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SEARCH OF METHODS OF CLAMPING OF THIN WALLED CYLINDRICAL DETAILS WITH THE USE OF GENETIC-MORPHOLOGICAL APPROACH

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ABSTRACT

The article introduces a generalized classification of thin-walled cylindrical details and a new approach of genetic morphological synthesis of methods of their clamping based on the latest advances in various areas of science and technology. The article shows that structural solutions of thin-walled cylindrical details used inmachine tools, machines, apparatuses and other technological equipment can be classified not only by the ratio of length to outer diameter and end face and by the presence of an end face, but by the availability of outer and inner projections as well. Such a diversity of shapes of various thin-walled cylindrical details influences the choice of the method of clamping them within processing quality assurance.

The article gives examples of various methods of axial, radial, tangential clamps, where they are described as genetic codes and structural formulae using them as elementary material medium of hereditary information in mental experiments of a material point. It is noted that the suggested generic-morphological approach with universal genetic synthesis operators can be one of prerequisites of employing the artificial intelligence for anticipation and synthesis of clamping mechanisms and machine tooling in various fields of mechanical assembly manufacturing.

1. INTRODUCTION

The fundamental feature of the present time in the context of challenges of the fourth industrial revolution called **INDUSTRY.4.0** [3] is creation of new machinery and newtechnologies in the sector of production facilities of an economically developed country that focuses attention on the artificial intelligence, environment, integration of science, education, manufacturing and service industry as well as on pursuing core objectives as follows:

1- Increase in productivity.

2- Improvement of the quality of products.

3- Reduction of costs for environmentally friendly manufacturing with energy and material resources saved.

4- Improvement of conditions and reduction of proportion of manual work.

5- Facilitation and reduction of monotonous intellectual work.

6- Enhancement of technological and functional capabilities of equipment.

This defined the global development trends for mechanical engineering. Pursuing the mentioned objectives in a sovereign highly developed country is impossible without local mechanic engineering industry. In practice of mechanical processing there are a considerable number of products, in which thin-walled cylindrical details (TCD) are employed [5,7].

LITERATURE REVIEW

Many years of practice have shown that disregard of the road map of development of technical systems (TS) in processes of their designing, manufacturing and operation results in making unsustainable systems. Unfortunately, engineering scientists usually pay no regard to the common patterns of system development and analysis of difficulties and contradictions arising in the process of development of applied approaches and techniques of making systems of certain functionality [1].

In the course of evolution of complex TS classified as anthropogenic [9], i.e. resulting from consciously targeted Human activity, the same laws are observed as those in living systems that have their own development programs, since the availability of such a program is a fundamental feature of living systems. The development programs have a genetic nature materialized in the genetic profile of each living organism. For this reason, the availability of its own development program until recently was considered a unique feature that distinguishes any living system from an artificialone.

Discovery of new imitative effects and phenomena makes it possible to foresee for many years ahead the development of science and technology to solve the most complicated problems, among which there are engineering, economic, social, spiritual, environmental, informational,

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and biological and others [1, 4, 10]. A Human, as the Nature's apprentice and one of its perfect creations, makes use of their intelligence as a result of acquiring new knowledge and its preservation in the form of genetic information inherited from generation to generation in different ways; The obvious examples of this with the use of the system-morphological approach can be a well-known D.I. Mendeleev's Periodic table of elements, the Periodic table of electromagnetic field primary sources recently discovered by Professor V.F. Shinkarenko from Igor Sikorsky Kyiv Polytechnic Institute [8-10].

The latter classification is based on spatial forms of the field sources with six geometrical classes of surfaces: cylindrical, cone-shaped, flat, toroid-flat, spherical, toroid-cylindrical. As applied the TS, the method of morphological analysis became a frequent practice [4]. Employing of the system morphological approach and the TS evolution theory with a fresh angle on the material point [6] as a medium of genetic information gave an impetus to the genetic-morphological synthesis of clamping mechanisms [2,4] that made it possible to create brand new competitive designs and implement them into the industry.

