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Issue Article

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FEATURES OF ENGINEERING ACTIVITY IN MODERN REALITY

Abstract*: In the article, the authors for the first time made an attempt to combine the material necessary for students to prepare them into a single complex called "Fundamentals of Engineering." With such an organization of training, one can count on the emergence of graduates of higher educational institutions who master the basics of engineering and are capable of independent innovative activities. Just as in the 19th century blocks of academic disciplines were formed related to the targeted training of specialists in engineering specialties, so now there is a need to form a new block of academic subjects that reflect the needs of innovative development of society. A new block, reflecting the level of development of modern civilization and focused on the humanistic path of its development, is the following group of disciplines: fundamentals of engineering, history of science and technology, philosophy of science and technology, methodology of scientific and technical creativity, protection of intellectual property, technical aesthetics, fundamentals of scientific research.*

Key words*: artistic creativity, works of art, ideas, individual, consumer properties, fundamentals of engineering, innovation, engineering, regions of Russia.*

Language*: English*

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Introduction

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In the early nineties of this century in Russia there was a demand from society for specialists capable not of routinely following established social and technical canons, but of active creative innovative activity, of adapting their professional qualities to the operating conditions of new technology and market relations developing in Russia. The relevance of the task, in addition, is dictated by the need to eliminate and prevent in the future the current significant lack of demand by society for specialists receiving higher technical education according to outdated social, scientific and technical principles, which has led and still leads to obvious and hidden unemployment, to the loss of only work in their specialty, but also the meaning of life for an entire social stratum - engineers and scientific and technical workers in Russia.

This particular situation is clearly reflected in the system of higher technical education, where it became especially aggravated during the period of so-called perestroika and then the denationalization of enterprises. Today it has become obvious that even a “good engineer”, filled with precise technical knowledge acquired at a university, is just a good performer of a given algorithm and, least of all, a creator. Life requires that an engineer be both a qualified expert in modern production and a creator of new scientific and technical projects, such as the Russian engineers I.P. Bardin, A.N. Tupolev, V.G. Shukhov and others. To solve this problem, there is only one way - to form a creative engineer, or an innovative engineer, already at a university, for which it is necessary to mobilize all the means that reveal the factors and driving forces of scientific and technical creativity. They are discussed in the monograph as very specific ways of forming a new type of engineer. These factors include psychological, philosophical, economic, sociological; in the monograph they are considered comprehensively and systematically. The leading one, in our opinion, is the factor of humanization of education. Social and philosophical problems of innovative, scientific, technical and engineering activities have now emerged as a relatively independent field of epistemology. Knowledge about scientific and technological progress, scientific and technological revolution, scientific and technical creativity, obtained only within the framework of historical, sociological, philosophical, psychological, pedagogical, economic and technical sciences, cannot fully reveal the inner essence of socio-technical innovations in scientific and technical areas of activity of modern society. Therefore, there is a need not only to improve, but also to develop a general concept for the further development of the system for training specialists with higher technical education and the methodology for its management. The creation of a new paradigm for the educational process becomes not only a pedagogical, technological or environmental problem, but also a socio-economic task, the successful solution of which determines the success of the development of the entire society. An analysis of the literature devoted to engineering activity indicates significant interest among the world community in issues related to the formation of an innovative engineer. There are many works that explore various aspects of engineering and innovation activities. These include, first of all, the works of V.V. Alekhina, L.V. Yatsenko and others.

Main part

Consideration of engineering activities and scientific and technical activities in general cannot be carried out in isolation from such a concept as “engineering art”. The definition of this concept with fairly detailed argumentation is given in the article. Here we will present, at least briefly, a view of art as a special kind of activity of representatives of various sciences.

The work of M.E. Markov can be considered fundamental in this direction. Markov, which provides the foundations of the functional theory of the arts. As the author rightly points out, “... if the essence of an object is its function, then clarifying the essence of art requires a functional approach to it.” His works provide the structure of the process of social cognition, in which the subject of analysis is the function of the implementation of the cognition process by each individual, the result of which becomes the property of all members of society. The structure is based on the procedure of transition from the primary creative process, which involves artistic creation or scientific research, to the product of creativity, which includes works of art or a scientific treatise; then to the interpretative creative process, which includes not only artistic performance, but also teaching and scientific popularization, and, finally, to the final (addressed) process with its direct perception of paintings, performances, films, books, lectures, lessons. As the final result of this process, M.E. Markov takes “changes in personality and behavior.” The functional approach to the analysis of art discussed above, although different in form from those used in science and technology, is in essence completely identical to them. What is important is not so much the coincidence of the analysis procedure as the inclusion of the entirety of scientific activity in the logic of the process of cognition at the level of art. Here the features of the sociologization of scientific creativity are clearly visible. Probably the first to notice this characteristic feature of the process under consideration was the French philosopher and sociologist Jean Marie Guyot. Alfred Fouillet writes: “According to Guyot, the peculiarity of the nineteenth century, and mainly of the centuries to come, in all likelihood, will be the creation of a social science that will dominate all other sciences that previously seemed independent of it: religious, metaphysical, moral, the science of education and, finally, aesthetic.”

Guyot, of course, could not, more than 100 years ago, talk about sociotechnical systems in the modern understanding of this term and analyze relationships in human-machine systems, justifying the primacy of the social in relation to the technical. But he very accurately noted the main function of art: “The most important task of art is to produce an aesthetic emotion of a social nature." And indeed, technical achievements have no less, and perhaps even greater, impact on society in comparison with "pure art." Moreover, in real, everyday life they come to the fore, since all members of society, without exception, are forced (and, perhaps, coerced) to use various technical devices.

The history of the development of engineering activity goes back more than one millennium. Legends and traditions quite convincingly indicate that long before our era, humanity was capable of constructing such artificial and skillful structures that cannot be accomplished without special (engineering) theoretical work. Let's take the famous "wonders of the world" as an example. According to most historical sources that have reached us, the seven wonders of the world are usually considered to be:

1. Pyramids in Egypt (3–2 thousand BC). The most grandiose - the pyramid of Cheops (146.6 m high) - according to Herodotus, was built by 100,000 thousand people over 20 years.
2. "The Hanging Gardens of Babylon" in Babylon - terraces (VII century BC).
3. Temple of Artemis in Ephesus (~550 BC).
4. Statue of Zeus at Olympia by Phidias (~430 BC).
5. Halicarnassus Mausoleum (mid-IV century BC).
6. "Colossus of Rhodes" - a statue of the sun god Helios on the island of Rhodes (~292–280 BC).
7. Lighthouse of Alexandria (~280 BC).

