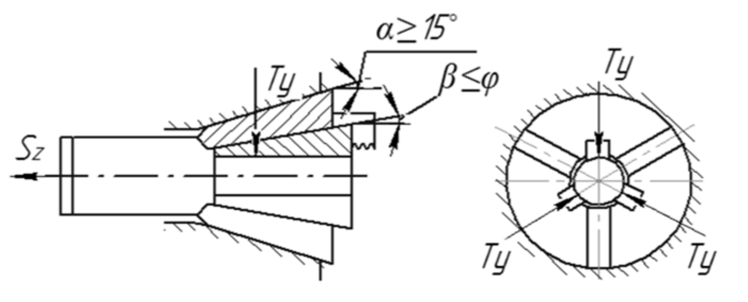
Continuation of table 3

1	2	3	4	5	6
21		M_x	$\underline{T_y}$	5	$\underline{3}$
22		$\underline{M_x}$	$\underline{T_y}$	$\underline{5}$	$\underline{3}$
23		M_y	$\underline{T_y}$	6	$\underline{3}$
24		$\underline{M_y}$	$\underline{T_y}$	$\underline{6}$	$\underline{3}$
25		M_x	T_x	5	4
26		$\underline{M_x}$	T_x	$\underline{5}$	4
27		M_y	T_x	6	4
28		$\underline{M_y}$	T_x	$\underline{6}$	4
29		M_x	$\underline{T_x}$	5	$\underline{4}$
30		$\underline{M_x}$	$\underline{T_x}$	$\underline{5}$	$\underline{4}$
31		M_y	$\underline{T_x}$	6	$\underline{4}$
32		$\underline{M_y}$	$\underline{T_x}$	$\underline{6}$	$\underline{4}$

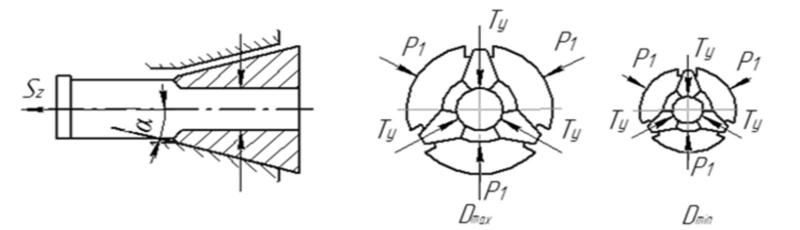
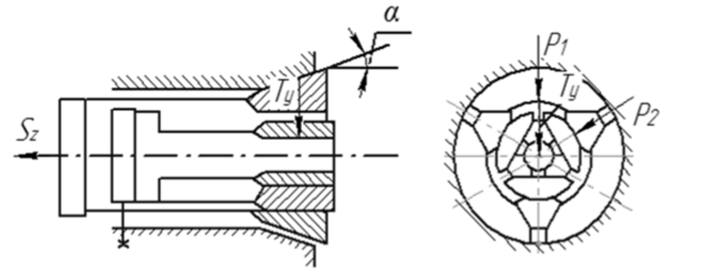
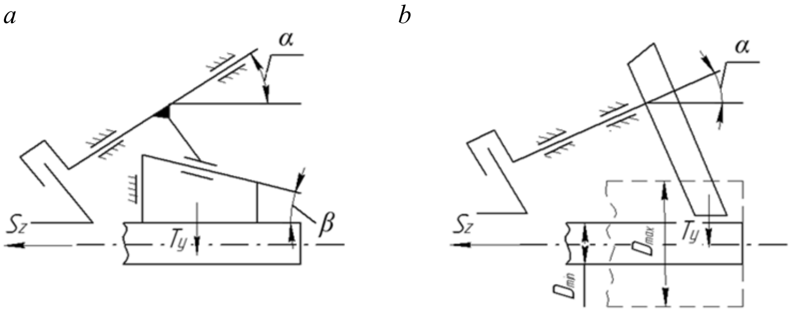
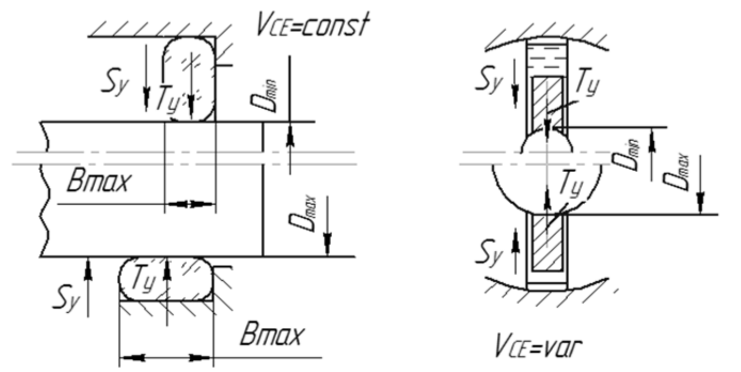
Example of the evolution of structures and CE circuits for bodies of rotation according to Fig. 3 by wide-blandness criterion is shown in Table 4.