This article is dedicated to searching for the methods of clamping thin-walled cylindrical details (TCD), for which there are well-known classifications by their shape and size ratio [5,7,11], one of which is shown in Fig. 1 [7]. It characterizes the affiliation of details to a certain class by the ratio of their overall dimension's length L (height B) and outer diameter D_{out}. However, the classification does not stipulate areas of outer and inner surfaces that can be determinative with the account taken of the symmetry when technological equipment, a method of clamping, methods of processing, cutting conditions and cutting tools are chosen; For example, in work [5] it is noted, that the turning of TCD is often not possible, when using the common hydraulically operated 3- or 4-jaw chucks. In this work, compensation by different models is designed and realized by an intelligent, adaptive and interchangeable turning tool holder with integrated sensors and actuators.

RESEARCH METHODOLOGY

Before you begin to search for new methods of clamping, you should take an advantage of advances in the module technology by Professor Bazrov B.M. The module technology of manufacturing details is based on of the principle of combining of the detail surfaces intended for joint performing of the final service function of the detail. From this perspective you should take into consideration the structural concepts of TCD used in machine tools, machines, apparatuses and other technological equipment and suggest a classification not only by the ratio of length to outer diameter and the presence of an end face, but by the availability of outer and inner projections as well. Such a diversity of shapes of various TCD influences the choice of the method of clamping them within the processing quality assurance. For that purpose, we suggest a morphological model (Table 1) that can serve as a generalized classification.

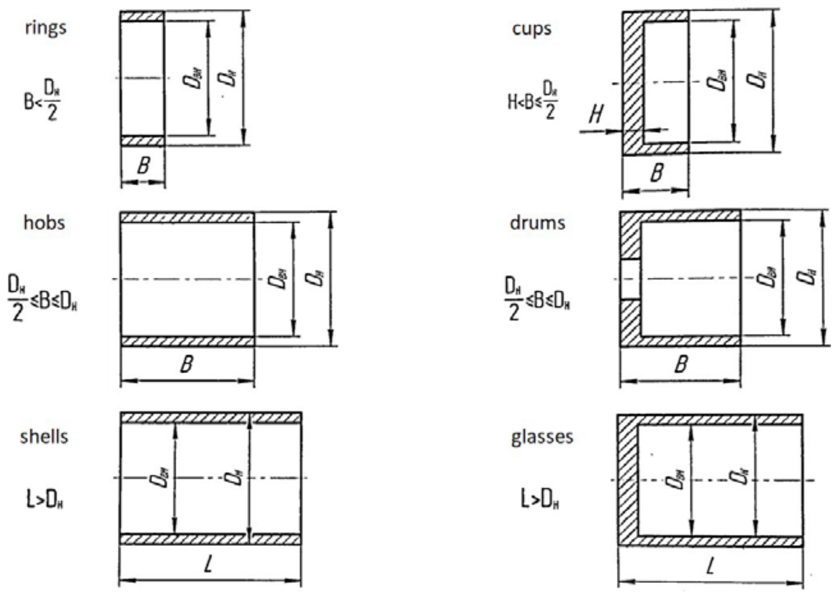

Fig. 1. Well-known Classification of the Thin-Walled Cylindrical Details [7]

***Table 1** Morphological Table of the Thin-Walled Cylindrical Details (Generalized Classification)*

1. Axes of symmetry	**2.** Ledges	**3.** Bolt ends
Two	No	No
One	Outside	Deaf
	Inwardly	With opening
	2.4. Outside and inwardly	