No one will deny that these "miracles" are works of art. However, almost all of them were not so much miraculous as engineering creations. At least six of the above miracles were primarily technical structures, i.e. requiring design and calculation from their creators. Therefore, it is legitimate to talk about engineering art from the very beginning of engineering activity. And further achievements, which the world community is especially proud of, are primarily engineering structures: the Eiffel and Ostankino towers, spaceships, etc., etc. Any miracles created by the mind and hands of man are united not only by the amazing grandeur of the plans and the majesty of execution, but also by two main features characteristic of any engineering activity: the processes of design and calculation. The presence of these very signs determines the legitimacy of the opinion that such acts are impossible without appropriate engineering work. There is another aspect of scientific and technical activity, which M. Guyot was also one of the first to highlight. He writes: "A sociologist, remarkable for the originality of his points of view and the subtlety of his mind, Gabriel Tarde, has admirably demonstrated that the social world, and even the whole world, is entirely subject to two types of forces, namely, imitation and innovation. And further: "Individualization is a task that is included in the general laws of innovation: and everything that is individual, personal, original, ingenious, is subject to the same laws... Hence, in the private world of art, as in the entire social world, one can consider two classes of people: innovators and repeaters, that is, geniuses and the public." Taking into account the above, we can safely say that the works of M. Guyot are the starting point for modern works related to the new science of innovation. An example is the study of A.I. Prigogine "Innovation: incentives and obstacles", dedicated to the analysis of innovative and routine processes. Emphasizing the sociality of any type of activity, M. Guyot writes: "The highest task of the nineteenth century was, apparently, the desire to highlight the social side of the human individual and the animate being in general, to which too little attention was paid by the egoistic materialism of the previous century." Directly concerns M. Guyot and scientific activity, speaking about scientific analysis and artistic synthesis: "Synthesizing, creating is always a matter of art, and in this regard, the creative genius of the sciences is always connected with art; inventions of applied mechanics, chemical synthesis are an art... true genius is recognized by the fact that it is broad enough to rise above the real, and logical enough to never wander away from the possible." This thesis of M. Guyot wonderfully expresses the meaning and deep essence of the entire methodology of scientific and technical creativity. The question of what role art plays in the system of training an engineer and in his activities,raised by almost all major figures in science and technology. One of the most famous organizers and founders of the Russian engineering school is Viktor Lvovich Kirpichev, whose works represent an example of an interdisciplinary and humanistic approach to the organization of training engineers. At the grand opening of the Kyiv Polytechnic Institute on August 31, 1898, he said: "The Polytechnic Institute is a higher educational institution designated for training engineers, that is, as the name itself shows, people of genius, capable of inventing and organizing new things. The concept of an engineer's activity is necessarily connected with the requirement of creative ability and constructive activity, the ability to do something new. If someone intends only to routinely copy antiquity, he does not need to graduate from a higher educational institution; his work will be that of a craftsman, not an engineer." Already at that time, during the formation of engineering activity, the need for a synthesis of humanitarian, natural scientific and technical knowledge was understood. Therefore, it is no coincidence that V.L. himself Kirpichev and other scientists refer to the example of Leonardo da Vinci as an example of an engineer: "At the dawn of the Renaissance, we meet a man who should be looked at as the founder of engineers, preparing the ideal type of the engineering profession. This is Leonardo da Vinci. He combines a scientist, a practitioner and an artist; all three of these sides must be developed in a real engineer." And, continuing, V.L. Kirpichev directly points out the need for compulsory artistic education of the future engineer: "Engineers are obliged to take care of the beauty of their structures, and, therefore, they must receive an artistic education. The essence of the requirements for an engineer was well expressed symbolically during the construction of the Zurich Polytechnic School. There, the department of general sciences - the university one - is connected with the department of applied sciences - the technical one - in a hall that is an art museum. This indicates the composition of engineering education: you need to start with pure science and build applied knowledge on it; but at the same time, do not ignore art. Those who think that works of technology are necessarily ugly and that industry is becoming more and more incompatible with art are very mistaken." At the same time L.V. Kirpichev proposes to introduce into teaching such provisions that can form the humanistic basis of any human activity. Noting that "in the technical field, fantasy is called invention," he said: "... there are numerous similarities between the three categories of brilliant people - scientists, poets, inventors." It is also logical that, like modern developers of the methodology of scientific and technical creativity, L.V. Kirpichev emphasizes the importance and possibility of developing imagination: "For young children, reading fairy tales is very important in this regard."The result of proposals in the direction of a humanistic approach to the education system can be the parting words of L.V. Kirpichev to all present and future generations of engineers working in Russia: "All sorts of templates, establishing samples, and ready-made designs are also harmful for the development of engineering. They kill imagination, take away our field of activity, and create deadness. Would it be good if we covered all of Russia with the same buildings: all churches, stations, bridges would be of the same type!" There is another Russian, purely national aspect of the issue under consideration. So, for example, in the old days in Rus', the builders of cities, bridges, dams - all those whom we now call engineers - were called "rozmysli". Thus, the Russian name "rozmysl" essentially anticipated the understanding that was established in Europe only in the 19th century. It was the Russian thoughts that personified what, combined with their natural intelligence and practical art, cemented by high spirituality and responsibility in relation to the projects being implemented, can be designated as a humanistic approach to technical work. Therefore, when approaching the analysis of engineering activity, it would be necessary, first of all, to show a retrospective of the emergence of all engineering "miracles" from the Ancient World to the present day. However, the purpose of this study is not to demonstrate the technical achievements of mankind, but to clarify those methodological aspects of engineering activity that are directly related to the humanization of engineering education. In connection with the above, it is useful to compare the views of V.L. Kirpichev and modern authors on the origin of engineering activity. On the origins of the emergence of engineering as a profession, Professor V.L. Kirpichev said in his speech at the opening of the Congress of Workers on Mining, Metallurgy and Mechanical Engineering on April 17, 1913: "Engineering has greatly advanced, received much greater importance than before, and this happened for two reasons: first, a period of intensive industrial growth began ... the second reason: industry has changed its character... Automata have replaced the former slaves, and the engineer plays the role of a commander, a genius, a leader of a crowd of slaves" (by a crowd of slaves we mean machines and mechanisms). The origins of engineering activity in the modern interpretation are analyzed in detail in the works of V.G. Gorokhov and V.M. Rosina. The prehistory of engineering activity is associated with the fact that "in the Middle Ages there was no engineering activity in the modern sense, but rather a technical activity organically connected with the craft organization of production." The origin of engineering activity and its specific features from a methodological point of view are, according to the same authors, as follows: "For an engineer, every object in relation to which there is a technical task, on the one hand, acts as a natural phenomenon, subject to natural laws, and on the other - as a tool, mechanism, a machine, a structure that must be built artificially. The combination of "natural" and "artificial" orientations in engineering forces the engineer to rely both on science, from which he draws knowledge about natural processes, and on existing technology, where he borrows knowledge about materials, structures, their technical properties, manufacturing methods, etc..d. But the object of modern activity is also the connections between man and machine, economic, organizational and even social connections. The complex differentiated structure of modern engineering activity necessitates its management and the organization of its constituent activities into a single whole." It is in such approaches that the transition from technocratic to humanistic engineering activity lies, which was accurately noted by V.L. Kirpichev: "The construction of devices for saving labor, for making it easier, for its safety, for the hygiene of work - this is a worthy field for the occupation of active minds, and I think you will agree with me that technology represents a vast field for humane and educational activities." The close connection of engineering activities with humanitarian and artistic activities is confirmed by attempts at conscious and often intuitive preservation of art in relation to scientific and technical activities, considered in various modern domestic and foreign works. Of interest is the assessment of R. Shannon's work “System Simulation Modeling - Art and Science” by the editor of the translation, who writes: “The book is entirely devoted to precisely that part of the simulation experiment, which is art, since processes such as the selection of essential factors for building a model, introduction simplifying assumptions and making correct decisions based on models of limited accuracy rely largely on the engineering intuition of the researcher and the practical experience of a particular manager.” An analysis of the previously discussed socio-technical and historical-philosophical processes allows us to conclude that the new social, economic and environmental problems that arose before humanity at the beginning of the 21st century require a reorientation of the engineer training system. In society and in the system of higher technical education, a clearly defined demand arose for the study of “the history of science and technology,” “philosophy of technology,” and “methodology of scientific creativity.” Consequently, there is a need to move from methods and techniques of inventive creativity, from setting purely engineering and technical problems to solving social and sociotechnical problems. And such a transition is possible only through the humanization of education. Regardless of a specific academic discipline or even an entire scientific field, future engineers have to study various laws and theories as part of each training course. This is explained by the fact that even in the natural sciences, not to mention the technical ones, there is hardly an examplewhen one theory or law would cover and explain the entire set of phenomena in a given field of knowledge. Therefore, it will be fair, albeit categorical, to state that there are no single, universal laws and theories suitable for all areas of knowledge. Examples confirming this statement can be given as many as you like: from general philosophical laws, of which there is a whole group even within the framework of dialectical theories, to very different theories of the origin of the Earth and such purely applied areas as, for example, the theory of gluing. All theories and laws are based on axioms, i.e. “the initial provisions of a scientific theory, accepted as true without logical evidence and underlying other provisions of this theory.” These axioms are that real, that fundamental basis, those postulates - “positions, judgments, statements accepted within the framework of any scientific theory as true due to evidence”, on the basis of which the knowledge base of each specific subject is subsequently built - theorems, patterns, dependencies, etc. In interdisciplinary research, especially when using a systems approach, demands inevitably arise for the development of more universal theories, since theories and patterns operating in a single subject area can never, even by definition, “satisfy” another area of knowledge; thereby creating the prerequisites for the development of more universal theories. Examples illustrating interdisciplinary breakthroughs include such sciences as physical chemistry, social psychology, etc.“satisfy” another area of knowledge; thereby creating the prerequisites for the development of more universal theories. Examples illustrating interdisciplinary breakthroughs include such sciences as physical chemistry, social psychology, etc.“satisfy” another area of knowledge; thereby creating the prerequisites for the development of more universal theories. Examples illustrating interdisciplinary breakthroughs include such sciences as physical chemistry, social psychology, etc.

Combining new poly directions into single complexes allows us to reach the level of metatheories similar to the theory of the noosphere by Vladimir Ivanovich Vernadsky. He was also one of the creators of anthropocosmism - a system in which the natural historical natural (cosmic in general) and social and humanitarian trends in the development of science harmoniously merge into one whole. Thus, V.I. Vernadsky combined into a real scientific paradigm the idea of humanization of scientific knowledge from the side of the natural scientific picture of the world. The “counter” paradigm for explaining the universe from the side of scientific, artistic and theological knowledge was the philosophy of unity of Vladimir Sergeevich Solovyov and his concept of “integral knowledge”, based on an intuitive comprehension of the world based on the moral efforts of the individual. Ignorance or misunderstanding of complex processes, which were largely explained in his teachings by V.I. Vernadsky and V.S. Soloviev, led a large army of scientists and technicians to a situation of internal and external discord, which, in turn, resulted, as a rule, in technocratic, purely pragmatic solutions to any problems. Edouard Shuret, a French writer, philosopher, musicologist, spoke wonderfully about this confrontation, the process of internal split personality: “As long as Christianity affirmed the Christian faith among European peoples - still semi-barbaric, as they were in the Middle Ages - it was the greatest of moral forces, it shaped the soul of modern man. As long as experimental science sought to restore the legitimate rights of reason and protected its boundless freedom, so long it remained the greatest of intellectual forces: it renewed the world, freed man from age-old chains and gave his mind indestructible foundations. But since the church, unable to defend its fundamental dogmas from the objections of science, has locked itself in them, as if in a windowless dwelling, opposing faith to reason as an indisputable absolute commandment; since science, intoxicated by its discoveries in the physical world, turning the world of soul and mind into an abstraction, became agnostic in its methods and materialistic in its principles and in its goals; Since philosophy, confused and helplessly stuck between religion and science, is ready to renounce its rights in favor of skepticism, a deep discord has appeared in the soul of society and in the soul of the individual. Religion responds to the needs of the heart - hence its magical power; science responds to the demands of reason - hence its irresistible power. But a lot of time has passed since these two forces stopped understanding each other. Religion without evidence and science without hope stand against each other, powerless to defeat each other. Hence, deep division and hidden hostility - and not only between the state and the church, but also within science itself, in the bosom of all churches, as well as in the depths of the conscience of all thinking people.

