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A NEW VIEW ON THE MATERIAL POINT AS A CARRIER OF GENETIC INFORMATION WHEN CREATING TECHNICAL SYSTEMS

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ABSTRACT

A non-traditional genetic-morphological approach to the use of a material point for solving the problems of synthesizing technical systems such as "object" and "process" is proposed, which is illustrated on clamping mechanisms for bodies of revolution and kinematic cutting schemes.

1. PROBLEM STATUS

The creation of new developing technical systems (TS) is impossible without analyzing and taking into account the accumulated human experience, which, like genetic information, is transmitted from generation to generation on various media.The continuous expansion and complication of TS and the functions they perform confirms the dialectic of their development over time.If the first devices designed to expand the physical capabilities of a Human in the performance of a particular job were elementary tools in the form of sticks, stones, axes, knives, etc., then at the present stage of development of human society, one has to deal with entire systems thatnot only replace physical and routine mental work, but also lend themselves to automatic control and intellectualization, and also allow you to carry out work processes with optimal parameters and modes.Large vehicles have appeared, which include CNC machine tools and mechatronic systems, robotic technological complexes, and even flexible automated factories [14, 15]. The development of any TS includes evolutionary processes that characterize quantitative changes, and revolutionary processes that reflect qualitative changes.A retrospective analysis of the development of the TS is carried out precisely from these positions, focusing on the achievements of science and technology.Vehicles are changing rapidly, their designs are being improved, they are becoming more productive, higher quality and more reliable, multifunctional, energy efficient, quickly adaptable and adaptable to changing environmental conditions. Long-term practice has shown that ignoring the concept of ES development in the processes of their design, production and operation leads to the creation of unviable systems [2,13]. Unfortunately, representatives of technical sciences usually neglect the study of the general laws of development of systems and the analysis of difficulties and contradictions that arise in the process of developing applied methods and techniques for creating systems of a certain functional purpose. During the evolution of complex TS, which are classified as anthropogenic (AGS), i.e.created as a result of the purposeful activity of Man, the same laws are observed as in living systems that have their own development programs, since the presence of such a program is a fundamental property of living systems. Development programs are of a genetic nature, materialized in the structure of the genome of every living organism.Therefore, the presence of one's own development program until recently was considered a unique property that distinguishes a living system from an artificial one [24, 28].

Previously subjected to devastating criticism, cybernetics, called the "corrupt girl of imperialism", and genetics, called "pseudoscience" paved the way for knowledge and their use in the TS [11, 14, 16, 23, 28]. In recent years, the knowledge gained in genetics has begun to be used in various fields of science and technology, since genetics is an interdisciplinary field of knowledge that studies the laws of heredity and structural variability in natural and natural-anthropogenic systems [25]. The presence of intersystem analogies is evidence of the commonality of the system principles of structural organization in developing systems of different physical nature. The elemental basis and fundamental properties of such integral structures are ordered by periodic generative systems that perform the function of genetic programs for the structural organization and development of complex systems. The discovery and cognition of generative systems in a particular field of knowledge is of general scientific and interdisciplinary significance, since it is directly related to the emergence and formation of a new scientific

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paradigm that determines the transition from fragmentary research to system research [7, 25].

According to the system-structural approach, the creation of complex systems is based on the concept of elementarity, the doctrine of the property of elementary structures that serve as a theoretical basis for the generalization and synthesis of knowledge in modern fundamental sciences [23]. In this case, the methodological basis is the principle of the existence of a limited number of elementary (generating) structures, which is confirmed by research in various fields, for example: all living organisms are formed from 24 chemical elements; the entire color scheme is formed from 7 colors; all musical works are written from 7 notes; the whole variety of numbers consists of 10 digits; all electromagnetic field sources contain 6 geometric classes of surfaces.

Granovsky G.I. [4] proposed to describe various principal kinematic schemes of cutting as a combination of two elementary movements: rectilinear and rotational with their digital coding - the scheme number, which was used in the theory of machine tool layouts on a modular basis [14].