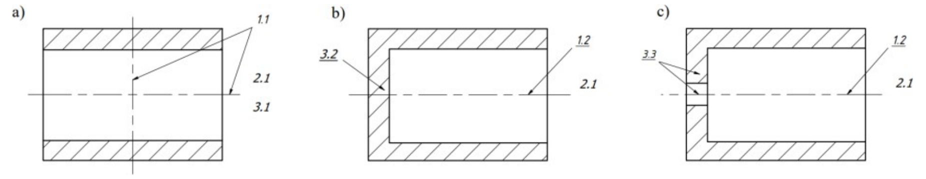

Fig. 2. Presentation of well-known classification of the thin-walled cylindrical details (Fig. 1) as morphological formulas: a) 1.1 – 2.1 – 3.1; b) 1.2 – 2.1 – 3.2;

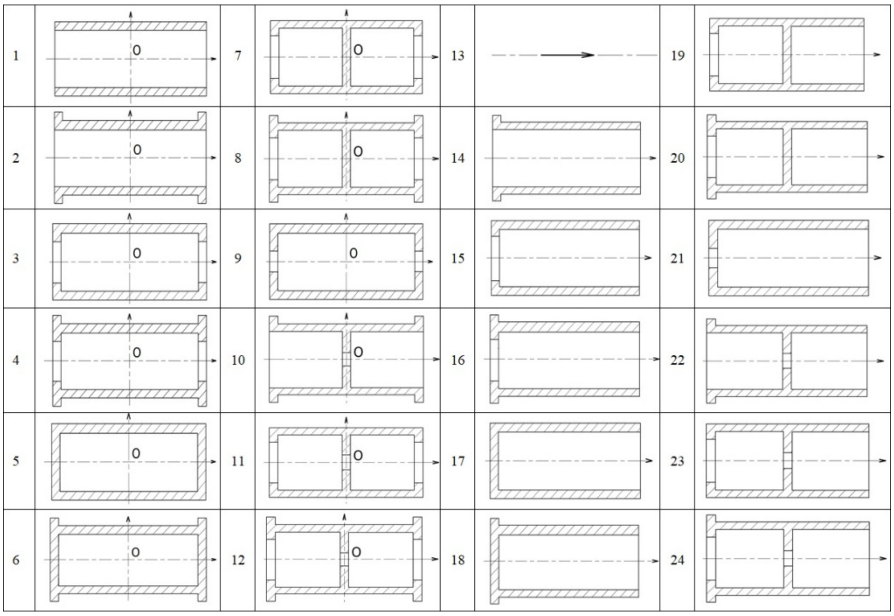

Fig. 3. Generalized Classification of the Thin-Walled Cylindrical Details: With Two Axes of Symmetry (1-12) and One Axes of Symmetry (13-24)

***Table 2** Complete Array of Abominations of Alternatives of Signs, Characterizing the Forms of the Thin-Walled Cylindrical Details (Table 1)*

№ form	Morphological formula	№ form	Morphological formula
1	1.1 – 2.1 – 3.1	13	1.2 – 2.1 – 3.1
2	1.1 – 2.2 – 3.1	14	1.2 – 2.2 – 3.1
3	1.1 – 2.3 – 3.1	15	1.2 – 2.3 – 3.1
4	1.1 – 2.4 – 3.1	16	1.2 – 2.4 – 3.1
5	1.1 – 2.1 – 3.2	17	1.2 – 2.1 – 3.2
6	1.1 – 2.2 – 3.2	18	1.2 – 2.2 – 3.2
7	1.1 – 2.3 – 3.2	19	1.2 – 2.3 – 3.2
8	1.1 – 2.4 – 3.2	20	1.2 – 2.4 – 3.2
9	1.1 – 2.1 – 3.3	21	1.2 – 2.1 – 3.3
10	1.1 – 2.2 – 3.3	22	1.2 – 2.2 – 3.3
11	1.1 – 2.3 – 3.3	23	1.2 – 2.3 – 3.3
12	1.1 – 2.4 – 3.3	24	1.2 – 2.4 – 3.3