For no matter what we are, no matter what philosophical or social school we belong to, we carry in our souls these two hostile worlds, seemingly irreconcilable, although they arose from the equally inherent, never-dying needs of man: the needs of his mind and the needs of his hearts." If you follow the theories of V.I. Vernadsky and V.S. Solovyov, then with such a movement it becomes inevitable to reach those eternal truths from time immemorial, and from the point of view of science - axioms on which any religious teachings are based. These axioms are nothing more than commandments, or, in modern language, a system of values, the only, unique and universal basis of human spiritual and material existence that humanity has created over the long history of its development. These fundamental commandments are the sources of any truly humanistic movement. Without a corresponding value orientation, no positive, personal human development and the development of society, science and technology as a whole is possible. Here lies the true meaning of the humanization of education, including, and perhaps primarily, higher technical education. All educational subjects should be imbued with the spirit of humanism, not only the humanities, natural sciences, but also special ones. Textbooks and teaching aids must be humanized. How to achieve this? Indeed, religious courses should not be placed within special disciplines! Well, of course not - it's both unrealistic and funny. But the principles of humanization themselves must be laid as the basis of any academic subject, any academic discipline. These principles are the universal methodology with which you can humanize any area of engineering activity. The methodological basis of humanization should be, as follows from the analysis of the development processes of the philosophy of technology and engineering as an art, the principles of historicization, sociologization and streamlining of science. The principle of historicization should be based on the history of science and technology, including the history of discoveries and inventions. The principle of sociologization is a comparative analysis of the development of scientific and technical achievements of mankind in accordance with the social needs of society. The principle of ordering or logization presupposes the substantiation of the development of science as a single, integral system, i.e. “technologization” of the presentation of material within each training course. So, the humanization of education should mean more than just the expansion of university curricula by including individual humanities disciplines. By humanization of higher technical education we mean exactly:

firstly, the humanization of all educational material, mainly textbooks and teaching aids, which today are almost completely faceless and contain a description of only ready-made knowledge intended for memorization;

secondly, the logical systematization of educational material so that the science taught appears not as a set of knowledge, but as a logically coherent developing system.

Ready-made knowledge, as D.I. said. Mendeleev is not yet science; ready-made knowledge separated from the methods of obtaining it is “slavery to what is being studied.” Science is not ready-made knowledge, but a creative activity for the production of knowledge. Creativity can only be taught by studying the experience of the history of science and technology. At the same time, humanizing educational material presupposes the formation of cognitive activity in students, and logical systematization is a way of systematically consolidating information. If the above principles are taken into account when constructing a training course, then engineering activity, both at the level of setting problems, and during their solution, and in the process of implementation, will never act to the detriment, but only to the benefit and benefit of all humanity.

Speaking about the socio-philosophical aspects of innovation and engineering activity, it is necessary, first of all, to turn to the general definitions on which further reasoning is based. First of all, these are the concepts, namely:

"activity";

"innovation";

“innovation process”;

"creation";

"structure";

"innovation" and some others.

The concept of “activity” could be defined using a Russian language dictionary. This is an occupation, labor, work. But this concept also has a deep philosophical meaning, which can be revealed as a form of active attitude towards the surrounding world, the content of which is its purposeful change and transformation. The concept of activity includes the goal, means, result and the process of activity itself. Within the framework of the topic under consideration, it is important to note the variant of classification of activity that divides it into reproductive, i.e. aimed at obtaining an already known result using known means, and productive activity or creativity associated with the development of new goals and corresponding means, or with the achievement of known goals with the help of new means. It follows from this that the concept of "creativity" can be defined as the creation of spiritual and material values that are new in design, as an activity that generates something qualitatively new, something that has never existed before. The concept of "structure" could also be defined according to the Russian language dictionary as "structure, internal structure." But the structure of what? What object? Obviously, the concept of structure cannot be applied to such an object as a pile of sand or a pile of stones. Therefore, the concept of structure is used only in relation to a systemic set of elements, and not to a summative set. At the same time, by system we mean such a multitude of elements or components that represent a single integrity and in which all elements are so interconnected that they influence each other and transform each other. One or more elements cannot be removed from a system without changing its quality. Based on this, the concept of structure can most briefly be defined as "stable orderliness of a qualitatively unchanged system." Taking into account the above, we can define the concept of structure somewhat differently as "a set of stable connections of an object that ensure its integrity and identity with itself, i.e. preservation of basic properties under various external and internal changes." The concept of "organization" can be considered related to the concept of "structure". This is a stable orderliness of a qualitatively changing system, i.e. process. Another form of definition of the concept of "organization", which has a social connotation, is as follows: an organization is an association of people who jointly implement a certain program or goal and act on the basis of certain procedures and rules. For us, this form of definition is interesting because it is comparable to the basic concepts of system analysis. A few words about other, less general, but no less important concepts related to innovation.

The concept of "innovation" is usually revealed as "the science of innovation", and the creation, development and dissemination of various types of innovations is considered as the subject of innovation. Various authors, depending on the direction of their specialization, provide very diverse definitions of the concepts of "innovation", "innovation", "innovation process". Let us present those that best correspond to the solution of the problems posed in this study. Innovation can be defined as a purposeful change that introduces new, relatively stable elements (both material and social) into the implementation environment (organization, settlement, society, etc.). Innovation is considered as a new order, custom, method. The most successful definition of the main innovative contradiction inherent in any system is given by A.I. Prigogine: "If a norm as a social standard preserves the existing, then innovative activity and innovations "knock down" the functioning of the system, changing the existing." He also introduces the "golden rule" of innovation: the system will only be open to innovations when their development becomes a condition for its preservation. Taking into account the above, new variants of definitions are introduced that are necessary for the semantic linking of the transition of concepts from innovation to engineering activity. Such definitions primarily include:

innovative structure of the enterprise - the relationship between the divisions of the enterprise, the main function of which is to ensure the development and implementation of innovations (innovations);

creative activity - the development of something new, related to the change and development of a given object, as well as the development of fundamentally new objects that include the same or a new function;

creative activity in the innovative structure of an enterprise is the functioning of enterprise divisions, which allows obtaining new developments and ideas that ensure greater efficiency of the organization (enterprise) according to specified criteria.

The stages of the innovation process that determine any scientific and technical activity can also include movement along the traditional chain from fundamental discovery to production, namely:

1) fundamental discoveries;
2) applied research;
3) introduction of new technology into production.

Of course, the main basic factor influencing the concept of training programs is the social status of the specialist: researcher, designer, student, etc. At the same time, the experience of preparing students for innovative activities has shown that the presence or absence of one's own task should be recognized as the main criterion of the learning process. Both situations are very specific. The absence of a specific task (as a rule, these are students or young professionals) requires the training system to develop artificial motivation among students to solve problems directly in the process of presenting the training course. Moreover, the complexity of this situation can be compensated by increased curiosity, ambition and the spirit of competition characteristic of young audiences. The presence of a specific task arouses deep interest in the audience, but at the same time requires an individual approach, since the listener is naturally interested in the method of approach to solving his own problem (graduate students, inventors, designers). The basic concepts of this study include: "technology", "engineering activity", "engineering thinking" and "engineering art". There are an extremely large number of publications that use these concepts. Their number amounts to not tens, but hundreds of works in various fields. But still, these categories are most deeply and consistently revealed in dissertation research related to the analysis of philosophical and social problems of science and technology. The concept of "technology" is adequately defined in the works of V.I. Belozertsev as a social material system that serves as a conductor of transformative human activity, a means of knowledge, use and subordination of forces, properties, laws of development of nature, man and society in satisfying natural and social needs. It is interesting to note in this regard that in the study by L.G. Titarenko proposed a generalizing definition of technocratic consciousness. Technocratic consciousness is considered as a specific ideological orientation of public consciousness as a whole (or individual social strata and groups), aimed at absolutizing the scientific and technical factor in the development of human civilization and the role of scientific and technical specialists (or their individual groups). Already in these definitions two trends are clearly visible, namely:

the first of them is the orientation of technical activity to meet social needs;

the second is the recognition among specialists involved in technical activities of a special, specific worldview.

