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THE SYSTEM FOR THE CONVERSION OF MATTER, ENERGY AND INFORMATION - THE MISSING ELEMENT IN THE THEORY OF TECHNICAL SYSTEMS

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Abstract: The last years of the past century were characterized by the rapid development of engineering. Technical sciences have also made their evolutionary leap. What is still missing is a generally accepted scientific subject that systematizes the existing knowledge in one scientific complex, based on the general principles in the structure, design and use of the technical systems. The paper presents results from the analysis of the object of the study and the contents of a general science of the technical systems.

Key words: system for the conversion of matter, energy and information, technical system, executive organs of the technical systems

1. INTRODUCTION

To ensure their continued existence human beings incessantly organize artificial processes in nature whose purpose is to change the properties of the object of impact in a way that is needed. It has been conclusively proved that the desired transformation of the object can be achieved through targeted impact of physical, energetic or informational nature [2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14].

The development of engineering is associated with the aspiration of man to transfer his functions to a machine, in the artificial processes organized by him. In the beginning he replaced his hand with a wooden or stone wedge, then he ceased to be the source of energy, and finally he transferred the process control to the machine. At present, man has created a large amount of technical means - complex technical systems that he uses in all fields of his activity.

Along with the development of engineering, machine science has also undergone an evolutionary development. Well-developed branches of engineering sciences have been designed that study the engineering objects according to the different spheres of human activity – machine-building, transportation, agriculture, construction, etc. Over the years there have also been developed such engineering subjects as the theory of machines and mechanisms, machine elements, strength of materials and mechanics that clarify questions, valid for all machines.

The world of science still lacks a common subject that will sort the existing knowledge about the technical systems into a single set of concepts, definitions and general principles based on the common things in their structure, design and use. In other fields of knowledge, for instance, those of minerals, animals, plants and human society, the studied object is classified and examined in the stringent framework of a unified scientific system.

A number of scientists [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18] in the field of engineering have contributed to solving this complex problem. In the works of Prof. Hubka the contents of a general science of machines has been outlined, but there are still some important items that have remained poorly defined:

1. the structure (matrix) of the existing information about machines has not been described so that each machine would take its place in it;
2. no abstract model of the system for conversion of the matter, energy and information has been designed, a model which can clarify objectively the internal links in it and which can be valid for all artificial processes in nature, organized by man;
3. no abstract model of the machine based on its executive organs has been designed, so that this model would be valid for each specific case, too;
4. there have been proposed no conventional algorithms for functional and structural analysis as well as synthesis of the technical systems, based on the hierarchical relationship between the system for the conversion of matter, energy and information, the technical system and executive organs of the technical system.

2. STRUCTURE (MATRIX) OF THE EXISTING INFORMATION

The artificial processes organized by man involve complex systems of a different origin. The processes themselves take place in an environment, whose components, in most cases, cannot be precisely defined. The human subject uses various technical means to implement pre-planned impacts on the object. The uniform approach to the study of technical systems requires the design of such an abstract model that is stripped of the specific information and for which all general laws are valid. The determination of the appropriate level of generalization can be illustrated by the diagram shown in Fig 1.

According to their origin the systems in nature are divided into natural and artificial ones. Natural systems are organic and inorganic. Artificial systems are man-made. They in turn are chemical, social and technical ones. The classification of technical systems according to their origin coincides with the conventional classification of areas of their use – machine-building, transport,
agriculture, construction, etc. The diagram has developed further the classification of the technical systems used in the field of transportation. The transfer to an even lower level of generalization is illustrated on the diagram by tracing the classification of vehicles. The diagram can be completed for instance, with the classification of cars depending on the fuel tank capacity of engines and their design features.

The technical systems in other areas of human activities can be classified in a similar way. This has already been done in existing branches of technical sciences or is being done in the emerging technical sciences.

The diagram presented in Fig. 1 is one possible way of classifying and systematizing man-made technical systems. It shows the location of each particular technical subject and at the same time the "matrix" is open for the addition of new branches.

3. ON THE OBJECT OF RESEARCH IN THE NEW SCIENTIFIC SUBJECT

Another thing that is seen from Fig. 1 is that the object of study in a general science of technical systems should be such an abstract machine that does not carry the specific features of the different technical systems, used for example, in machine-building, transport, agriculture or in construction.

![Diagram of systems classification](image)

Fig. 1. Classification of systems according to their origin

At the same time this abstract machine must possess all those properties that are common to all existing technical systems. Such a high degree of generalization can be achieved by going out of the scope of the individual branches of engineering sciences, and by creating an interdisciplinary science, in which the object of study is
the abstract technical system, devoid of any specific features.
The contents of a general science of the technical systems should provide answers to the following questions:
- conceptual system used;
- systematics of the technical systems;
- system for the conversion of matter, energy and information;
- technical system;
- executive organs of the technical system;
- generalized algorithms for functional and structural analysis and design of the technical systems;
- operation cycle of technical systems;
- evolution of the technical systems.
A number of scientists have devoted their studies to clarifying the above-defined basic principles [2, 3, 5, 6].
Going beyond the scope of individual technical sciences, they have created the knowledge base, related to the general principles in the creation, structure and use of technical systems.
At present we are witnessing an extremely great variety of technical systems designed and used by man. The time has come that this "information space" be structured.