**New alternatives are distinguished by a line in № 2- № 24 form*

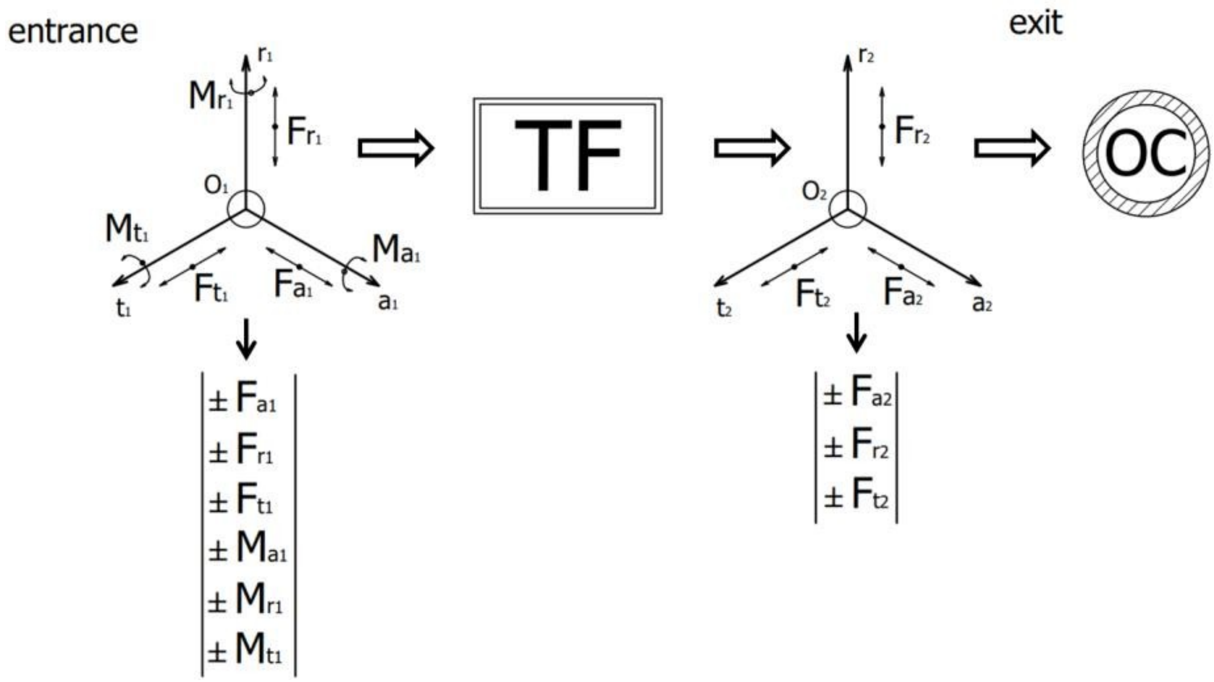

Fig. 4. Transmission and Transformation (TF) of Information to the Object of Clamp (OC) –the Thin-Walled Cylindrical Details

According to the mentioned morphological model (Table 1) the class of details shown in Fig. 1 is described only with three morphological formulae with the respective alternatives (Fig. 2) instead of twenty-four, one of which (combination of alternatives 1.2 - 2.1-3.1) is not realizable (Table 2, Fig. 3).

Among the details with two axes of symmetry the known forms refer to: №1 - rings, bushings, sleeves, tubes, №2 – bearing rings, bands of drums for ropes in handling facilities, №3 – outer rings of needle roller bearings, №10 – car wheel discs etc. Among the details with one axis of symmetry the known forms refer to: №14- flanges, racks,

№15, 16 – overhung drums, №17, 18 – cups, barrels, etc. Certain forms can be unknown or will come into use in future.