We will also find confirmation of these trends in other studies. If we turn to the concept of "engineering activity" itself, then according to the dictionary "Scientific and Technological Progress", engineering activity can be defined as an activity aimed at applying scientific knowledge to create technical objects - structures, mechanisms, devices, machines, etc. — and management of their manufacturing process. This definition seems unjustifiably narrowed. Considering the quality of engineering training as a social problem, A.B. Kurlov in his work defines engineering activity as a creative process, the purpose of which is the creation of means, methods and technologies for material transformation of the environment and the professional socialization of the subject of these transformations. At the same time, it is noted that the creative intensity of engineering work presupposes the formation and development of appropriate abilities in the subject in preparation for engineering activity. Moreover, the main function of the engineering personnel training system is the development of creativity.

IN AND. Martinkus, classifying engineering activities by intellectual functions, proposes the following classification of types of engineering activities, namely:

managerial (organizational),
design,
technological,
inventive,
scientific

For us, it is also important to consider the social function of engineering activity. IN AND. Martinkus, in our opinion, was able to come closest to understanding the essence of engineering activity, considering "creativity" as a subsystem included in a more general philosophical system - "labor activity" with the subsequent inclusion of this system in the supersystem "cognition". Having linked knowledge, work and creativity into one structure, V.I. Martinkus analyzes the change in the world as a result of purposeful cognitive, creative labor activity. The social function of engineering and creative activity, in his opinion, is to develop the spiritual and practical activity of people, to change the boundaries of possibilities in technical and social relations, and to update the structure of such relations. Subsequently, D.O. Gusev supplemented and developed this approach. He gave a philosophical and methodological analysis of the dialectics of the formation and development of the social functions of engineering activity. Engineering activity, at the same time, is considered as a developing social phenomenon. In version D.O. Gusev's engineering activity is presented as a system of the following social functions: the function of applying natural scientific, technical, social and humanitarian knowledge for technological organization and development of material production; functions of producing technological knowledge, i.e. knowledge of the operating principles and methods of creating technical devices; functions of producing technical knowledge, i.e. knowledge of what a given technical device is, what principles underlie its functioning.

V.V. Alekhine approached the consideration of engineering activity through an analysis of the characteristics of engineering and technical work, the content of which he includes: the scientific and cognitive work of an engineer, engineering and technological work, engineering and design work, engineering and operational and engineering organizational work. An attempt to generalize such studies was made by A.I. Rakitov. He comes to the conclusion that engineering thinking by its nature is systemic and activity-based. Introducing the division of types of knowledge into scientific, technical, engineering and everyday, A.I. Rakitov considers the process of creating artifacts and the direct activities of managing them as a subject of engineering knowledge. He considers the goal towards which engineering thinking should be directed to be the creation of effective means of activity and conditions for human life, the creation of an artificial habitat.

The leading concept in this monograph is "engineering art". The actual history and logic of the development of this concept will be given below in subsequent sections. We note here that, despite the long-standing traditions of using the concept of "engineering art," it was not possible to find its specific and clear definition in publications, despite a thorough bibliographic search. Most works devoted to the study of such topics or using this concept are, at best, limited to an eclectic-descriptive version of the presentation of its semantic content. The following definition is proposed. Engineering art is an expedient activity aimed at studying, creating and managing artificial objects, the result of which is an original solution of a high functional and aesthetic level. This definition reflects the categories of philosophy, sociology, economics, engineering psychology, history of technology, technical aesthetics, and ergonomics. In fact, expediency is based on knowledge of the laws of technological development and is based on a systematic approach to the problem. Originality includes a logical-intuitive way of thinking, formed with the help of various methods and techniques of scientific and technical creativity. The functional and aesthetic level is the result of optimization of solutions, the embodiment in the object of activity of the principles of design and economic sciences with the help of the professional knowledge of an engineer. The inclusion of scientific and technical creativity (STT) in innovation activity as one of the main structural elements is beyond doubt. However, the role and place of NTT in innovation activity is not clearly defined. In addition, it is extremely important to understand the origins of the emergence and development of NTT to consider the “root system” of such processes. Below, an attempt is made to introduce a new conceptual category that determines the need to involve the NTT apparatus and the degree of its use. A huge number of articles, a large number of book publications and dissertations are devoted to the processes of development and research of new things. The classification of such works is associated with the consideration of various aspects of innovative activity: psychological, social, pedagogical, scientific, technical, historical, philosophical and even fantastic.

What is important for us is the fact that, regardless of the specific topic, all authors directly or indirectly have to touch on various aspects of the activities associated with the STT process. And this is no coincidence. Without defining the goal, the means to achieve it and the characteristics of the performer, talking about NTT is simply pointless. Since one of the main goals of this article is to establish relationships between the social and technical aspects of STT, and the result is the development of methodological material for the academic discipline “Scientific and Technical Creativity”, it is first necessary to determine the basis of STT. The history of inventions and discoveries, which is directly related to engineering activities, is, in essence, the history of technology as the main component of social production or the history of the socio-technical development of mankind. We have already talked about the role and place of the engineer in innovation. It is obvious that NTT is a natural part of engineering. But what is primary, what is secondary and what is the source that determines the direction of development of scientific and technical technology, and therefore engineering activity as a type of labor activity, remains not clear enough to this day. If we consider the sequence of development of ideas about the world from the point of view of the technocratic approach, we will come to the following chain: primitive mythology - art - philosophy - natural science - exact sciences - technology. If we imagine as the basis of innovative processes mental activity, connected by the above-mentioned categories, we get a chain of activity processes: thinking in images - entry into scientific thinking - thinking in concepts - practical transformation of the world. At the same time, any social changes are determined by the general type of culture - the spirit of the era. It is obvious that the practical transformation of the material culture of mankind is based on technique and technology. What is the basis, motive, driving force for the development of technology and engineering? These are two sources: social and scientific-technical. This thesis must be understood as follows. The social factor is determined by the needs of social production; scientific and technical factor - potential opportunities associated with the level of development of science and technology. As they say, this is the internal logic of the development of science. Both of these sources, when combined, form a certain common basis for the development of technology, which, in turn, is humanity’s tool for the practical transformation of the world. In works on the history of science and technology, as well as in philosophical and sociological works, external and internal factors in the development of science and technology are considered, as a rule, in a certain opposition. At the same time, some researchers consider external factors to be leading, and internal factors to be subordinate, secondary, or even not playing a significant role at all. This direction of the sociology of science is called externalism.In contrast, a movement arose called internalism. Researchers who support this direction highlight the factors of the internal logic of the development of science. The externalist and internalist positions of scientists of various specialties (sociologists, economists, historians of science) are sufficiently discussed in detail in the essay by S.R. Mikulinsky "Methodological issues of historical and scientific research." Although at present, in essence, there are no longer extreme externalists and internalists, the opposition between external and internal factors in the development of science has been preserved. For us, this question is important because in the aspect of the problems of scientific and technical creativity, considered in this work, there is an urgent need to study not only the relationships between external and internal factors, but also their deep integration into something unified, synthetic. There is a need to talk about the integrative factor. The fact is that, unlike scientific creativity, the result of which is fundamental science, scientific and technical creativity leads to integrative results, to the organic unity of a scientific discovery and its technical implementation. External and internal factors of the

NTT process are inseparable from each other. They cannot act in isolation even over a very short period of time, since they are implemented at strictly defined and modern discrete levels of development of science, technology, and production. An example is the emergence of synthetic rubber (SR) production. Despite the birth of this idea back in the 19th century, the production of SC itself could not have arisen either earlier or later than the 1920s–1930s. It was by this time that a phased social order for rubber rubber appeared from the auto and aircraft industries, which until then, due to the small scale of these industries, had made do with natural rubber. At this point, chemistry had just discovered methods for polymerizing SA monomers. And, finally, by this time, the industry had just created the technical prerequisites for the production of monomeric raw materials SA from alcohol and petroleum hydrocarbons. If these prerequisites did not exist, there would be no innovation itself - SC, despite the presence of a social order and a solution to a scientific problem with the help of chemistry. There is an urgent need to study not only the relationships between external and internal factors, but also their deep integration into something single, synthetic. There is a need to talk about the integrative factor. The fact is that, unlike scientific creativity, the result of which is fundamental science, scientific and technical creativity leads to integrative results, to the organic unity of a scientific discovery and its technical implementation. External and internal factors of the NTT process are inseparable from each other. They cannot act in isolation even over a very short period of time, since they are implemented at strictly defined and modern discrete levels of development of science, technology, and production. An example is the emergence of synthetic rubber (SR) production. Despite the birth of this idea back in the 19th century, the production of SC itself could not have arisen either earlier or later than the 1920s–1930s. It was by this time that a phased social order for rubber rubber appeared from the auto and aircraft industries, which until then, due to the small scale of these industries, had made do with natural rubber. At this point, chemistry had just discovered methods for polymerizing SA monomers. And, finally, by this time, the industry had just created the technical prerequisites for the production of monomeric raw materials SA from alcohol and petroleum hydrocarbons. If these prerequisites did not exist, there would be no innovation itself - SC, despite the presence of a social order and a solution to a scientific problem with the help of chemistry. There is an urgent need to study not only the relationships between external and internal factors, but also their deep integration into something single, synthetic. There is a need to talk about the integrative factor. The fact is that, unlike scientific creativity, the result of which is fundamental science, scientific and technical creativity leads to integrative results, to the organic unity of a scientific discovery and its technical implementation. External and internal factors of the NTT process are inseparable from each other. They cannot act in isolation even over a very short period of time, since they are implemented at strictly defined and modern discrete levels of development of science, technology, and production. An example is the emergence of synthetic rubber (SR) production. Despite the birth of this idea back in the 19th century, the production of SC itself could not have arisen either earlier or later than the 1920s–1930s. It was by this time that a phased social order for rubber rubber appeared from the auto and aircraft industries, which until then, due to the small scale of these industries, had made do with natural rubber. At this point, chemistry had just discovered methods for polymerizing SA monomers. And, finally, by this time, the industry had just created the technical prerequisites for the production of monomeric raw materials SA from alcohol and petroleum hydrocarbons. If these prerequisites did not exist, there would be no innovation itself - SC, despite the presence of a social order and a solution to a scientific problem with the help of chemistry.