Smirnov V.A. [17], analyzing the ways of constructing scientific theories, came to the conclusion that there are two fundamental systems of thinking. At the semantic level, the first one is represented by set-theoretic thinking and implemented in the axiomatic method of constructing a theory. The second system is based on genetic, constructive thinking [18]. In practice, the objects of a genetically constructed theory are, although effectively defined, but abstract objects, which, for example, can be symbols of the alphabet or other languages for describing the area or object under study. The two systems of thought are based on different and even incompatible conceptions of truth. Any design of solid structures is associated with geometric constructions, since the nature of human consciousness is arranged in such a way that all new ideas are perceived by them much better if they are accompanied by pictures explaining the essence. That is why almost any construction is easier to explain, describe or comprehend if it is presented not in the algebraic language of formulas and equations, but in graphical means of diagrams, diagrams and visual models, i.e. the language of geometry [5, 10, 11]. In addition to the language of geometry, for evolutionary synthesis and the construction of scientific theories, they began to use the genetically constructive method [17], in which the initial concepts are not descriptions of empirically fixed objects and phenomena, but so-called constructs. The term construct is used to refer to some abstract model (an ideal object generated by creative thinking and imagination and existing only in the language of the corresponding conceptual systems). Objects of this kind serve as a means of representing knowledge about those characteristics of the studied fragment of reality that cannot be directly observed under any conditions. Introduction to the structure of the theory of ideal models makes it possible to very successfully use such a cognitive tool as a thought experiment. Representing imaginary objects in a certain symbolic form, the researcher can make certain transformations in it, introduce characteristics that are not found empirically into the content of constructs, consider entities of interest to him in such conditions that may be impossible in a real situation. All this allows you to see the object under study in some new perspective and discover such ways of describing it that previously remained unused. Such possibilities are due to the fact that the meaning of constructs is determined solely by its connections with other terms that are part of the structure of the corresponding theoretical system. In this regard, mental operation with ideal objects can change the nature of the connections that exist between the linguistic means of a certain concept, and thereby open up the possibility of a qualitatively different description.

2. TRADITIONAL CLASSICAL VIEW OF A MATERIAL POINT

Mechanics as an ancient science of the laws of motion of bodies [1, 5, 6] is used in the study of various physical phenomena, chemical and biological processes, in the design of technological processes in various industries, in the construction of various structures, in the creation of various machines, mechanisms, components and parts, in the study of natural phenomena on the Earth, under the Earth, under water, in the air and in Space [6]. The laws of mechanics govern the movements of living beings, the processes in living organisms, the study of which makes it possible in medicine to diagnose diseases and create artificial organs of the human body. There is practically no area of knowledge where knowledge of the basic laws of mechanics is not required. The discovery of seemingly paradoxical new effects and phenomena [26], objectively existing in Nature, makes it possible to foresee the development of science and technology for many years to come, to solve the most complex problems facing humanity, including energy, environmental, raw materials, information, social and etc. [10].

In theoretical mechanics [1, 5, 19], the section of statics is devoted to the general doctrine of forces and the study of the equilibrium condition of material bodies under the action of forces, which are a vector quantity and determined by a numerical value (modulus of force), direction and point of application.

The section of kinematics studies the geometric properties of the motion of bodies without taking into account their inertia (mass) and the forces acting on them. On the one hand, kinematics is an introduction to dynamics, and on the other hand, it serves to study the transmission of motion in mechanisms. The movement of bodies takes place in three-dimensional Euclidean space. The main task of kinematics is to determine all kinematic quantities (trajectories, velocities, accelerations, etc.) knowing the law of motion of a given body (or point).

In the dynamics section, the laws of motion of material bodies under the action of forces are studied, while taking into account both the acting forces and inertia (the property of changing the speed of its movement faster or slower under the action of applied forces) of the material bodies themselves. Mass is a quantitative measure of the inertia of a body, therefore, in order to abstract from taking into account the influence of the shape of bodies (mass distribution), the concept of a material point is introduced as a material body that has a mass, the dimensions of which can be neglected when studying its movement. Particles are considered to be material points, into which anybody is mentally divided when determining one or another of its dynamic characteristics. When studying the motion of one material point, the study of the motion of a system of points and, in particular, a rigid body should precede [1, 19].

