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# METHODOLOGICAL PRINCIPLES OF SYNERGETICS

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*In the paper analysis of the main characteristics of the synergy is carried out.*

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Synergetics is popular in modern science because it considers the conditions and principles of self-organization, self-development of material systems, in their unity and complementarity. The use of synergetic methodology and its principles allows a new approach to the study of scientific problems. [1]

The concept of "self-organization" in synergetics is associated with the concept of dissipative structure, that is, such a structure that spontaneously occurs in open non-equilibrium systems. Under the influence of various energy disturbances coming from the environment, the system goes into a non-equilibrium state, and the elements begin to act in concert, that is, coherent. Coherent behavior, in this case, means a joint and coordinated action and is the factor that characterizes the processes of self-organization. Interaction, that is, as an energy connection of elements, acts as a driving force and fundamental essence of self-development of the system [1].

These systems have to deal with a lot of problems: adaptation to the external environment, goal achievement, maintenance of internal forms of existence, complex structuring, variety of forms of manifestation. The greater the number of different factors affecting the system and the wider the range of changes, the more complex the organization of the system. And the simpler and more elementary the system, the fewer factors affect its stability, and therefore systems tend to simplify their organization. But, at the same time, such organizational simplification reduces the number of opportunities for the development of the system, prevents various innovative processes, limits the possibility of its self-improvement. Progress in the development of the system occurs by increasing the heterogeneity of the elements and the number of their connections, when there are more effective functions and internal impulses to further separation, to improve the integrity of the system, which means, in turn, a better adaptation to the external environment, the effectiveness of the implementation of reproduction mechanisms, the establishment of a more efficient structure that ensures reliable performance of vital functions [2].

A complex system develops at all levels of its existence through the ability of self-government and self-regulation, the choice of optimal forms of activity. This choice is made according to the laws of interconversion of stability and variability (chaos and order), in which the various trajectories of the further process are tested nonlinearly until the attractor attraction force determines which of them is optimal for the formation of a higher type of ordering of the system. As a result, we can conclude that the variety of individual properties of the system is determined by the ratio of its so-called «essential forces» capable of different variations [3].

Any system is characterized by the desire for self-preservation, which is achieved through the action of two mechanisms: conservative, which ensures the stability of the system by preserving the positive experience of the past (the so-called system memory), and innovative, which determines the adequate response of the system to disturbances from the external environment and thus ensures its development [4]. That is, the system is a unity of stability and variability, which can be characterized by the basic principles of synergetics. Consider these basic principles of synergy below, and they can be divided into several sections: the principles of sustainability and the principles of variability. The principles of stability include the principle of homeostaticity, hierarchy and self-determination, and the principles of variability – nonlinearity, openness, instability and observability [5].

The first principle that we consider, and which relates to the section of stability, is the principle of homeostaticity, which characterizes

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the stable existence of the system, the so-called "order phase" of the functioning of its internal elements, the correction of which occurs due to negative feedbacks. The ultimate goal of all complex reactions of the system is self-stabilization, that is, maintaining the system in an equilibrium state, which is achieved by means of negative feedbacks, which, in turn, eliminate the disturbances of the medium. This principle is contained in all complex self-regulating systems, and it consists in maintaining the parameters essential for the preservation of the system within acceptable limits through the processing of environmental disturbances, as well as in countering the information coming from it, which violates the stability of the main elements of the system [6]. The degree of complexity of the organization of homeostasis is determined by the complexity of the system, but it is almost always based on a set of negative feedbacks that have a stabilizing effect. Feedbacks are selective and configuration, that is, only properly organized impact leads to a certain change of processes in the environment [7].

The system seeks to develop mechanisms that block the growth of negative trends in it. In dissipative systems, the so-called "search for stability" plays an important role – the role of natural selection. The stable existence of an integral system implies a dynamic equilibrium and a constant interchangeability of the expansion of one element and the splitting of the original integrity of another element. The expansion of the element involves the formation of additions to itself, which should pass into the phase of "splitting" and, in the process of interaction of elements", into the phase of "reproduction" [8]. Any interaction "splits" the element into many parts, and in the end, each of the elements of the system acts as a set of projections of its single entity. A separate element "attaches" to itself as a complement a variety of elements of a holistic systemic reality, thereby expanding its internal space and realizing the desire for the fullness of existence and self-determination. The law of stability, to which the interaction of parts is subject, pre-sorts the material, and thus it plays the role of a filter.

The system becomes complete when it begins to reproduce itself on its own basis. That is, the law of the whole system is the ability to undergo changes, while maintaining its essence, itself. It is both a prerequisite and a result of itself, so it is able to Express its inner qualities and hidden potential, multidimensional and constantly changing wealth of its own virtual contents, capabilities and energies.