The theoretical prerequisites for something new in science also appear as a result of not only the requirements of production (the action of social order), but also what has already been achieved in production, and this can serve as a condition for setting up new experiments (the action of social security), i.e. production (as an external factor in the development of science) both stimulates the emergence of something new (social order), and acts as a limiting factor (social restrictions) or creates technical conditions (social security). The history of science knows many examples of premature discoveries that were not accepted by either science or industry due to the fact that they appeared either away from the main path of development of science and technology, or at the wrong level of scientific and technological progress.

All this makes us talk not so much about external and internal factors in the development of science and technology, but rather about a single integrative factor. When using a problem-based approach both in the learning process and in the process of solving creative problems, we are often faced with ambiguity in the interpretation of the procedure for its implementation. In fact, to successfully resolve any problem, both universal and specialized knowledge are required. By introducing two levels of problem analysis - horizontal and vertical - we will get a clear idea of the need to combine both levels. At the same time, multiple solutions are allowed. Each of them can be designated by a point, the position of which in a rectangular coordinate system is determined by the relationship between the degrees of specialization and universality of the approach applied to solving the problem. There is an analogy here with how the search for necessary information is usually presented. This technique is often used when planning the time expenditure of graduate students and researchers. The abscissa axis represents time, and the ordinate axis represents the amount of information. Over time, the graduate student, having selected the necessary information to conduct specific research, concentrates his efforts in a fairly narrow range. NTT techniques and methods can connect special and universal knowledge with each other. To review the entire search field, it is useful to use brainstorming, synectics, morphological analysis, and to go deeper into the problem - FSA, ARIZ (TRIZ). At the same time, the choice of search field is largely determined by social order, and the search path is determined by the algorithms of NTT methods. Analysis of various factors allows us to divide all activities related to engineering in the field of scientific and technical technology into two types: socio-technical and educational and methodological. The need for such a division is due to the fact that both the NTT methodologist, who helps find a solution, and the decision maker (decision maker) are forced, before developing practical recommendations or forecasting the direction of development, to go through a stage of work, the purpose of which is to define the problem associated with explaining the socio-technical aspects Problems. This activity is naturally woven into the system analysis, following the preparatory stage, the main content of which is to clarify the situation and then formulate the problem (Table 1). As for educational and methodological activities, it can also be divided into preparatory and main stages. Training in NTT methods is associated with acquiring knowledge about optimal options for solving problems; The independent work of a methodologist includes the selection of techniques and methods of scientific and technological progress for a specific socio-technical task.

Table 1. Stages and activities when using NTT

Activities	The first stage is preparatory		Second stage main		The third stage is final
	Clarifying situations		The work of a methodologist		Practical activities
	Target	Function	Target	Function	
Socio-technical	Practice support	Problem Statement	Definition of the task	Clarifying the socio-technical aspects of the problem	Forecast of development direction
Educational and methodological	Training in NTT methods	Solution Process Training	The solution of the problem	Selection of techniques and methods of NTT	Practical recommendations

It should be noted that the introduction of social factors may be conditional. However, like other methodological techniques, the use of these factors makes it possible to clarify and formulate the content of such concepts as “innovation”, “engineering”, “STT”. Just as in mathematics, techniques such as reducing fractions to a common denominator, artificially introducing a system of equations with the appropriate number of unknowns help solve a problem, so social factors can help make the unclear clear, the controversial - resolved, and the incomprehensible - explained. By causing the NTT process, social factors, interacting with each other, not only form the boundary conditions of engineering problems, transforming into innovative activity, but, ultimately, can determine both the direction of development and the methods of implementing innovation.

The next main property of social factors is their dual role. These factors are both the source and the driver of NTT. The development of social factors means both an increase in requirements for the development of production and an intensification of the requirements of the internal logic of the development of science and technology. Figuratively speaking, the processes occurring in scientific and technical technology, in engineering, in innovation, are derived from social factors. Comparison of the process of development of society with the concept of the structural-functional approach makes it possible to reveal the internal meaning of transitions in the multi-level model “elements - subsystem - system - supersystem”. An example is the transition from the evolutionary phase of the development of science and technology to the scientific and technological revolution. Thus, although the introduction of social factors is an artificial device, it helps to clarify the relationship between real factors operating in STT and innovation. A systematic approach to activities related to STT is reflected in the works of authors from different countries. Didactically successful is the option of a systematic approach to the presentation of material using graphic classifications - the coordinates of the existence of technology were outlined in the work by V.E. Steinberg. By developing this direction, we can represent the chains of areas of activity that interest us in space using a single structure: science - technology - technology. We should also agree with A.S. Tsesnek that, by developing such structures, one can move on to constructing matrices based on differentiated characteristics corresponding to a specific practical problem. And, indeed, such matrices contain significant heuristic potential, which makes it possible to increase the efficiency of engineering activities. However, no pedological developments can be successfully implemented without restructuring the learning process itself. Thoughts about the need to change the system of training students worried not only teachers, but also people of art. Here are a few quotes. F. Schiller: "Society makes position the measure of a person, it honors in one of its citizens only memory, in another only reason capable of counting, in a third only mechanical dexterity... Is it surprising that all other abilities are launched in order to educate the only that ability that gives honors and rewards? Antoine de Saint-Exupéry: "The theorist believes in logic. It seems to him that he despises dreams, intuition and poetry. He does not notice that they, these three fairies, simply disguised themselves to seduce him, like an amorous boy. He does not know that he owes his wonderful finds to these fairies. They appear to him under the names of "working hypotheses", "arbitrary assumptions", "analogies", but can the theorist suspect that, listening to them, he is betraying "severe logic" and listening to the melodies of the muses? A.P. Chekhov: "I thought that the intuition of an artist is sometimes worth the brains of a scientist, that both have the same goals, the same nature, and that, perhaps, over time, with the perfection of methods, they are destined to merge together into a gigantic,monstrous power." These statements can be summed up using the thesis expressed by G.N. Volkov: "An intuitively discerned image of the whole can unfold into a theoretical whole when it is built in accordance with the aesthetic and philosophical idea of the world, when it is recreated not arbitrarily, but according to certain laws that express the inner essence of this whole, its harmony, its nature, structure, its correspondence to the totality of experience and experimental data." These ideas are especially relevant for teachers involved in training specialists in various fields of science and technology. It is no coincidence that almost all countries of the world are concerned about the education crisis. This phenomenon is universal. Therefore, in a number of articles in the collection "Philosophy of Education for the 21st Century," the question is naturally raised that before moving on to campaigns for "humanization, technocratization, or educationalization," it is necessary to develop an education paradigm—a common denominator. A new scientific direction is proposed - philosophy of education. This term is understood as "a certain system of ideas about the world and a person's place in it, from which we can further identify the goals of education, its content structure, basic organizational principles, relationships between teacher and student, etc." Comparing the above with the activities of a scientist, we can draw the following analogy. By setting up an experiment, we accept working hypotheses. Having received the results of the experiment, we process them and present them taking into account certain assumptions, drawing conclusions. At all stages of this activity, regardless of their sequence, artistic, logical, and philosophical levels of thinking are involved (Figure 1).