4. A MODEL OF THE SYSTEM FOR THE CONVERSION OF MATTER, ENERGY AND INFORMATION

In the artificial processes organized by man, the technical system is the means by which the pre-planned effects on the object are realized. The desired change in the properties of the object takes place within a system for the conversion of matter, energy and information [5, 8, 12, 13, 14, 16, 17, 18]. From a hierarchical point of view, this system is of the highest level of complexity. The elements of the system (the human subject, the technical system and the object of impact), as well as the environment outside the system, are of a different origin. Each of these systems is studied in a corresponding field of human knowledge.

Fig. 2. An improved model of the system for the conversion of matter, energy and information

One of the milestones in the structuring of a general science of the technical systems is the design of a common abstract model of the system for the conversion of matter, energy and information. So far there has been no generally accepted model for the abstract representation of that system which meets the utmost
requirements for a high degree of generalization. Apart from the need to clarify objectively the links between the elements of the system for the conversion of matter, energy and information, the model should also comply with the following requirements:
- use of the apparatus for abstract representation of systems, designed in technical cybernetics;
- displaying the structure of the system according to the principles of interoperability;
- defining the environment as an external element for the system and examination of the technology in which the change in the properties of the object of impact is carried out as an objectively existing action plan (prescription, algorithm).

The proposed model of the system for the conversion of matter, energy and information is shown in Fig. 2.

The diagram uses the following indications:
- \(C_i^1\) – a set of the properties of the object before the process;
- \(C_i^2\) – a set of object properties after the process;
- \(M\) – material flow;
- \(E\) – energy flow;
- \(I\) – information flow.

In the model shown in Fig. 2 operators are the human subject and the technical system.

All modern technical systems have arisen as a result of the human effort to transfer its functions to the machine. From the stages in the development of engineering it is known that in ancient times the human has made the desired changes in the properties of the object without using technical means. Later he replaced his hand with a wooden or stone wedge, but for a long time afterwards he remained the only source of energy. Then the human began to use the energy of animals, water and wind. The steam engine was the first artificial source of energy created by man. Nowadays, technical systems use various in-built types of modern energy sources. Thus, technical systems have utilized the second substance in the process – the energy. The rapid development of automation and the use of digital electronic devices in control systems is a prerequisite for making use of the third substance in the artificial processes organized by man and that is information.

It is clear that the interaction between the human and the technical system depends on the degree of utilization of human functions by the technical system. Therefore, it is the means through which man acts on the object. In Fig. 2 the technical system is presented as a linking element (second operator) between man and the object targeted for impact.

If the sole operator in the system for the conversion of matter, energy and information is the human, the object properties change as a result of the direct impact of man on the object (Fig. 3).

The change of the object properties is done through the use of a technology, which is known in advance and has been accepted by man as an action plan during the process.

If the only operator in the system for the conversion of matter, energy and information is the technical system, the properties of the object of impact change as a result of the direct impact of the technical system on the object.
Due to the absence of the human subject, it is necessary that the technology used to change the object properties be introduced in one of the executive organs of the engineering system (the controlling one).

![Fig.4. A model of the system for the conversion of matter, energy and information, in which an operator is solely the technical system](image)

The preliminary planned change of the object properties is done according to a technology (prescription, algorithm), which is previously known. It remains unchanged throughout the total process or varies depending on the intermediate results obtained. The objective nature of the technology is emphasized by its separation from the operators and its connection to them through an information channel.

The object of impact is the passive element in the process. It passes successively through the exactly specified states of matter in the technology and its properties are changed step by step in the desired direction. The objects of impact in the processes organized by man have different origin, targeted impact. The object properties at the beginning of the process can be defined by the position vector $C_i = (C_1^i, C_2^i, ..., C_n^i)$, where $C$ is the corresponding property of the object, the base at $C$ is the number of the specific property, and the exponent is its size (the measure). At the end of the process the object properties have changed and its state can be described by the vector of $C_j = (C_1^j, C_2^j, ..., C_n^j)$. The necessity of the change of the object properties arises either due to the unsatisfactory condition $C_1$ or due to the need that has emerged $C_j$.

The environment in the proposed improved model of the system for the conversion of matter, energy and information is carried out of the system boundaries. It includes only those elements of the real environment, which are linked to the system components. In many cases it is impossible to define precisely all the sources of external influences. In the most general case the elements which are included in the environment involve the geosphere, biosphere, atmosphere and techno-sphere. Therefore the environment is connected with the elements of the system by bi-directional channels of physical, energetic and informational nature.

4. CONCLUSION

As a result of the analysis, the object of study has been defined and the contents of a general science for the technical systems have been synthesized. A classification of man-made technical systems in accordance with the fields of their use is proposed. This classification shows the location of a particular technical object, and at the same time the "matrix" is open for the addition of new branches. A model of the system for the conversion of matter, energy and information has been proposed, which was
designed using the set for an abstract representation of the systems of technical cybernetics. The system structure has been depicted in accordance with the principles of functional consistency. The environment has been taken outside the system boundaries, and the technology used to change the object properties has been defined as an objectively existing action plan.

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