Similarly with the suggested electromagnetic gene [10] in the periodical system of primary sources of electromagnetic field and due to self-organization principles and the genetic "simple-to-complex" principle when the known clamping principles are employed and new clamping principles are searched for, the material point as a genetic information medium in creation of the TS of "object" and "process" type [6] on the genetic level is notionally named a mechanical gene and it contains the information about translational Fig. 1: Transmission and Transformation (TF) of Information to the Object of Clamp (OC) –the Thin-Walled Cylindrical Details and rotational motions, loads and their directions (Fig. 4).

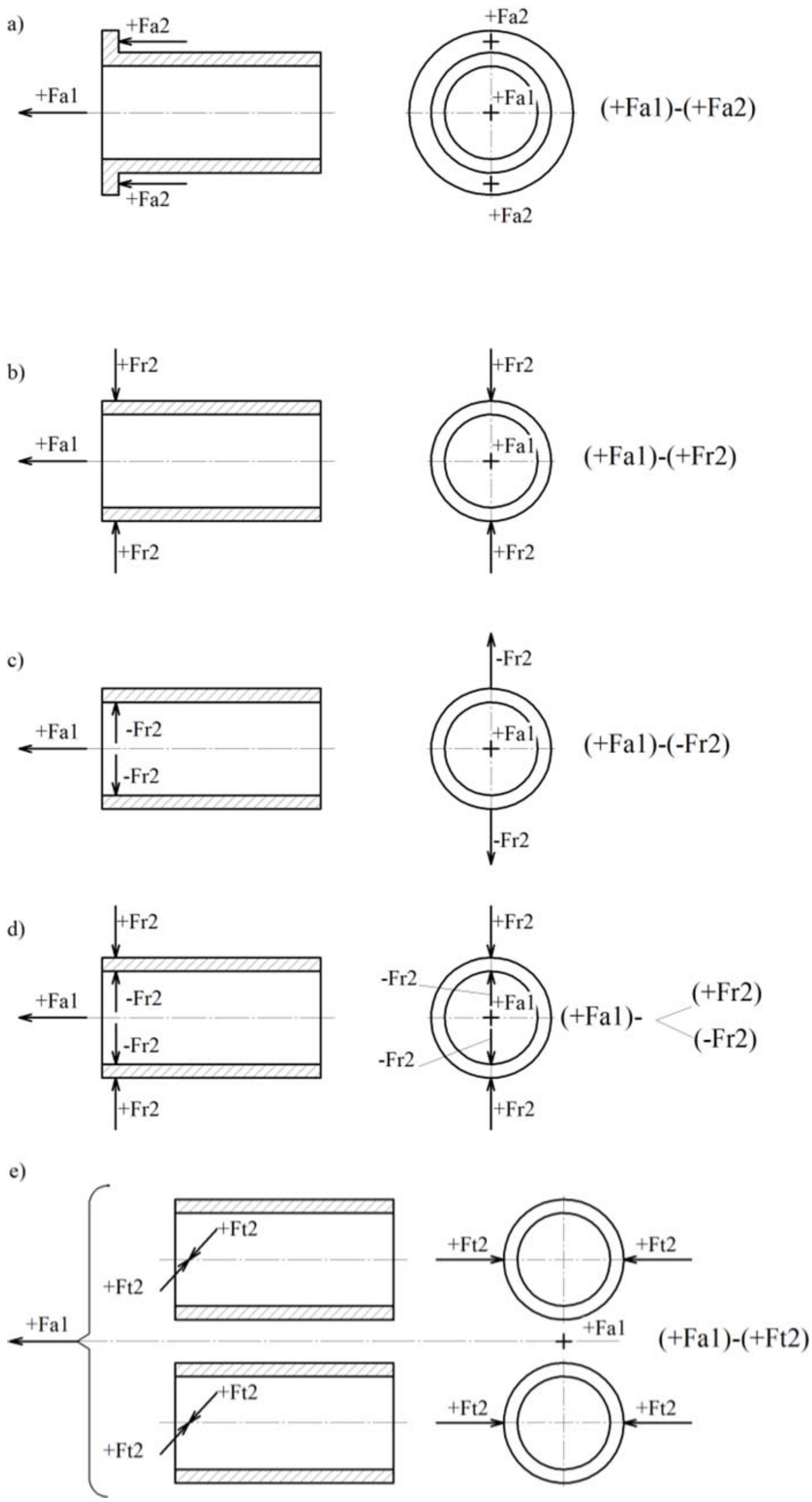

Fig. 5. Examples of Methods for Clamping Thin-Walled Cylindrical Details at the Object Level With Structural Genetic Formulas