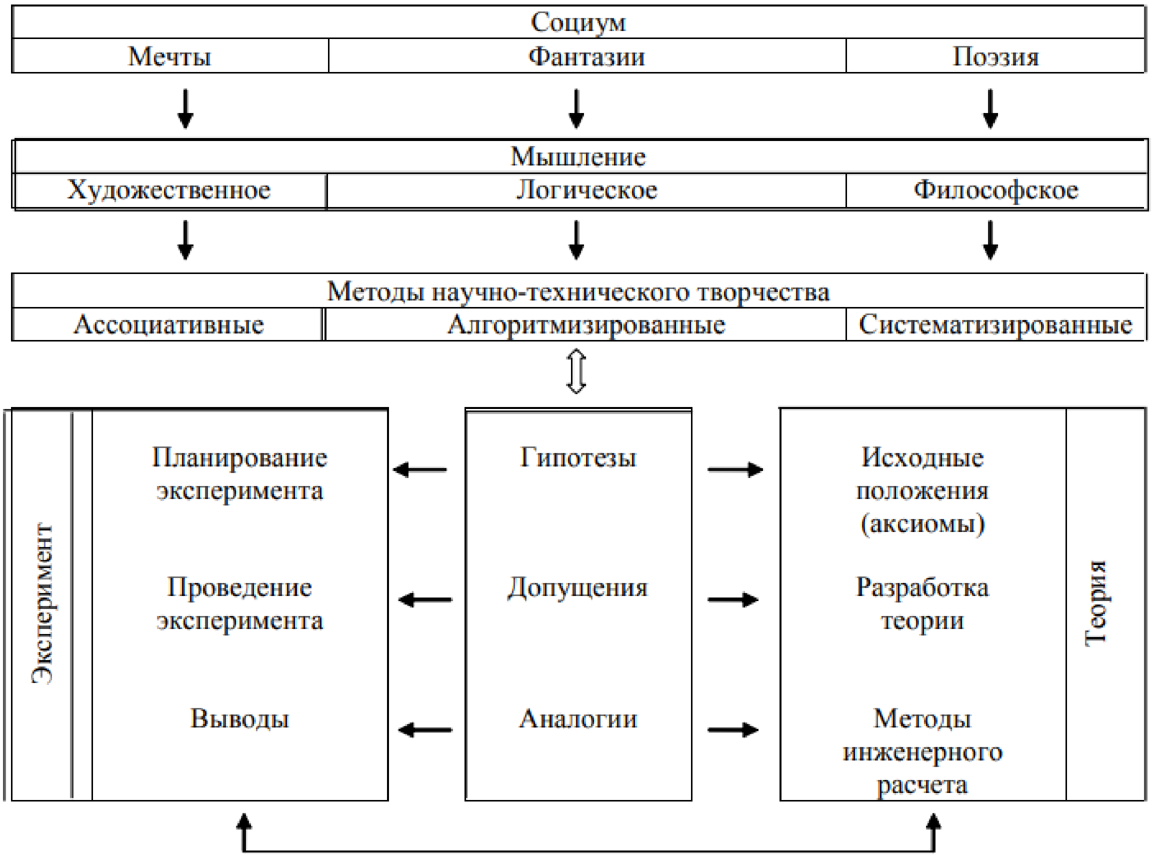


Figure 1. The relationship between scientific and technical creativity and innovation activities

NTT uses associative, algorithmic and systematized techniques and methods, which are, in fact, derivatives of various types of thinking. Society and nature determine the emergence and development of innovative processes. Using the NTT methodology, they not only systematize existing knowledge, helping to optimize the experiment and navigate theoretical work, but also develop a person's intellectual abilities. At the same time, it should be taken into account that the use of a socio-technical approach to solving problems is associated with some propaedeutic preparation, namely:

firstly, the learning process should be aimed at nurturing universal personality traits, including an orientation toward imaginative thinking. Art, as Balzac put it, is "concentrated nature". Here the image is directly excited from the image, association from association, bypassing long logical transitions and rational orderings. If the mind pedantically climbs the endless ladder of concepts and categories, then imaginative thinking immediately grasps the essence of the problem, all the richness of the concrete. Therefore, intuition can be considered a “tool” of imaginative thinking;

secondly, the student should develop the skills of analysis (both structural and functional) and synthesis. In this case, one cannot do without mastering philosophical and methodological categories and the apparatus of formal logic.

Let us summarize what has been said in the form of the principles of engineering activity that should be embedded in the scientific and technological process, namely:

Identification of a social problem as a stimulus for NTT. A good technique is to “search” for a problem between opposing opinions.

Identification of scientific and technical opportunities. Here it is appropriate to use the full power of the forecasting apparatus associated with information technology.

Using social factors and heuristic techniques as a source of NTT.

The processes of teaching NTT (the activity of a teacher-methodologist) and using NTT (the activity of an innovator: scientist, engineer, manager) are inextricably linked with the questions of what NTT is and how to teach an NTT course. From a formal point of view, these are two different questions. Most of the literature on NTT is devoted to answering them. We tried, with the help of research data, to answer the question: what should be the foundation, the foundation on which a building of engineering art is built? And in this case, the process of cognition of NTT (formation of engineering thinking) and the process of NTT itself (as fundamental in engineering activity) constitute a single, harmonious in nature, whole. Without such an approach, the large arsenal of available NTT techniques and methods is simply a beautiful palette from which one can choose one or another color, either based on random information about NTT, or focusing on the (always limited due to objective reasons) amount of knowledge which the teacher managed to give during class. In order to move away from the usual structure of a training course, which is traditional when teaching certain technical disciplines, a radical rethinking of the perception of scientific and technical technology is required. Here we are faced with a situation that is specific to Russia, and is often not taken into account by both domestic and foreign experts. Until recently, we did not take irrational factors into account at all. Even representatives of such sciences as philosophy and psychology were forced in their publications (at best) to pass over in silence issues of the transcendental, mystical, etc. What can we say about the art of engineering? Those fundamental works on creativity that were published specifically in Russia (the period 1900–1930) are, in fact, simply forgotten, since the training of engineers has been pursuing a strict course towards narrow professionalization for more than one decade. Based on the above, the author considers it necessary (in preparation for innovative activities) to introduce special topics into the educational material to explain concepts such as “faith,” “intuition,” “knowledge” and their relationships. Only in this case can we count on the formation of a Russian engineering corps, the level of which will be determined not only by the ability to copy foreign developments, but by a very capacious and original Russian qualification characteristic - “an engineer from God.” Persons working in the field of inventions and discoveries contribute to the development of culture. Culture is an improvement in the economic coefficient of transformation of life according to W. Ostwald.

Attempts to qualitatively and quantitatively assess various types of human activity have been made repeatedly. It is no coincidence that entire subdivisions such as laboratories and institutes of SOT (scientific organization of labor) arose, in which various criteria for labor efficiency were developed and then applied in practice. The division of labor activity processes into mental and physical led to the development of a whole set of relevant indicators. However, if the situation with the assessment of physical labor was quite clear, then in the assessment of mental labor specific difficulties always arose. Therefore, despite the actual practical implementation of various methods and norms, life itself, over time, “buried” various proposals for assessing the effectiveness of mental work. This, for example, was the case with the standardization of the activities of one of the largest engineering departments - the design department. An assessment based on the number of formats submitted by the designer, of course, could be a criterion for labor productivity, but what about the quality of what is drawn on a piece of whatman paper? We are not talking about the number of errors in dimensional chains, although this also matters. We are talking about the level of design elaboration. An analogy with a writer’s payment for an author’s sheet is quite appropriate here. Whether he is Leo Tolstoy at least three times or, on the contrary, a pathetic compiler, with the above approach they will receive the same material reward. Below we will consider various options for criteria, starting with assessing the performance of technical devices and ending with an attempt to formulate a criterion for the effectiveness of innovative activities. For us, it seems extremely important that regardless of the type of mental work, including in the process of scientific and technical creativity (STT), the teacher and the student must be imbued with an understanding of the dualistic - rational-irrational nature of this kind of activity. Therefore, the presented material first provides a brief retrospective overview of assessments of various activities, and then reveals the role of the rational and irrational in NTT. The first option for assessing labor efficiency, which found the greatest application, was the efficiency factor (EC), defined as a dimensionless quantity showing “what part of the total input energy W is useful. (Wuseful) is used in the device under consideration.” Efficiency is a purely technical indicator. By analogy, in economics they use the indicator of production profitability. For example, if we take the indicator of the level of profitability to current costs, then it is defined as “the ratio of profit to the cost of commercial or sold products.” Or more generally, “profitability P is defined as the percentage of the amount of profit to the total cost of goods sold.”

where O is the volume of products sold in wholesale prices of the enterprise; Cp - full cost of products sold; Wp - profit from product sales.

There is a whole group of economic indicators similar (in structure) to profitability: capital productivity, turnover ratio, etc.

It is also impossible not to mention a very common way of assessing an individual by IQ. One of the options for defining it is as follows where IQ is intelligence quotient; UM - mental age; IV - true age.

It is easy to see that all variants of this kind of assessment can be conditionally attributed to the “human efficiency factor”, considered as an intelligent system.

An interesting transition is from purely economic indicators to indicators that take into account the employee’s motivation—his interest. L. Zhdanov proposed the following formula for this:

where X is the correction factor for working conditions; KR - amount of work; B - material well-being of the employee.

At the same time, the amount of work, according to the author of the formula, depends on the intensity of labor, duration of work, qualifications of the worker, perfection of technology and organization of the business. The concept of a productivity coefficient is also introduced, which makes it possible to compare work results:

where KP is the performance coefficient; ND - the number of units of work actually completed; NT is the theoretical number of units of work that can be done in the same time.