The second principle of synergetics also refers to the section of stability and is called the principle of hierarchy of the system. This principle assumes a certain level organization of internal elements of the system. The main meaning of the structural hierarchy is the relationship between the levels of the system, which are not subject to complete reduction, that is, which can not be translated into a more simple and generalized form. Each of the levels in the system, which make up its organic integrity, is a prerequisite for the existence and development of the following levels. Each level has its own internal connection of elements, their relations and impulses of development. Each level of such hierarchy has its own integrity and internal concentration, internal measure and the prospect of self-development. The levels of the system complement each other, and their internal development is optimized under the influence of each other [9].

According to G. Haken, a complex system has two levels of description: at the micro level, that is, at the level of elements, which is described by the so-called "state parameters", and at the macro level, that is, at the level of cooperative effects, which is described by "order parameters". Order parameters set the ontology, the law of existence of the system, describing in a concise form the meaning of its behavior and attractors. In the process of evolution of the system there is a coordinated action of its elements at the micro level, which are connected to the structure and transmit to the system part of their functions, degrees of freedom and move to a higher level of this hierarchy, that is, to the macro level. G. Haken formulates the synergetic principle of subordination, according to which the parameters of the order subordinate the parameters of the state, that is, their change controls, and synchronously controls the behavior of many components and individual parts of the system. The relationship between the order parameters and the state parameters of a particular system is described by the so-called concept of circular causality, that is, the state parameters form the order parameters, but are controlled by them. As a result of such interaction between parts of the system, coordinated and coherent relations are established, which enhances the role of synergistic processes.

Another principle that relates to the section of stability is called the principle of self-determination of the system. This principle is associated with the interaction of different sides of the system, reproducing the conditions of formation, self-adjustment and self-deployment. For the elements of a complete system, internal

connections are more essential than external ones, since the set of possible evolutionary paths is limited, because they must correspond to the internal properties of this system [10].

The nature of the reaction of the system to external influence is determined by the nature of its internal self-determination. That is, self-organization means the transition of the system to a consistent state, in which the reason is found in the self-unfolding of the form that is inherent in the system. The more the system is internally integrated, the more individual and original it is. Also, the more complex the organization of holistic education, the more parameters affect the maintenance of the stability of its existence. The existence of an internal reason for the self-development of the system makes it difficult to predict the processes of its self-determination, since the system, in this case, is difficult to formalize and unify, and it is open and dynamic in nature. Synergetics also offers to make predictions about the possible state of the system is not the current state or past experience, and from the future state. Because the system, developing, falls into the field of attraction of a particular attractor structure, which builds it in accordance with its parameters. Therefore, the identification of attractors of evolution or, in other words, the transition to another state of the system is to determine its future state. In this case, the future is both deterministic and uncertain, because the behavior of the system often depends on random factors. The future is determined by the spectrum of possible ways of the system evolution, which are set by the General trends of the environment development and the formation of the system's own functions. In the process of self-organization, the system evolves in such a way that centers of purposeful development gradually appear in it. That is, in the current state of the system there are its future situations that serve as a target determination of the behavior of the system. The purpose acts as a specific expression of the needs of the system and the way to meet them, while actively influencing the process of forming its integrity. Elements of the system are combined and function for a specific purpose, that is, the goal is a system factor that affects the selection of degrees of freedom of the elements and selects interests in accordance with the possibilities of their implementation. There is a unification, because isolated from each other elements of the system can not provide all its goals. Summing up, we can say that the preservation of its systemic quality is the main target characteristic of the life of the system [11].

The next principle refers to the section of transformation, and it is called the principle of nonlinearity, which is based not only similarity, but also deviation from it. The greater the deviation from the equilibrium state, the faster the process of systemic change [12]. The direction of development of the system is not in the form of unambiguously defined cause-and-effect relationships, but as a result of the intersection of various events that reinforce each other, changing or maintaining certain trends. The nonlinear nature of the system provides the possibility of its multivariate development, which is allowed by the recognition of certain provisions:

• the system is characterized by the presence of an internal complex structure of heterogeneous and polymorphic character;

• it is impossible hard obstavlyaya and programming trends of evolution of complex systems, only self-managed development;

• denial of the existence of a universal frame of reference, absolute criteria and assessments of the system's behavior;

• any complex system, there are alternative scenarios based on some its predictable transformations in the points of bifurcations;

• the whole and the sum of the parts are qualitatively different structures, since the part can take on the functions of the whole, and the roles of the parts can change; the result of the sum of the effects of the parts is not equal to the sum of their results;

• the evolution of the system is carried out through the search for an adequate response to the impact of the environment, because of which it is possible to change the goals of the system, its parameters, the importance of important elements.