3. A NEW LOOK AT THE MATERIAL POINT

Philosophers, among whom the term “monado” [3], borrowed from the Greek philosophy of Giordano Bruno, Leibniz (his philosophy is called “monadology”), were engaged in attempts to restore order in the vast diversity and multidimensionality of the world.According to Leibniz, the foundations of existing phenomena or phenomena are simple substances or monads (from the Greek monados - unit).The idea that there are no absolutely similar monads or two completely identical things in the world, Leibniz formed as the principle of "universal difference" and at the same time, as the identity of "indistinguishable", putting forward a deeply dialectical idea - monads, self-expanding all their contents due to self-consciousness.They are independent and self-active forces that bring all material things into a state of motion, form an intelligible world, from which the phenomenal world arises. For the process of evolution from disorder to order (the entropy in the system must decrease), the concepts of self-organization and interdisciplinary science of synergetics have arisen in open systems [7, 8, 21]. Self-organization is a process of ordering (spatial, temporal or space-time) in an open system due to the coordinated interaction of many elements that make up this system.Synergetics (eng. Synergetics, Greek syn - "general" and ergos - "action") as an interdisciplinary science [8], which studies the processes of self-organization and the emergence, maintenance of stability and decay of structures (systems) of various nature based on the methods of mathematical physics(“formal technologies”). According to the author of the theory of synergetics Herman Haken [21]: “The main distinguishing feature of complex systems is their truly inexhaustible diversity, which cannot be sorted out, despite numerous attempts to fully understand the nature of complex systems ... .We are faced with the acute problem of finding unified principles that would allow us to properly approach the study of such systems ..."

In the expanding variety of objects and systems created by Nature and Man, general principles of their structural organization are observed, which manifest themselves in the form of intersystem analogies or hidden intrasystem homologies.Such properties take place both in natural (biological, chemical, electromagnetic, etc.) systems, and in systems of natural-anthropogenic origin (numerical, linguistic, technical, etc.) [25]. Thanks to the principles of self-organization and the genetic principle “from simple to complex”, a new view of the material point is proposed as a carrier of genetic information when creating a TS of the “object” and “process” types [11, 12, 14, 16, 22]. For the first time, the material point in the force flows of clamping mechanisms was announced by the author in the report [9] with their alphanumeric coding. This material point at the genetic level is conditionally called a mechanical gene and carries information about translational and rotational movements, loads and their directions (Fig. 1). A material point can be immobile, like information about static AGS (structures, supporting systems of technological equipment). If we turn to the origins of the creation of mechanical systems by Man, then the tools of the Stone Age were simple forms of bodies.

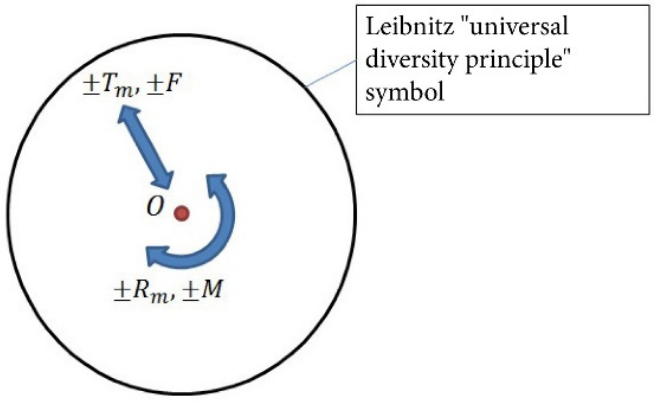
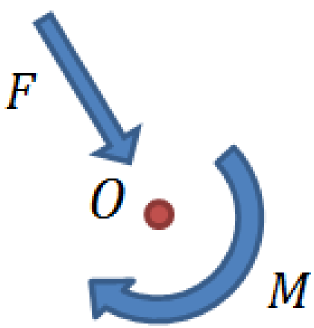
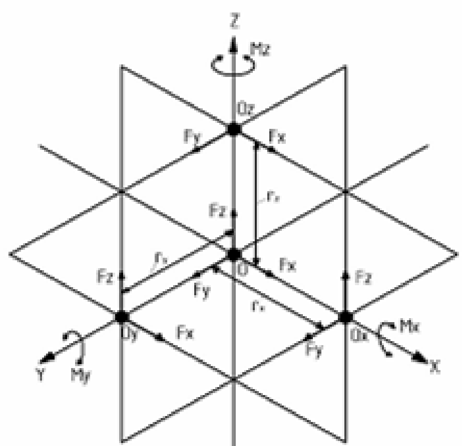