The most generalized option for determining the effectiveness of activities can be considered the option proposed by V. Gasparsky. Having introduced the definition of praxeology as the science of the effectiveness of actions, the author proposes to evaluate effectiveness by the quality of the result:

where is the quality of the result; W—result (positively assessed effect); C - goal (maximum possible effect).

Graphically, the quality of the result is proposed to be assessed using the usual linear relationship.

While recognizing the unconditional usefulness of this approach, it should be taken into account that there is still a long way to go from general discussions about the development of rational and effective actions to the possibility of their application in a specific situation. There are a number of studies devoted to the need to represent by a single dependence both the results of economic calculations - relations of type (1) and (2), and general methodological approaches - relations of type (6). In particular, V. Hubka gives the following definition of economic efficiency: “The ratio of beneficial effect/operating costs is called economic efficiency.” This definition comes closest to the terms used in functional cost analysis (FCA). Note that FSA is one of the few methods that have found international recognition and effective practical application in various fields of activity. The FSA method is based on a combination of purely economic calculations (for example, the cost of manufacturing products) and the determination of consumer properties (usually by calculating the level of product quality through the functions it performs). The relationship between these criteria can be written in symbolic form as follows:

where E is production efficiency; UPS - level of consumer properties; 3 - costs.

By analyzing and generalizing the concepts included in dependencies (1)–(7), we can come to the conclusion about the identity of these expressions, which essentially contain, regardless of the form of recording, the categories of “part” and “whole” in different interpretations. Using the concept of integrity as one of the main components of the systems approach, D. Michie and R. Johnson introduced in their work a generalized version of assessing the effectiveness of activities. It is proposed to evaluate a person’s ability to manage the world around him using a relationship that is a fraction, the numerator of which is the power of the means of cognition and control, and the denominator is the complexity of the environment in which these means are used.

where SU is the degree of control; P - cognition; C - complexity.

And here, as well as in dependence (7), a positive assessment criterion is the rapid growth of the numerator compared to the denominator. Otherwise, the complexity of the surrounding world will completely exclude the possibility of understanding it. It would probably be possible to continue the presented series of dependencies, but, in our opinion, the main methods and approaches to assessing the effectiveness of activities have already been covered. Table 2 shows the performance objective function and related concepts discussed in previous sections. Depending on the object being assessed, stages of development and generalization of the target function can be distinguished (Figure 2).

Table 2. Objective Function Evaluation Parameters

No.	Objective function	Parameter relationship	Object being assessed
1	Degree of intelligence	Mental age True age	Man as a system
2	Degree of harmony (I am a concept)	Scientific + Intuitive	Individual
3	Degree of usefulness	Energy used Energy input	Technical system
4	Profitability level	Profit Cost	Economic system
5	Degree of achievement of results	Result Goal	Sociotechnical system
6	Efficiency level	Quality Costs	Technical and economic system
7	Control degree	Cognition Complexity	Socio-technical-economic system

Consideration of options for assessing the effectiveness of activity is inevitably associated with the use of a group of concepts, the semantic content of which determines not only the choice of efficiency criterion, but also establishes the level, capabilities and nature of the activity process itself, in particular scientific and technical creativity. Turning in this regard to such concepts as "thinking", "cognition", "creativity", we can come to the conclusion that in the process of scientific and technical creativity, concepts work and function that are interconnected in two semantic "chains" (Figure 2).

Considering these chains, one can clearly see that in fact both of them contain two elements as indispensable components, reflecting the rational and irrational principles in the process of cognition. Therefore, within each chain one can identify its main lines of connections that determine the productive (creative) or reproductive (routine) type of activity.

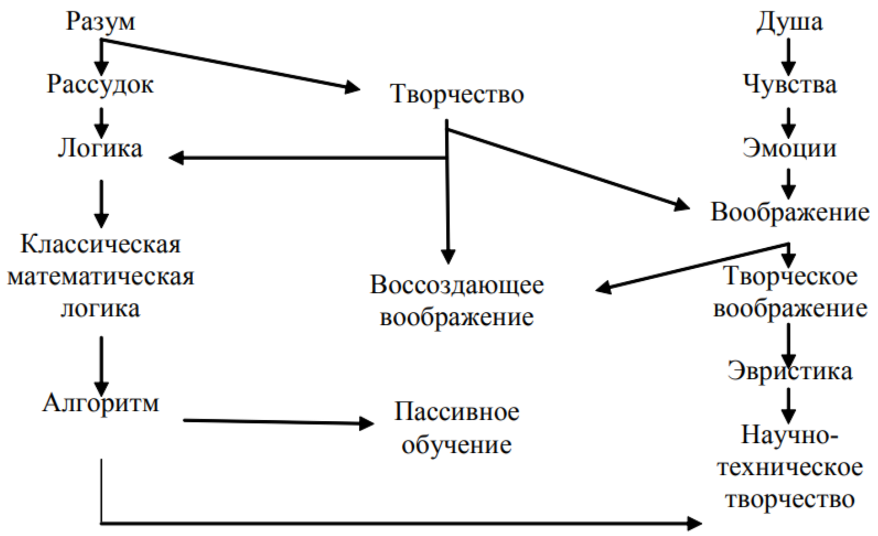


Figure 2. Two "chains" of concepts

The use of classical mathematical logic leads to the possibility of algorithmic problem solving; using creative imagination to develop heuristics. By introducing the ratio of the logical (algorithm) and the illogical (fantasy), you can try to find out which class of tasks a specific objective activity belongs to. And here we cannot do without mentioning the relationship between two procedures of scientific creativity: observation of facts and faith. Even such a major scientist, an enemy of positivism and spiritualism, as D.I. Mendeleev, recognized the role of faith, intuition and insight in the knowledge of natural and social phenomena in the study of material substances. This role is especially significant, according to D.I. Mendeleev, occurs at the stage of generalizing facts, putting forward hypotheses, theories and scientific forecasts. Mendeleev did not at all deny the role of the "religious frame of mind" in comprehending the secrets of nature, adhering to a rationalistic attitude towards religion rather than opposing religion to science. He likened the persecution of religious beliefs to burning for witchcraft. Science here will be understood for now only as the scientific meaning or body of knowledge about facts and laws brought into a system, where these facts and laws are interconnected by certain relationships and mutually determine each other. In other words, scientific knowledge is by definition that which can be proven using formal logic. Approaching the definition of the concept "religion" with caution, we can state that in any definition the key concept is faith. At the same time, we cannot agree with the definition of faith as the antipode of knowledge. It seems that with good reason theology can be defined not only as a form of social consciousness, but also as one of the forms of abstract-intuitive knowledge. If, taking into account the above considerations, we introduce P as the degree of rational (logical), and I (irrational) as the degree of spiritual, then the degree of harmony (SG) in a person's knowledge of the surrounding world is equal to:

$$SG = R + I. \qquad (1)$$

In essence, expression (1) confirms the semantic content of the concept of "conscience," which "manifests itself both in the form of rational awareness of the moral significance of the actions performed, and in the form of emotional experiences." The content of the rational and irrational can be seen more clearly if we imagine a three-dimensional figure made up of two planes P and I. The angle of rotation of these planes and the integrity of the circles can help determine the degree of harmonious development of a person. The incompleteness of the filling of the resulting spherical structure is similar to the shape of the human aura, when gaps and voids indicate an unhealthy body. Let's try to introduce a relationship between the rational and the irrational to determine the degree of innovation:

Of course, this relationship should be treated with a certain degree of convention, considering its components as parameters of fuzzy, vague sets. At the same time, with its help it is easier to understand the features of innovative activity.

Thus, in the case of using the laws of only formal logic, we are dealing with ordinary thinking (I = 0 and SI = 0). If only imagination is involved in thinking, not based on knowledge (laws), then a case of pure fantasy (utopia) arises (Figure 4).

Developing Figure 4, we can identify zones of inventions related to the development of devices, methods and fundamentally new technologies (Figure 5). Returning to Table 2, in particular to target function No. 5 - the degree of achievement of the result and No. 6 - the degree of efficiency, we introduce the concept of efficiency of innovation activity (EID), defined as the ratio of the degree of innovation (SI) to the costs invested in the innovation process (CI):

Analyzing assessments of the effectiveness of activities and taking into account the influence of both the rational and the irrational on the result and on the process of activity, let us summarize the possible use of the above reasoning in specific, in particular engineering activity.

As A.V. points out. Kudryavtsev, depending on the type of problem, a different strategy for finding a solution can be chosen. At the same time, the choice of a particular strategy, and therefore the corresponding solution method, depends primarily on the amount of available information. When there is a small amount of information, an intuitive search strategy is used; when the solution is completely clear, a strict calculation is used. A specialist in a given subject area, setting a specific task and understanding the degree of innovation of the problem that needs to be solved (10), can determine in advance the area and nature of future activity (Figure 3–5).

