

Basic Methodological Principles of Technical Creativity

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Abstract—This research is relevant due to the need to improve the efficiency of engineering activities in the conditions of modern scientific and technical progress. To solve this problem, we showed the importance of creativity in the development of technical systems. Technical creativity optimization is associated with the use of methodological approaches. Different methodological approaches which reflect various structural levels of technical creativity are considered in the research. Technical creativity features associated with qualitative and quantitative processes of technical systems improving are shown. Differences in methodological approaches are indicated. There is particular importance in the development of technical systems has a methodology for resolving technical contradictions. The study is novel in the methodological approaches differentiation which reflects processes of development and improvement at various structural levels of technology.

Keywords—*methodological approaches; technical creativity; qualitative and quantitative changes; technical contradiction; technical system; development and improvement of technical systems; technical creativity optimization; scientific and technical view of the world*

I. INTRODUCTION

In the generally accepted classification of creative activity, four relatively independent types of creativity are distinguished: technical, scientific, artistic, and social [1].

This research provides the analysis of features for the technical creativity only and highlights both general and significant points of this type of activity. Historically we can consider technical creativity as the first type of creativity. Not without reason, it is admitted as a source and basis of other activities. The focus of attention in technical creativity is in the practical problems solution, in the material

embodiment of the technical laws in devices, in features and natural phenomena expressed using laws of science. Technical creativity is the process of new facilities development which increases production efficiency.

The concept of "technical creativity" is used in modern scientific literature with reference to the development of technical systems only. In other cases, the concept of "engineering creativity" is used since it has broadest content. This is explained by the fact that modern engineering activity includes many types of work: the executive engineer, the organizing engineer, the design engineer, the process engineer, the design engineer, etc. Nevertheless, the main activity of the engineer is the creation, improvement, technical and technologies systems development, search for new technical ideas and solutions. And in this point of view concepts of "engineering creativity" and "technical creativity" coincide.

II. BASIC METHODOLOGICAL PRINCIPLES OF TECHNICAL CREATIVITY AT VARIOUS STRUCTURAL LEVELS OF TECHNOLOGY

The embodiment in technical systems of objective natural laws expressed in the laws of science is an important methodological principle of technical creativity used in the development of technical systems. Special attention should be paid to the fact that the natural laws and therefore the laws of science, on the basis of which technical systems are created, cannot be changed, created, and destroyed. They exhibit their activity only in certain conditions. This is a very important methodological position for engineering activities. In the developing process of any technical systems it almost always becomes necessary to eliminate or weaken one or another adverse event in the functional process of technical system or at least regulate their performance. This process is

carried out either on the basis of changes in the working conditions of the technical system, since the law operates only under certain conditions, or by changing the interaction of the laws of science embodied in this technical device. The application of laws interaction in technical systems is the most complicated creative activity and one of the significant methodological principles of technical creativity [2]. We will give the following example to clarify the idea. In a submarine, the effect of the gravity law is weakened by Archimedes buoyant force. So the submarine performance is based on the interaction of these laws. In other words, all technical systems operate on this principle, i.e. they impersonate one or another law of nature, science or the interaction of laws. And the implementation of this principle is the most difficult task in technical creativity.

Methodological principles being interconnected with the analysis of the structural technology elements interaction are also important for technical creativity. Any level of technology development is determined by the content of the three components of technology: materials - energy - knowledge [3]. In each historical epoch their balance changed significantly. Let's take for example space technology: the problem of new materials creation was lasting and difficult to solve. I.e., it is impossible to determine which structural element in the technique is more significant and which one is less. Today, great importance in some branches of technology is given to energy sources. But it should be noted that a certain mismatch in the development of these three components within the general technological expansion brings difficulties in technical problems actual solution and slows down the development of technology in general. So the solution of these problems requires from the engineer not only creative activity but also a broad outlook in technical problems knowledge. Moreover, his scientific and technical worldview should not be descriptive-scientific but creative-scientific [4].

Amongst the various types of technology, the prime leading place belongs to the equipment of material production or production equipment. It could be divided into three levels: a separate technical tool, the industry of technology, aggregate technology. Common factors for each of them are different and have their own specifics. The creative nature of improving each level is determined by self- methodology.