Fig. 1. Material point (O) - a mechanical gene that carries information about displacements and loads of translational (±T_m; ±F) and rotational (±R_m; ±M) indicating the direction

A set of material points form a material body, the state of equilibrium or movement of which depends on the nature of interaction with other bodies, i.e.from those pressures, attractions or repulsions that the material body experiences as a result of these interactions.With the help of a gene, hereditary information is transmitted in a number of generations (the laws of mechanics, theoretical mechanics, the theory of machines and mechanisms, strength of materials, machine parts, etc.) [10, 11]. By analogy with the electromagnetic field [23], in mechanics we can talk about a force field, which can serve as an initial structure containing an ordered set of mechanical genes with a given spatial sequence of their placement (distribution) within the boundaries of a geometrized topological space (surface). The value, which is a quantitative measure of solid-state mechanical systems at the genetic level in the form of a material point O (Fig. 2) in Euclidean space, is the force F.





a) *b)*

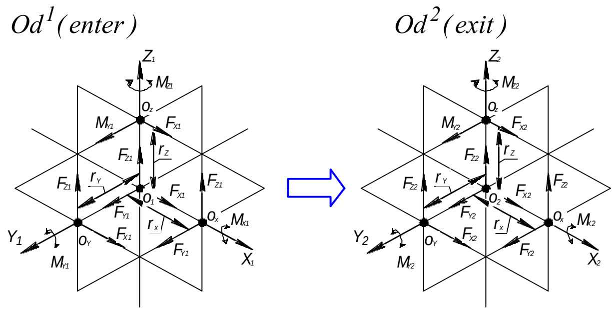
Fig. 2. Mechanical gene - a moving material point (a) in the XYZ Cartesian coordinate system (b)

This force F can be mentally applied directly to a material point, which causes its translational movement in space along the coordinates X, Y, Z (F_x, F_y, F_z), or at a certain distance-radius (r_x, r_y, r_z), which indicates about the rotation of a material point around the coordinate axes X, Y, Z under the action of moments M:

$$M_x = F_y \cdot r_z - F_z \cdot r_y$$
$$M_y = F_z \cdot r_x - F_x \cdot r_z$$
$$M_z = F_x \cdot r_y - F_y \cdot r_x$$

Using the genetic-morphological approach [11, 12, 16], the transfer of displacement, force and energy in space can be represented as a force (energy) flow from one material point O_1 at the input in the coordinate system $X_1\ Y_1\ Z_1$ to another material point O_2 in the systemcoordinates $X_2\ Y_2\ Z_2$ (Fig. 3), giving 144 variants of streams (parental chromosomes).

a)



b)

$$M_{EN} = \begin{vmatrix} \pm F_{X1} \\ \pm F_{Y1} \\ \pm F_{Z1} \\ \pm M_{X1} \\ \pm M_{Y1} \\ \pm M_{Z1} \end{vmatrix} \rightarrow M_{EX} = \begin{vmatrix} \pm F_{X2} \\ \pm F_{Y2} \\ \pm F_{Z2} \\ \pm M_{X2} \\ \pm M_{Y2} \\ \pm M_{Z2} \end{vmatrix}$$

Fig. 3. Generalized model of power (energy) flows in a mechanical system (a) and the corresponding morphological model-matrix (b)

The vector of force F or moment M can have a directly opposite direction, which we will consider positive in the direction of the coordinate during translational movement and clockwise during rotational movement (the rule of the right hand is that if the thumb is directed along and towards the positive coordinate, then the bent fingers will show the directionrotation).The negative direction of force F or moment M will be denoted by underlining from below, i.e. $\underline{F_x}, \underline{F_y}, \underline{F_z}, \underline{M_x}, \underline{M_y}, \underline{M_z}$.