Table 4

Schemes of chucks and theirs forcing (energing) streams

№ structure (fig.1)	Type of chuck	Structural scheme of chuck	Casting force contour	Forcing (emerging) stream
1	2	3	4	5
I	With an elastic solid cylindrical sleeve		Open, closed	S_y-T_y
II	With an elastic solid collect		closed	S_z-T_y($\underline{S_z}$-T_y)
III	Collect with elastic petals		closed	S_z-T_y($\underline{S_z}$-T_y)
IV	Self-adjusting collect		closed	S_z-T_y

Continuation of table 4

1	2	3	4	5
V	Wide range collect with a single animation		closed	$S_z(P_1)$-T_y
VI	Wide range collect with double animation		closed	$S_z(P_1$-$P_2)$-T_y
VII	Cartridges Wide wedge piston (a) or quickset with multi-cam (b)	a b 	closed/open	S_z-T_y
VIII	Wide range of cartridges with a constant (a) and reconfigurable multi-profile-cams (b) the volume of the clamping elements	a b 	closed/open	Sy-Ty

Conclusion

The genetic classification of energetic (power) flows in the clamping mechanisms of various versions summarizes the properties of the elastic force structures of these mechanisms and constitutes the systematic basis for understanding of the fundamental principles of the structural organization and natural development of mechanical, electromechanical, hydraulic, pneumatic, electromagnetic, magnetic and other force clamp systems such as bodies of rotation similar to the genetic classification of the electromagnetic field primary sources [9].

In the proposed classification of the interaction of the clamping element with the clamping object (components, work pieces or tool) various principles and laws of mechanics are reflected, including the topological invariance principle of the field sources, the principle of symmetry [8]; the principle of two nets, the principle of conservation of the basic types of mechanical and other energy converters, the law of energy conservation, D'Alembert's principle, Hooke's Law etc.

Анотація. *У статті розглянута генетична класифікація енергетичних (силових) потоків в затискних механізмах різного виконання, яка узагальнює властивості породжують пружно-силових структур цих механізмів і становить системну основу для пізнання фундаментальних принципів структурної організації та закономірного розвитку механічних,*

електромеханічних, гідравлічних, пневматичних, електромагнітних, магнітних та інших систем затиску деталей типу тіл обертання за аналогією з генетичною класифікацією первинних джерел електромагнітного поля. У запропонованій класифікації характеру взаємодії затискного елемента і об'єкта затиску (деталі, заготовки або інструменту) відображені різні принципи і закони механіки, серед яких принцип топологічной інваріантності джерел поля; принцип симетрії [6]; принцип парності; принцип збереження базового виду механічних та інших перетворювачів енергії ; закон збереження енергії; принцип Даламбера; закон Гука та ін.
Ключові слова: *затискні механізми, енергії, потужності, потоки, цанги, патрони широкого діапазону, жива огорожа патрони*

***Аннотация.** В статье рассмотрена генетическая классификация энергетических (силовых) потоков в зажимных механизмах различного исполнения, которая обобщает свойства порождающих упруго-силовых структур этих механизмов и составляет системную основу для познания фундаментальных принципов структурной организации и закономерной развития механических, электромеханических, гидравлических, пневматических, электромагнитных, магнитных и других систем зажима деталей типа тел вращения по аналогии с генетической классификацией первичных источников электромагнитного поля. В предложенной классификации характера взаимодействия зажимного элемента и объекта зажима(детали, заготовки или инструмента) отображены различные принципы и законы механики, среди которых принцип топологичной инвариантности источников поля; принцип симметрии[6]; принцип парности; принцип сохранения базового вида механических и других преобразователей энергии; закон сохранения энергии; принцип Даламбера; Закон Гука и др.*
Ключевые слова: *зажимные механизмы, энергии, мощности, потоки, цанги, патроны широкого диапазона, живая изгородь патроны.*