The primary element of an aggregate technique or technique as a whole is a separate technical tool. It has all the features included in the definition of "technique", i.e. materially, manufactured, materialises a certain natural pattern and it is a conductor of the relationship between human being and nature.

The development of a separate technical device proceeds in two directions: the process of improvement and the creation of a new technical device. In the scientific literature these processes are shown with the help of ideas of qualitative and quantitative changes. Dialectical approaches to the research of qualitative and quantitative characteristics as well as their interconnection have significant methodological importance in technical creativity.

Improving the form, interaction, structure, aesthetics, etc. – these are quantitative changes. Quality changes are associated with the alteration of operation mode and functional parameters.

Qualitative and quantitative changes in technology are done on the basis of resolving contradictions that arise in technical systems in the working process. Contradictions also arise in case of a discrepancy between the functionally significant characteristics in the process of construction improvement. I.e., while improving some system features the deterioration of others happens. For example, changing the engine to a more powerful one gives us the result in speed but might heavy up the construction, increases the fuel consumption rate, etc. The same situation could be detected in any technical system within the process of improvement [5].

The process of contradictions resolving which is resulting with the transfer to a new technical system differs significantly from the process of structure improving as a part of this operation mode. I.e., in the first case we speak about qualitative changes and in the second - about quantitative. Certain techniques for resolving contradictions correspond with these phases which are detected by test of the technology development history analysis. There are various methods for resolving technical contradictions in the improvement and development of technical systems. In this research we will note only some of them briefly for illustration.

Methods how to split contradictions in space got widespread use. They are effective in the case when the technical system needs to be improved using this very operation mode and there is no transfer to another technical device.

Splitting of contradictory features in time can be applied both in the case of improving the system using one operation mode of a technical device and in the transfer to a new wholesomeness. Methods of dividing a working cycle into intervals are used usually giving the system different features in different times, filling in pauses, making intermediate steps, combining or dividing several cycles in time, making a transfer to a pulsed action, to vibrations, etc. Quite often the split of contradictory features could be combined not only in space but also in time.

More complex contradictions are resolved of is done on the basis of system transfers with focusing on the system features. This method is associated with the physicochemical features of a technical device and matches to a higher level of technology contradictions resolution. Sometimes these methods are used simultaneously or in various combinations. It depends on the specific requirements and conditions for the development of the technical system.

Methods contradictions resolution is associated with certain stages of technical systems upgrade. There are only five of them [6]:

- The process of improvement is not associated with the elimination of contradictions. There is the fine

tuning of the various parts of the mechanism with their adjustment.

- It includes minor inventions obtained as a result of eliminating contradictions with methods which are traditional and standard for the industry generally changing only one block of the technical system.
- It is described by contradictions resolution using methods being the knowledge of single science (chemistry, physics, etc.). One of the system elements is completely changed;
- The new technical system creation with the completely resolved contradictions of the old one. But also the new system performs functions of the previous. Contradictions are removed by the methods of other sciences. For example, the physical problem is solved by chemical methods;
- The invention of a fundamentally novel type which is due to the appearance to a new advent in science and technology. It may even lead to the formation of a new industry. For example, the invention of radio facilitated the creation of radio engineering.

Generally, in practice at least two adjacent levels of the improvement process could be coupled, therefore this classification is nominal. The development process of technical systems is usually limited to the first two, maximum three levels. Further improvement is associated with the creation of a fundamentally new technology.

III. METHODOLOGICAL PRINCIPLES OF TECHNICAL CREATIVITY IN TECHNICAL SYSTEMS QUALITY AND QUANTITATIVE FEATURES DEVELOPMENT

Patent agencies are focused on both qualitative and quantitative changes. Nevertheless, from the total volume of applications submitted to the patent fund, 85% describe quantitative transformations, amongst the rest only 1.5% of technical solutions are fundamentally new and 0.9% has no analogues. It should be noted that only in technology there is such a unique phenomenon as a patent fund which facilitates the work on the analysis and search for technical creativity development patterns.

The significance level of qualitative changes depends on the assessment of the basic scientific and technical principles. More significant are those that are focused on modern scientific achievements as since they allow opening new areas of technology. Furthermore, the well-known principles were used in related industries and finally, traditional, standard solutions but in various interactions, combinations [7].