The systematic genetic and morphological approach makes it possible to successfully combine structural studies in various fields of science and technology due to its interdisciplinary nature using the relevant philosophical categories, provisions of the general systems theory. According to the degree of functional and structural organization, ACS are static (building structures, supporting systems of technological equipment, etc.) and dynamic (machine tools, machines, their mechanisms and drives), which are characterized by continuous and discrete processes of transformation and metabolism (matter), energy and information [2, 13]. Recently, there has been a penetration of evolutionary genetic ideas into technical and humanitarian disciplines (genetic electromechanics, hereditary mechanics, technological heredity, genetic psychology, genetic linguistics, genetic history, evolutionary cybernetics, genetic standardization, etc.) [23, 25].

4. EXAMPLES OF APPLYING A NEW LOOK AT A MATERIAL POINT

4.1. Evolutionary and genetic synthesis of chucks

In accordance with the generalized model (Fig. 3), all power (energy) flows in clamping chucks are described below by the morphological matrix with one input and output, giving 48 parental chromosomes [12]. The matrix is presented in a cylindrical coordinate system, where the following designations are introduced:

$$F_{x1} = F_{a1};\ F_{y1} = F_{r1};\ F_{z1} = F_{t1};$$
$$M_{x1} = M_{a1};\ M_{y1} = M_{r1};\ M_{z1} = M_{t1};$$
$$F_{x2} = F_{a2};\ F_{y2} = F_{z2} = F_{r2}.$$

$$M'_{EN} = \begin{vmatrix} \pm F_{a1} \\ \pm F_{r1} \\ \pm F_{t1} \\ \pm M_{a1} \\ \pm M_{r1} \\ \pm M_{t1} \end{vmatrix} \rightarrow M'_{EX} = \begin{vmatrix} \pm F_{a1} \\ \pm F_{r2} \end{vmatrix}$$

The most commonly used parental chromosome $F_{a1} - F_{r2}$, and for 2/3 of the parental chromosomes, their use is not yet known. At the object level of genetic information for clamping chucks, there can be different closures of power flows in the form of elementary power circuits at the output [9, 10, 12]. As the structure becomes more complex by introducing various transducers, populations of clamping chucks appear, and among the known simple mechanical transducers, seven are used [12]: lever, wedge, spiral, plunger, screw, gear, spring (Fig. 4).

Arbitrary power flow structures (parental chromosomes), which play the role of generative elements, become more complex in the process of genetic development, forming combinatorial groups of n-th generation descendant chromosomes using five universal synthesis operators: replication, crossing, inversion, crossing over, and mutation [10, 15, 22]. Below is a description of the clamping mechanism at various levels of structural organization (parental chromosome $F_{a1} - F_{r2}$ or $F_{x1} - F_{y2}$):

genetic, F_{x1};

chromosomal, $F_{x1} - F_{y2}$;

object, $F_{x1} - F_{y2}\ (1K_R)$;

population, $F_{x1} - LV - F_{y2}\ (1K_R)$;

specific, $F_{x1} - LV - F_{y2}\ (1K_R) - CL$;

system,
$E - EM - F_{x0} - (WD - LV) - F_{x1} - LV - F_{y2}(1K_R)$.

Here E is an electrical energy source;EM – electromechanical transducer (primary), which creates axial force F_{x0} at the input of the clamping drive ($Pr Z$); (WD-LV) - hybrid wedge-lever transmission and amplifying mechanism in the clamp drive with output force F_{x1}, which is the input to the clamping chuck, LV - lever converter in the clamping chuck; F_{y2} (1·KR) is the output radial clamping force F_2 with a closed power circuit (number 1, and if the circuit is open - number 0) and the number of clamping elements n, determined by the replication multiplier KR (for a three-jaw clamping chuck KR=3).