1. *Kuznetsov, Y.N., V. Voloshin, V.N., Nedelcheva, P.M., El-Dahab F.V.* Clamp mechanism for high-speed and high-precision machining: Monograph / Ed. Kuznetsov, Y.N. – Gabrovo: Vasil Aprilov University Press, 2010.– 724 p.
2. *Kuznetsov, Y.N., Ibrahim Al-Refo.* Accuracy of installation in collet. – NTU "KPI" Bulletin. – Mechanical Engineering. – № 37, 2000. – p.85–96.
3. *Kuznetsov, Y.N., Kushik, V.G., Yurchishin O.Y.* Wideband and multi-clamping mechanisms: theory and practice: Monograph / Ed. Kuznetsov, Y.N. – K.: OOO "ZMOK" - OOO "GNOSIS", 2011. – 424p.
4. *Kuznetsov, Y.N., Kushik, V.G., Firanskiy, V.B., Gumeniuk, O.A.* Tool chucks: Monograph / Ed. Kuznetsov, Y.N. – K.: OOO "GNOSIS", 2012. – 286p.
5. *Kuznetsov, Y.N., Hamuyela, J.A. Guerra, Hamuyela T.O.* Morphological synthesis of machines and mechanisms: Monograph / Ed. Kuznetsov, Y.N. – K.: OOO "GNOSIS", 2012. – 416p.
6. *Odrin, V.M.* Morphological analysis method of the technical systems. - M.: "ВНИИПИ", 1989. – 312p.
7. Self-adjusting clamp mechanisms: Reference book / Kuznetsov Y.N., Vachev, A.A. Syarov, S.P., Tsrvenkov, A.J.: Ed. Kuznetsov, Y.N. - K.: Technical, Sofia. State Publishing House "Technical", 1988. – 221p.
8. *Urmantsev, Y.A.* The symmetry of nature and the nature of symmetry. – M.: "Muisl", 1974. – 229p.
9. *Fomenko, A.T.* Geometry and Topology. Mathematical images in the real world. – Moscow: M. Un. Publishing House, 1992. – 432p.
10. *Shinkarenko, V.F., Kuznetsov, Y.N.* The genetic programmes of complex evolving systems. Proceedings of the International Conference "UNITEKH'11", TU – Gabrovo, 2011 vol.2 part 1, 2. – p.33–54.
11. *Shynkarenko, V.F.* Fundamentals of the theory of electromechanical systems evolution. – K.: Naukova Dumka, 2002. – 288p.
12. *Yudin, G.E.* Systematic approach and activities. – M.: Nauka, 1978. – 392p.
13. *F.Zwicky.* Discovery, invention, research through the morphological approach. – Toronto, New York: MeMillan, 1969.
14. *Weisser W.*Flexible Spannsysteme fur die Drehbearbeitung // Industieanzeiger. – 1979. – № 82. – p.41–42.
15. *Acuro.* Balancing system for tool holders, grinding wheels and rotors. Operating manual. Schunk GmbH & Co. KG. Lauffen/Necar, 2003. – 99p.
16. *Leopold I., Schmidt G.* Bewertung von HSC – Spannfuttern // Werkstatts – technik. – 2001. – № 9 (91) – p.556–564.

REFERENCES

1. *Kuznetsov, Y.N., V. Voloshin, V.N., Nedelcheva, P.M., El-Dahab F.V.* Clamp mechanism for high-speed and high-precision machining: Monograph / Ed. Kuznetsov, Y.N. Gabrovo: Vasil Aprilov University Press, 2010. 724 p.
2. *Kuznetsov, Y.N., Ibrahim Al-Refo.* Accuracy of installation in collet. NTU "KPI" Bulletin. Mechanical Engineering. No. 37, 2000. p.85–96.
3. *Kuznetsov, Y.N., Kushik, V.G., Yurchishin O.Y.* Wideband and multi-clamping mechanisms: theory and practice: Monograph. Kyiv: OOO "ZMOK".OOO "GNOSIS", 2011. 424p.
4. *Kuznetsov, Y.N., Kushik, V.G., Firanskiy, V.B., Gumeniuk, O.A.* Tool chucks: Monograph. Kyiv: OOO "GNOSIS", 2012. 286p.
5. *Kuznetsov, Y.N., Hamuyela, J.A. Guerra, Hamuyela T.O.* Morphological synthesis of machines and mechanisms: Monograph. Kyiv: OOO "GNOSIS", 2012. 416p.
6. *Odrin, V.M.* Morphological analysis method of the technical systems. Moscow: "ВНИИПИ", 1989. 312p.
7. *Kuznetsov Y.N.*, Vachev, A.A. Syarov, S.P., Tsrvenkov, A.J.: Ed. Kuznetsov, Y.N. Self-adjusting clamp mechanisms: Reference book. Kyiv: Technical, Sofia. State Publishing House "Technical", 1988. 221p.
8. *Urmantsev, Y.A.* The symmetry of nature and the nature of symmetry. Moscow: "Muisl", 1974. 229p.
9. *Fomenko, A.T.* Geometry and Topology. Mathematical images in the real world. Moscow: Un. Publishing House, 1992. 432p.
10. *Shinkarenko, V.F., Kuznetsov, Y.N.* The genetic programmes of complex evolving systems. Proceedings of the International Conference "UNITEKH'11", TU Gabrovo, 2011 vol.2 part 1, 2. p. 33–54.
11. *Shynkarenko, V.F.* Fundamentals of the theory of electromechanical systems evolution. Kyiv: Naukova Dumka, 2002. 288p.
12. *Yudin, G.E.* Systematic approach and activities. Moscow: Nauka, 1978. 392p.
13. *F.Zwicky.* Discovery, invention, research through the morphological approach. Toronto, New York: MeMillan, 1969.
14. *Weisser W.*Flexible Spannsysteme fur die Drehbearbeitung. Industieanzeiger. 1979. No 82. p.41–42.
15. *Acuro.* Balancing system for tool holders, grinding wheels and rotors. Operating manual. Schunk GmbH & Co. KG. LauffeNecar, 2003. 99p.
16. *Leopold I., Schmidt G.* Bewertung von HSC Spannfuttern .Werkstatts – technik. 2001. No. 9 (91). p.556–564.