The system is included in various spheres, system connections that defines ambiguity and uncertainty of its behavior. The viability of the system depends on the necessary measures of complexity and diversity of its elements, as the specificity of this activity is a nonlinear relationship between its essential bases and character. In other words, the system-forming set of properties and qualities is manifested in the activity, but it is also formed by this very activity. In the system there is a coordinated (coherent) interaction of different goals, which can affect the future trajectory of the system in an uncertain way: this is due to the nonlinear nature of the factors affecting the system.

Programming and prezedenti development of the system virtually impossible. Only self-controlled development of the system by means of topologically ordered and timely correct various resonant influences is possible. Thanks to

this resonance effect, nonequilibrium oscillations turn into a stable system. Effective control action on a nonlinear system can only be resonant, that is, consistent with the internal processes and properties of the current system. In this case, it is not the force of impacts that is important, but the topology, that is, the architecture of the impact. From this it is assumed that one of the important problems is the organizat

The next principle is the principle of openness of the system, which allows us to consider it as an evolving structure according to the laws of synergetics. Synergetics explores the processes that occur in open systems, in which, in turn, under certain conditions of chaos and uncertainty can occur ordered structure, which is a characteristic of self-organization. Open systems perceive different models of activity and their ways of development. Self-organization and self-reproduction of the integrity of the system implies its fundamental openness to the environment: at the point of instability, the system becomes open, and this allows it to be structured, complicated and receive new information. That is, the impact of the environment sets in motion the whole set of processes that occur in the system itself. The openness of the system is also related to the principle of self-determination, which is explained by the presence in the system of free energy and information obtained from the external environment. Moreover, the system can encode this energy and information in its own structure and use it for the organization of its life. That is, in the process of adapting the system to changing environmental conditions, useful information is accumulated and with the help of it it is possible to increase the level of self-organization.

The next principle, which we will consider, is called the principle of instability of the system. In synergetics, instability is interpreted as one of the conditions of stability and dynamism of development, and chaos becomes an extremely important factor for the construction of new organizational forms of the system. States of instability or, in another way, the choice of further development, is also called bifurcation points. And it is at these points of bifurcations that the States of the system change.

The specificity of the self-developing system does not allow us to uniquely determine the causal condition that determines its behavior in a certain way and can unambiguously predict the dynamics of its development. As a result of the instability, innovative processes are carried out and new organized structures of the system are formed. It is due to the fluctuation that the processes of information reflection, a new type of energy and feedback arise as a way of energy and matter exchange, which is extremely necessary for self-organization.

System integrity is an important finding of proportionality and compliance and is the basis of a particular type of order. The order of movement is achieved through instability, constant change of direction of movement, that is, there is a recoding of diversity, which when changing the form retains the content. Also, the principle of instability is expressed in the concept of fractal: it is assumed that the world is fractal, and everything that surrounds us is also fractals, that is, everything is self-movement and change. The concept of fractal is based on the principle of self-similarity, that is, the ability to judge the whole by part: individual actions can be judged on the subject, by subjects – about society, by society – about the General state of the world. In itself, the idea of the fractality of the world is found in Heraclitus in his doctrine of the unity of opposites and variability of existence, as well as in Leibniz in the doctrine of the monad as the source of the Universe, and in Hegel in the doctrine of becoming as a transition from nothing to something.

And the last principle of synergetics as a methodology of science is called the principle of observability. According to this principle, the scientific theory should have an empirical basis and it is necessary to apply quantities and concepts that are operational and can allow experimental verification. The development of science is associated with the anthropic principle, personal, practical knowledge. This principle was introduced by M. Polani: "As human beings, we are inevitably forced to look at the Universe from the center within us and speak of it in terms of the human language formulated by the urgent needs of human communication. Any attempt to exclude the human perspective from our picture of the world inevitably leads to nonsense". The principle of observability implies the relativity of human ideas about the system, since it is associated with the unpredictability of changes in nonlinear processes, with the uncontrollability of the interaction of means of observation with the system, which, in turn, greatly limits the role of the observer of these processes and his ability to influence the behavior of synergetic systems.

Synergetics in this case speaks about the relativity of interpretations to the scale of observations and to the expected result, since according to the principle of complementarity in H. Boru, the observer, receiving information about

some values, at the same time can not receive information about others. That is, in the end result, observability is a process with an unpredictable result in advance. Such concepts in synergetics as order and chaos, stability and variability are also relative to the means and scale of observation. A complete description of the system is possible only in the aggregate of different complementary quantities and consists of the interaction between observers of different levels.

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*В работе проведен анализ основных характеристик синергетики.*


*Ключевые слова: синергетика, анализ, принципы взаимодействия систем.*