This is the general chart that allows patent agencies to assess the significance and novelty of technical solutions at the level of an individual technical tool. As practice shows, from an economic point of view, one should approach carefully to the implementation of qualitative and quantitative changes into production. At a glance, the new technology may be inferior in terms of the economy to the old but taking into account the potential, the rapid growth of

technology justifies the need to move to a fundamentally new type [8].

Quantitative changes are no less significant than qualitative. From the history of technology one can cite many examples when quantitative changes in a particular technical device gave a tremendous effect in various industries. For the example let's take the innovation of Diesel. He designed the engine which allows using heavier products of oil refining instead of gasoline. Applying the principle of a compression lighter which is based on the fact that highly compressed air heats up and ignites combustible material, Diesel created a practical, uncomplicated in control ICE, whose efficiency almost doubled? Diesel engines got widespread use in transport vehicles and in a number of other industries.

Quantitative changes used to be an important factor in tailoring the assignment of tasks and for creating an object that performs the specified functions in the best possible way with minimal negative consequences and with the lowest cost. A set of indicators depends on the specific task assignment. There possibly could be changes in features such as weight, dimensions, strength, performance, power consumption, reliability, cost, etc.

The next goal of engineering creativity is quite complicated. This is the invention of maximum number of options: ideas, schemes, types of design. At the moment contradictions arise - the improvement of some technical system qualities is associated with the deterioration of others. The resolution of this contradiction is quite a difficult task and has many search options. Furthermore, in order to reduce the search area, you need to remove all not entirely successful solutions. The set of optimal options is kept. Generally, there is no unique solution. And here the creative ability of an engineer is needed to justify the correct choice of the final model. There should be taken into account aesthetic factors, environmental and safety requirements, and many others. The engineer must bear responsibility for his choices. In other words, all human and technical culture is needed here.

Quantitative changes of a separate technical device have a certain limit. The construction within the certain principle of action mode cannot be improved infinitely. This process could be represented in diagram form [9]:

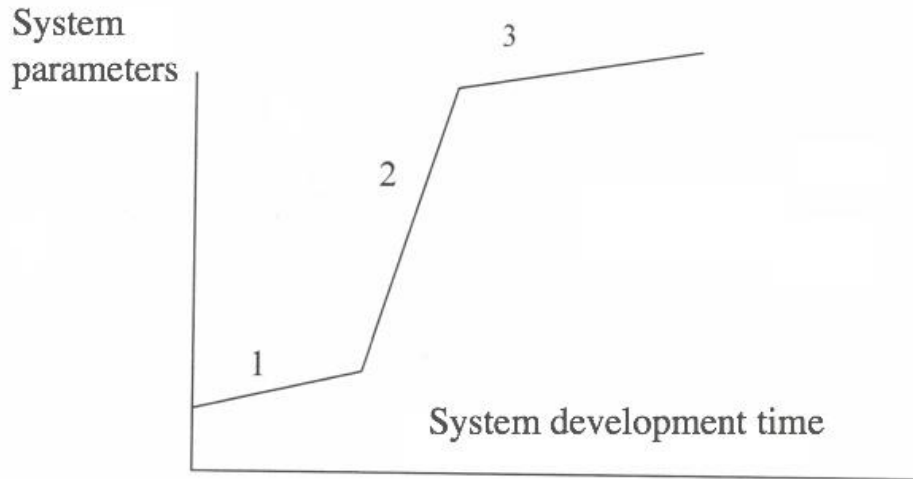


Fig. 1. The improvement process of a technical system.

As it shown in "Fig. 1", there are three periods on the graph: 1 - slow growth of the system improvement, 2 - rapid development, 3 - a rapid deceleration of improvement, retention. Furthermore, a transfer to a new technical design, i.e., to a qualitative change, is required. The main and, apparently, the most difficult creative challenge for the engineer is to create new devices and processes that are surpassing existing counterparts.