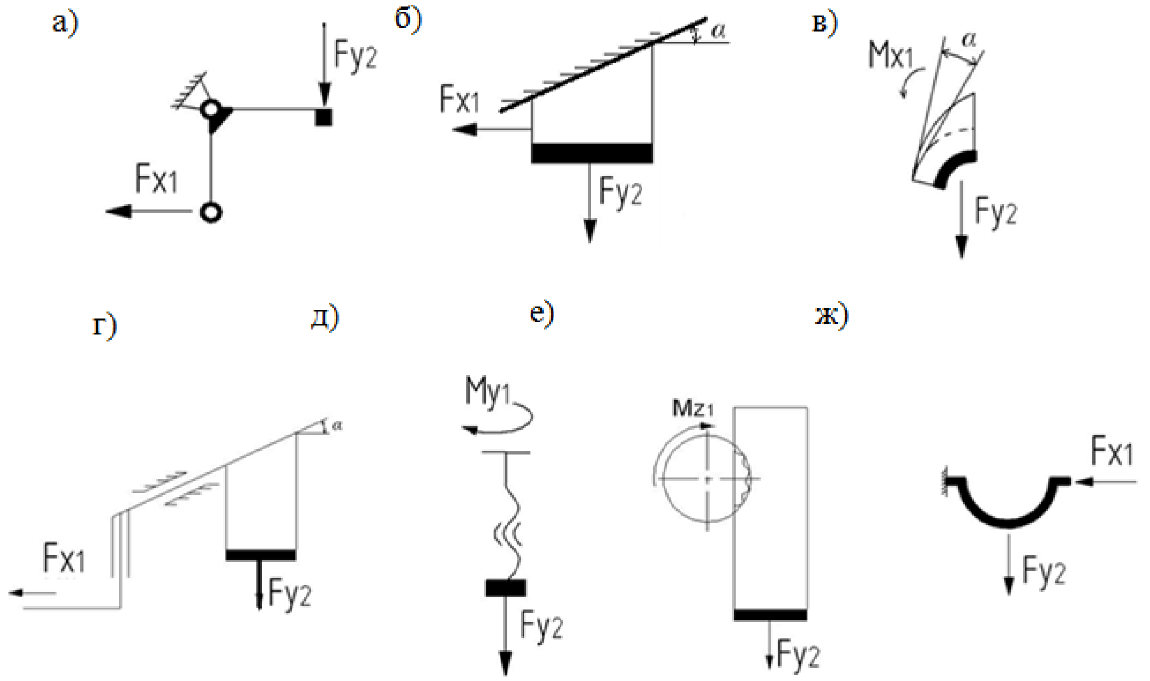


Fig. 4. Solid-state simplest mechanical transducers of displacement and forces: a - lever (LV); b - wadge (WD); c - spiral (SP); d - plunger (PL); e -screw (SC); h - gear (GR); g - spring (SR)

4.2. Implementation of the concept of creating new generation machines

The presented concept includes: -genetic-morphological multilevel approach to the classification, description, evolution, prediction and synthesis of complex TS [10, 16, 28];- application of frame and shell structures of load-bearing systems [11, 14, 15]; - aggregate-modular layout principle [14, 15]; - use of advanced information technologies and intelligent computer systems [14, 15]. The proposed concept has been successfully implemented in the creation of small-sized machine tools with computer control of various layouts, including those with parallel structure mechanisms (MPS), using a limited number of modules (linear movements with the additional function of a frame rib, a motor-spindle, rods of constant length, swivel joints,bases and traverses). In conditions of limited funding, the use of the modular principle in the development and manufacture of new generation machine tools is economically beneficial.In addition, full-featured desktop machines should be used in universities for research and teaching students at the level of world requirements.

4.3. Synthesis of technological principles-objects of the "process" type

Any technological principle can be represented as two material points that have come into contact and interact with each other - the processed object O_1 (part) and the processing object O_2 (tool) (Fig. 5), each of which performs translational and rotational movements in space insystem of their coordinates $X_1\ Y_1\ Z_1$ and $X_2\ Y_2\ Z_2$ [10, 22]. According to Fig. 5 with the main rotational motion ω (x_1, y_1, z_1), the material point O_1 can be described taking into account the translational movement of the feed S (x_1, y_1, z_1), and the radius of the coordinate R (x_1, y_1, z_1) and similarly the material point O_2 sets.

$$O_1\begin{Bmatrix}\omega_{x1},S_{x1},R_{x1}\\ \omega_{y1},S_{y1},R_{y1}\\ \omega_{z1},S_{z1},R_{z1}\end{Bmatrix};\quad O_2\begin{Bmatrix}\omega_{x2},S_{x2},R_{x2}\\ \omega_{y2},S_{y2},R_{y2}\\ \omega_{z2},S_{z2},R_{z2}\end{Bmatrix};$$