Information transfer from point O_1 at the input to point O_2 at the output with different coordinate axes a1r1t1 and a2r2t2 gives 72 variants of implementation of clamping principles (axial, radial, tangential) [4].

RESULTS

This article will address solid state mechanical transformers TF, which according to [4,6] are the following seven: lever (LV); wedge (WD); spiral (SL); plunger (PL); screw (SC); gear (GR); spring (SR).

The multilevel system-morphological approach to searching for the clamping principles on different levels of their simulation with the scope of information increased makes it possible to expand the data base from simple structures to complex ones on the following organization levels [4, 9]: chromosomal; object; population; specific; system; intersystem; met system. With this in mind, each level of the structural hierarchy maintains hereditary (genetic) information of the previous level, and each object of an arbitrary level of hierarchy is presented as a genetic code or a structural Formula.

Multi variance of the received solutions is increased due to using of five universal genetic operators of synthesis [9]; To illustrate the above, we present the fragments of methods of clamping thin-walled cylindrical details on the chromosomal object (Fig. 5) and object (Fig. 6) levels.

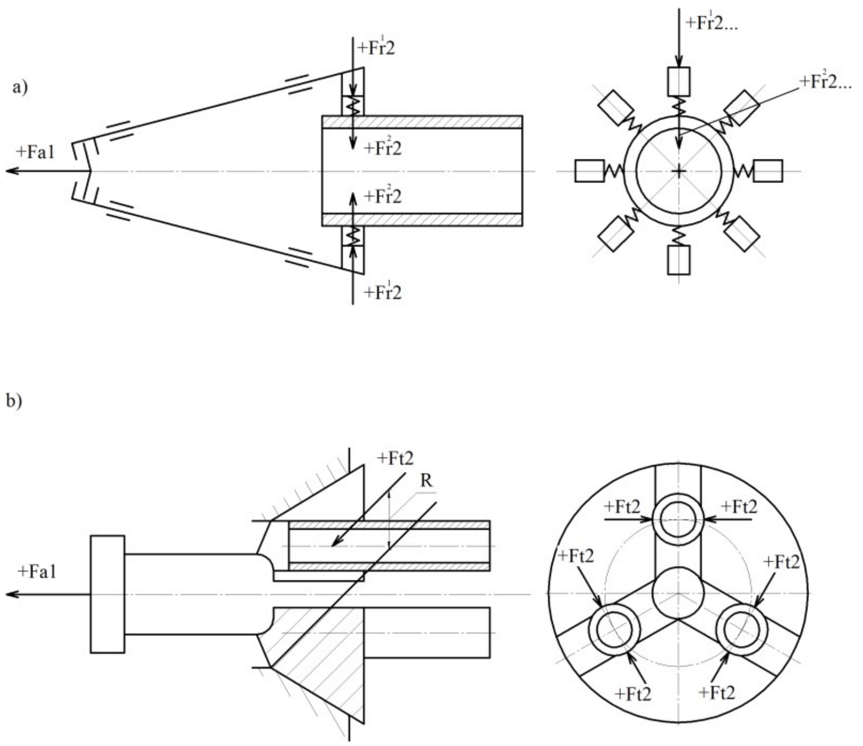

Fig. 6. Examples of Methods for Clamping Thin-Walled Cylindrical Details at the Chromosomal Level and Corresponding Structural Genetic Formulas: a) (+Fa1) – (PL x SR) – (+Fr2) or (+Fa1) – PL - (+Fr21) - SR – (+Fr22); b) (+Fa1) – WD – (+Ft2)