Qualitative changes of any technical device are usually associated with a change in the operation mode. This is a central concept in technology. It is based on the use of a certain natural regular pattern which appears in a specific form in one or other technical constructions. For example, Newton's Third Law is a background of a jet engine operation. It should be noted that in a theoretical form the laws of science are difficult and simply impossible to implement in technology. A certain understanding is necessary to apply the above laws in technical devices, i.e., it is necessary to develop a technical idea. The process of technical idea development is an independent, complicated creative activity which is reflected in scientific and technical creativity [10]. One should not confuse and mix scientific, technical and scientific and technical creativity. These are completely different and independent activities and they require the implementation of different procedures and different methodologies. Nevertheless, their interconnection is necessary in the creative activity of the engineer in the creation process of a leading edge technical device.

Qualitative and quantitative changes can be associated not only with the process of changing the technical design but also with its specific working conditions. For example, many technical devices working separately fall out while working together. This is due to resonant phenomena that disable the nodes of machines. This is the way the system feature appears and it can be both positive and negative in technology in various cases.

Qualitative and quantitative changes at the industrial level have more complicated and intermediate nature and the methodology becomes more complicated also. The branch of technology is a certain unity of technical facilities, a technical complex intended for the production of certain manufactured articles. Qualitative and quantitative changes in the industry depend on the included technical facilities, on the method of communication between those facilities providing with well-defined interaction aimed at a certain goal. One should bear in mind that the same technical facilities could be due to various branches of technology (electric motors, pumps, etc.). They can be applied in mechanical engineering, agriculture. In addition to similar technical facilities, any industry has specific ones determining its features.

The history of technology, in a certain sense, is the history of the emergence and development of industries. Each industry, despite qualitative and quantitative changes, is keeping its own specificity. The process of their interaction undergoes changes also. During certain historical periods they may take a different position influencing the development process of other industries (military technology). The question of the interaction and interconnection of industries is not researched enough, both from information and organizational sides of this problem. In practice, these processes are often carried out spontaneously and that slows down economic indexes significantly. For example, it could be noticed that inventions and achievements in one industry have long and difficult way of implementation into another [11].

Qualitative and quantitative changes in the industry are associated with the fundamentally new technical tool emergence. Sometimes this leads not only to qualitative changes in the existing industry but also to the origination of a completely new one. For example, the invention of a jet engine gave a qualitative leap in aviation technology and gave birth to the appearance of space industry.

We can talk about a qualitative change in the industry even when the balance and the interaction between the industries changes, the production of a particular industry are highlighted, for example, in computing technology.

Qualitative changes in technology generally or in an aggregate technology are associated with a change in the whole, the system "human - technology". Here one can select two positions:

1) Technology serves to enhance physical and intellectual capabilities;

2) The equipment performs all the functions in full and the human does not participate directly in the production process.

Nevertheless, the human is never excluded from production at all. Between the two stages there are several intermediate steps that reflect qualitative changes. For example, automation cannot be named as "the highest mode of mechanization" since it is a completely different quality. The transfer from mechanization to automation is associated with the emergence of a new stage in technology and technologies' functions and so the structure also will be different.

Quantitative changes in the aggregated technology are associated with reinforcing the constituent structural blocks. Qualitative and quantitative features are interconnected.

Any changes of all three levels of technology affect each other. Therefore, the engineer, changing a particular part of any technological level influences the development of the rest.

It should be noted that methodological approaches are important both for individual and collective technical creativity. In local practice, individual methods of technical creativity are developed essentially [12] [13]. In foreign practice, collective forms of work are used widely. It is common knowledge that modern production process in an innovative economy requires a regular, daily and effective process of technical creativity. The individual process of creativity has its own laws. An engineer, even being a very talented one, is not in position to generate new technical ideas regularly and constantly; today there are no conditions for the work of creators - individuals; there is no time to wait for the inventor to be inspired. Also this is impossible for large groups since it takes some time to organize, coordinate, develop, etc. And this problem in foreign practice is successfully solved by, the so called - creative groups [14] [15].

IV. CONCLUSION

In summary, it should be noted that the analysis of methodological approaches shows us a significant difference not only in the process of improving the qualitative and quantitative features of technical systems but in different structural levels of technological development. This causes the need to draw a distinction, make structural and classified those methodological approaches, which will allow one to create a logically based methodology for technical creativity.

On the basis of this methodology, it is possible to spread the use of information technology but not only the search matrix.

As advice, it should be proposed to include both local and foreign experiences in the methodology of technical creativity. At the moment there is no developed methodology for collective technical creativity. In foreign practice, only psychological aspects are used in collective technical creativity.

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