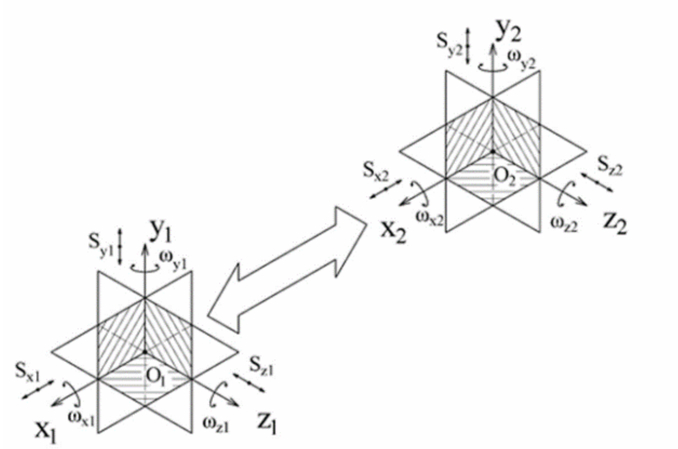


Fig. 5. The proposed spatial kinematic cutting scheme in the form of the interaction of two material points O_1 and O_2 in Cartesian coordinate systems

The interaction of these points O_1 and O_2 (Fig. 5) can be represented as a collapsed morphological model at the chromosomal level [22]:

$$M_{KC} = \left| \left\{ \begin{matrix} \omega_{x1}, S_{x1}, R_{x1} \\ \omega_{y1}, S_{y1}, R_{y1} \\ \omega_{z1}, S_{z1}, R_{z1} \end{matrix} \right\} \right| \wedge \left| \left\{ \begin{matrix} \omega_{x2}, S_{x2}, R_{x2} \\ \omega_{y2}, S_{y2}, R_{y2} \\ \omega_{z2}, S_{z2}, R_{z2} \end{matrix} \right\} \right|.$$

If there is no rotational or translational movement and the placement of points on the geometric axis of the machine, the value 0 (zero) is used as an alternative to the implementation of the feature in the morphological model.Using the genetic-morphological approach [10, 15, 22], from the morphological model, Fig. 6 shows the kinematic cutting scheme with the digital code 401 [4], which for specific processing schemes is written as variants of the genetic code at the chromosomal level:

$(\omega_{x1},0,0)-(0,S_{x2},0)$ - axial drilling of a rotating part (point O_1) by a non-rotating translationally moving drill tool (point O_2);

$(0,0,0)-(\omega_{x2},S_{x2},0)$ - axial drilling of a non-rotating part (point O_1) by a rotating and progressively moving coaxial tool (point O_2);

$(0,S_{x1},0)-(\omega_{x2},0,0)$– axial drilling of a progressively moving part (point O_1) with a rotating coaxial tool (point O_2);

$(\omega_{x1},S_{x1},0)-(0,0,0)$ - axial drilling of a rotating and progressively moving part (point O_1) with a stationary tool (point O_2).

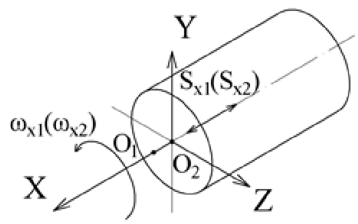


Fig. 6. Kinematic scheme of cutting, described by different variants of the genetic code at the chromosomal level

CONCLUSION

A new look at a material point as a carrier of genetic information allows one to effectively synthesize and anticipate the emergence of new TS of the “object” and “process” types.

REFERENCES

[1] Artobolevsky I.I. Theory of mechanisms and machines / I.I., Nauka (1988) 638 p.

[2] Balashov E.A. Evolutionary synthesis of systems, Radio and communication (1985) 328 p.

[3] Hegel F.G.W. Science of Logic - St. Petersburg (1997) 191 p.

[4] Granovsky G.I. Kinematics of cutting, Mashgiz (1948) 200 p.

[5] Zablonsky K.I., Belokonev I.M., Shchekin B.M. Theory of mechanisms and machines, Vishcha school. Head publishing house (1989) 376 p.

[6] IshlinskyA.Yu. Mechanics: ideas, tasks, applications / A.Yu. Ishlinsky. – M.: Nauka, 1985. – 624 p.