For clamping of a detail with an outer flange (projections) we have chosen an axial clamp (item a, Fig. 5), while for a projection-free detail a radial clamp outside (item b, Fig. 5), with the use of the genetic inversion operator a radial clamp inside (item c, Fig. 5), while with the use of the genetic crossover operator a hybrid radial clamp outside and inside (item d, Fig. 5). A multipoint clamp, a tangential clamp with the use of genetic replication operator can be implemented in case of misalignment of the axes of the details with respect to the axis of the axial force at the input (item e, Fig. 5).

CONCLUSION

On the base of the genetic-morphological approach a morphological analysis has been carried out, and a generalized classification of TCD has been suggested not only by the ratio of the length to the outer diameter and presence of an end face, but by the availability of outer and inner projections as well, that influences the choice of the method of their clamping. Through specific examples with the use of a material point as a genetic information medium we have shown the efficiency of search for new methods of clamping of TCD for further commercialization of results of creative thinking in business [1, 9].

REFERENCES

[1] Griffits C., Costi M., A guide to creative thinking, transl. From English U. Kurganova, Kharkov, publishing house "Morning": Fabula, (2020) 288 p.

[2] El-Dahabi F.W., Kuznetsov Yu.N. Genetic-morphological synthesis of machine-tool racking //Journal of Advanced Research in Natural Science,SRC MS, Seattle USA, (2020) 26-36

[3] Popov G., Basics of technological foresight and nakoki for reading research in a frame on Industry 4.0 // Conference "Industry 4.0 - Digitalization and perspective for spreading on the Bulgarian economy", Sofia Tech Park, (2017)

[4] Hamuyela Zh.A. Guerra Genetic and morphological synthesis of chucks, monograph / J.A. Gerra Hamujela, Yu.N. Kuznetsov, T.O. Hamujela; ed. Yu.N. Kuznetsova, Lutsk: Vezha-Druk, (2017) 328 p.

[5] Heisel U., Kang C., Model-based form error compensation in the turning of thin-walled cylindrical parts // Product Engineering, 5 (2011) 151-158

[6] Kuznetsov Yu. N., A new look at the material point as a carrier of genetic information in the creation of technical systems // Materials of the International Scientific and Practical Conference "Fundamental Foundations of Mechanics", Novokuznetsk: SRC MS, 1 (2016) 26-40

[7] Pashkov E.V., Technological foundations of turning thin-walled cylindrical parts: Textbook. manual for students of mechanical engineering. Specialist / E.V. Pashkov; Sevastop. state tech, Sevastopol: SevGTU, (2000) 425 p.

[8] Shinkarenko V., Makki A, Shymanska A., Kotliarova V., Genetic Synthesis of Electromechanical Objects of the Modular Type // 2019 IEEE International Conference on Modern Electrical and Energy Systems (MEES), Kremenchuk, Ukraine, (2019) 166-169

[9] Shinkarenko V., Kuznetsov Yu. Interdisciplinary approach to modeling and synthesis of difficult technical systems //Journal of the Technical University of Gabrovo, 52 (2016) 24-28

[10] Shynkarenko V., Makki A., Kotliarova V., Shymanska A., Krasovskyi P. Genetic Organization and Evolution of Electromechanical Objects with Adaptive Geometry of Active Zone, Advances in Science, Technology and Engineering Systems Journal, 5 (5) (2020) 512-525

[11] Shu-Qin Fan, Sheng-Dun Zhao, Chao Chen. Plastic Deformation Mechanism in Double-Roller Clamping Spinning of Flanged Thin-walled Cylinder//Chinese Journal of Mechanical Engineering, vol.31 (1), article id.56 (2018) 9 p.