[7] Korotkova G.P. Principles of integrity (on the question of the ratio of living and non-living systems), Leningrad. Univ. (1968) 160 p.

[8] Knyazeva E.N., Kurdyumov S.P. Synergetics. Nonlinearity of time and landscapes of coevolution, Komkniga publishing house (2014) 272 p.

[9] Kuznetsov Yu.N. Theoretical foundations of optimal design of clamping mechanisms. - Sat. report Anniversary scientific. conf. with international participation, dedicated to the 1300th anniversary of Bulgaria and the 90th anniversary of the BKP, Gabrovo (NRB) (1982) 37-58

[10] Kuznetsov Yu.N., Joaquim A.G., Hamuyela T.O. Morphological synthesis of machine tools and their mechanisms, Gnosis LLC (2013) 401 p.

[11] Kuznetsov Yu.N. Evolutionary and genetic synthesis of technological equipment of a new generation // Cutting and tools in technological systems: Intern. scientific - tech. Sat. - Kharkov: NTU "KhPI" 85 (2008) 149-162

[12] Kuznetsov Yu.M., Khamuyela Zh.A. Guerra, Poparov A. Genetics - a morphological approach to the creation and forecasting of the development of clamping mechanisms for rotating parts, Journal of the Technical University - Sofia. - Plovdiv branch, Bulgaria “Fundamental Sciences and Applications. – Bulgaria, 19 (2) (2013) II 7 - II 13

[13] Kuznetsov Yu.N. Novoselov Yu.K., Lutsiv I.V., Theory of technical systems, Sevastopol: publishing house of SevNTU, (2012) 256 p.

[14] Kuznetsov Yu.N. Creation of machine tools of a new generation using the genetic and morphological approach // Collection of reports int. scientific conf. UNITECH-10, v.2, November 19-20 (2010) 79-91

[15] Kuznetsov Yu.N. Dmitriev D.A., Dinevich G.E. Layouts of machine tools with parallel structure mechanisms, Kherson: PP Vishemirsky V.S. (2010) 471 p.

[16] Kuznetsov Yu.N., Shinkarenko V.F. Genetic approach is the key to innovative synthesis of complex technical systems // Journal of the Technical University Sofia, branch Plovdiv, Bulgaria “Fundamental sciences and applications, Vol. 16, Book 2 (2011) 15-34

[17] Smirnov V.A. Genetic method for constructing a scientific theory / Philosophical questions of modern formal logic (1962) 283 p.

[18] Stepin V.S. Theoretical knowledge (1999) 390 p.

[19] Targ S.M. A short course in theoretical mechanics / The main edition of the physical and mathematical literature of the publishing house "Nauka" (1970) 478 p.

[20] Urmantsev Yu.A. Evolutionism, or the general theory of the development of systems of the nature of society and thinking, Book house "LIBROKOM" (2009) 240 p.

[21] Haken G. Information and self-organization. Macroscopic approach to complex systems, Mir, (1991) 240 p.

[22] Hamuyela J.A. Guerra, Kuznetsov Yu.N., Hamuyela T.O. Genetic and morphological synthesis of clamping cartridges. - Lutsk: Vezha-Druk, 2017. - 328 p.

[23] Shinkarenko V.F. Fundamentals of the theory of evolution of electromechanical systems, Naukova Dumka (1989) 288 p.

[24] Shinkarenko V.F., Lysak V.V. Genetic programs for the structural evolution of functional classes of electromechanical systems 2 (2012) 56-62

[25] Shinkarenko V.F. Genetic programs for the structural evolution of anthropogenic systems. (Interdisciplinary aspect). Practice of the Taurian State Agrotechnological University. Vip.13, volume 4. Melitopol (2013) 11-20

[26] Trader G.Yu. Evolution of basic physical ideas, Naukova Dumka (1989) 368 p.

[27] Mason O.T. The Origins of inventions: A study of Industry Among Primitive Peoples, Cambridge, Massachusetts, The M.I.T. Press (1966)

[28] Shinkarenko V., Kuznietsov Y. Genetic Programs of Complex Evolutionary Systems. 11th Anniversary International scientific Conference “Unitech’11”, 18-19 November 2011, Gabrovo, Bulgaria. Vol. 1. (2011) 33-43