Figure 3. Zones of degree of innovation

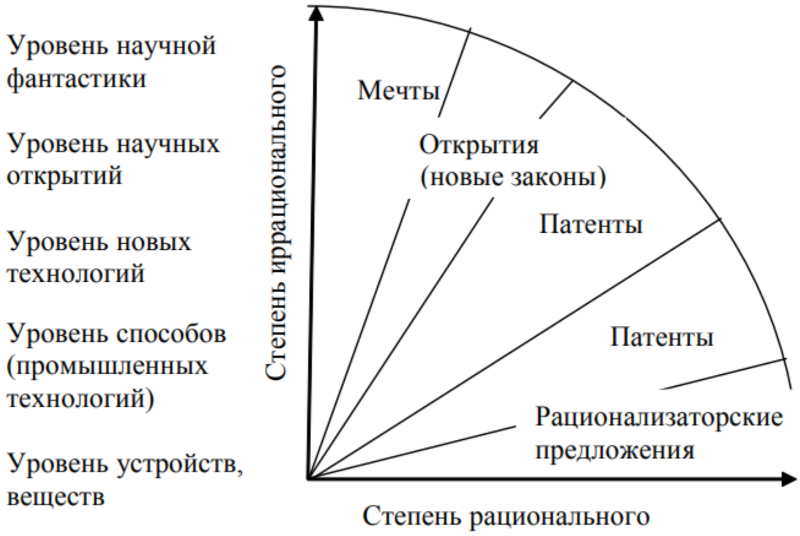


Figure 4. Development level zones

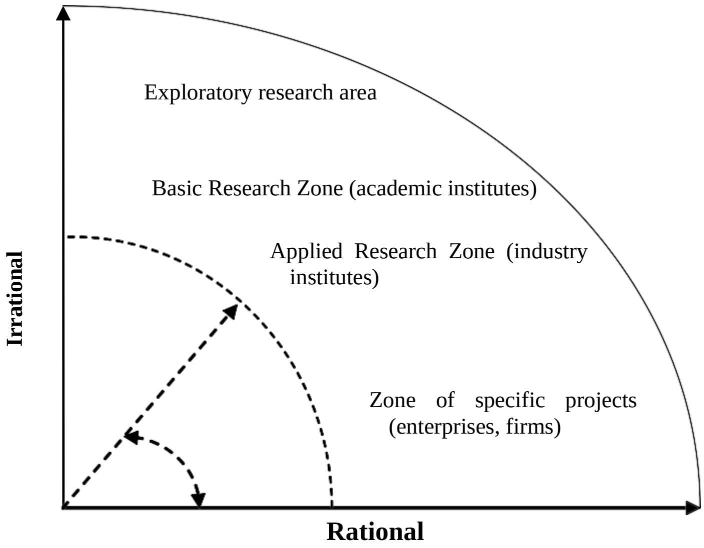


Figure 5. Definition of the area of activity

The degree of innovation beam (Figure 5) shows the direction of activity and helps to choose the appropriate strategy and methodological support as tools for solving this problem. Understanding the level of the task, the engineer will be able to navigate the choice of criteria for assessing the effectiveness of activities. Using the appropriate criteria, it is easier to select methods for their calculation, then moving on to the solution process itself. Using system analysis in research work and teaching practice is both simple and difficult. Attempts to teach systems thinking, at least at the level of a systems approach, are associated with two phases that are opposite in perception. Initially, the vast majority of students develop a sincere interest in the methods used in systems analysis. A clear formulation of the problem, structural and functional analysis, scientific methods of thinking - all this impresses the students. At the same time, in the higher education system, and more specifically, in textbooks intended for higher education, as a rule, there is no analysis of problems in subject areas. Genetic-functional analysis is even less common. Therefore, any information on a systematic approach literally “cleanses the brains” of a specialist, which are clogged with a mass of reference and subject sources. Successfully solved practical problems, analyzed together with the teacher in class, also evoke admiration. Students lively and joyfully discuss the possibilities that open up through the use of systems thinking. But after the learning process (phase 1), the process of independent attempts to formulate problems and solve problems begins (phase 2). And here a specialist (technological engineer, mechanical engineer, software engineer, economic engineer, etc.) encounters obstacles that most cannot overcome. Allegorically, the situation can be presented as follows. A student who has received a higher education diploma is introduced to systems analysis. Depending on the place and time of training, there are three options for obtaining knowledge about systems analysis, namely:

a) while studying at a university;

b) in the process of advanced training;

c) independent study.

But at the very first real task, two very significant obstacles arise:

1) a wall of misunderstanding, made of individual bricks filled with scattered information on various subjects and cemented by the psychology of traditional thinking;

2) the lack of clear and truly "working" tools with which to overcome this wall.

The first obstacle is due to the fact that the specialist does not know how to practically link his existing "database" with the principles of the systems approach; the second obstacle is essentially a consequence of the first. Therefore, we called these obstacles the wall of misunderstanding or inability, since in order to use subject knowledge, you need to know how to overcome this wall and with what tools. For these reasons, problems arise: how should an engineer be taught, at what stage of training can the ability to overcome obstacles appear, is it necessary to rebuild existing courses or introduce completely new ones, what recommendations are needed for a research engineer, and which ones for a production engineer? It is impossible not to mention the numerous publications devoted to these problems. The engineer's work is reviewed and constantly improved. But the fact remains real that, despite the abundance of material covering the above problems from different angles, it is very difficult to work with it on a specific task. Each specialist has to rethink and adapt existing teaching materials to their problems. Therefore, one of the most pressing tasks is to develop not only the technology of engineering thinking, but also tools for such technology. The originality of the style of engineering thinking is determined by the essence of the engineering approach to solving scientific and production problems. It is impossible to develop universal solutions suitable for all technical problems, but the basic principles of the solution methodology can be given. What are these principles based on? Whatever activity an engineer prepares for and whatever activity he engages in practice, it is always related to the production of products or preparation for this. Where should I start this activity? Of course, from an assessment of the goal, i.e. from an assessment of socio-technical needs. It is as a result of such activity that the engineer, acting as a subject, will be able to study and use the principles of engineering thinking in relation to the production of products, which in this case is the object of activity. Therefore, the author proposes a methodology for a systematic approach to assessing the consumer properties of products, based on the most successful, from his point of view, developments of domestic and foreign authors.

Speaking about the specific tasks facing the person making innovative decisions, the assessment of the quality of the finished product that is the result of his innovative efforts should be recognized as the main and even fundamental one. After all, in the end, the entire set of means and methods developed by humanity over its history and designated by such key concepts as science, technology and technology comes down to meeting the various needs of people. Without dwelling on the degree of actual need to realize these needs, let us consider the technical side of this issue. Usually, when assessing quality, we are talking about the performance characteristics or consumer properties of products. Before moving on to analyzing methods for assessing them, let's try to identify the relationship between such concepts as "quality" and "system approach". As already mentioned, there are many attempts to use systems analysis or a systems approach to solve a wide variety of problems. There is also general methodological literature such as textbooks for universities and general technical literature intended for self-education of engineers, textbooks that implement a systems approach and system analysis in relation to a specific task. The level of presentation and volume of information in such publications differ significantly. And this is understandable. After all, they have different purposes: from purely informational messages about system analysis in a newspaper or magazine essay to detailed analysis taking into account the specifics of the enterprise's work in a certain area. Our goal comes down to seeing the place and role of such a concept as "quality" both in the system analysis itself and in assessing consumer properties. A unique tool for forming such a vision is the laws of dialectics. The foundations of the chain of connections between the concepts of systems approach - systems analysis - quality are already included in the definitions. In fact, one of the main stages of system analysis is the consideration of the elementary composition, structure or organization of an object, i.e. its quality. In turn, quality and quantity, composition and structure belong to philosophical categories, the dialectical unity between which is established using the category "measure". Thus, if we talk about a systematic approach in relation to our task, then, in essence, we are talking about the "philosophy of engineering," "philosophy of technology," and ultimately, about the art of engineering. Without pretending to develop a new concept, we will try to carefully analyze the well-known philosophical categories in relation to the task at hand. It is generally accepted that the law of unity and struggle of opposites reveals the source of development, the law of the transition of quantitative changes into qualitative ones is the mechanism of development, and the law of the negation of negation expresses development in its direction, form and result. In essence, there is a fairly clear connection here with innovation processes and the range of concepts included in them: innovation, novelty, etc. This connection is even more obvious when using categories such as measure and norm. In fact, based on the well-known provisions on the relationship of dialectical laws, one can use the following graphical meta in relation to engineering: handicap: the source of development, the knowledge of which is oriented towards the law of the transition of quantitative changes into qualitative ones, can be seen in sociotechnical factors; the development mechanism, determined by the law of the transition of quantitative changes into qualitative ones, can be revealed through the quality/quantity relationship, in turn, directly related to the categories "measure" and "leap" (Figure 6). As for the use of the law of negation of negation, which essentially reflects the cyclical, or spiral, development, an analysis of this possibility is given in the extremely interesting work of A.F. Esaulov, where the methodological and psychological foundations of engineering creativity are considered on the basis of a polycyclic movement dictated by the law of negation of negation.

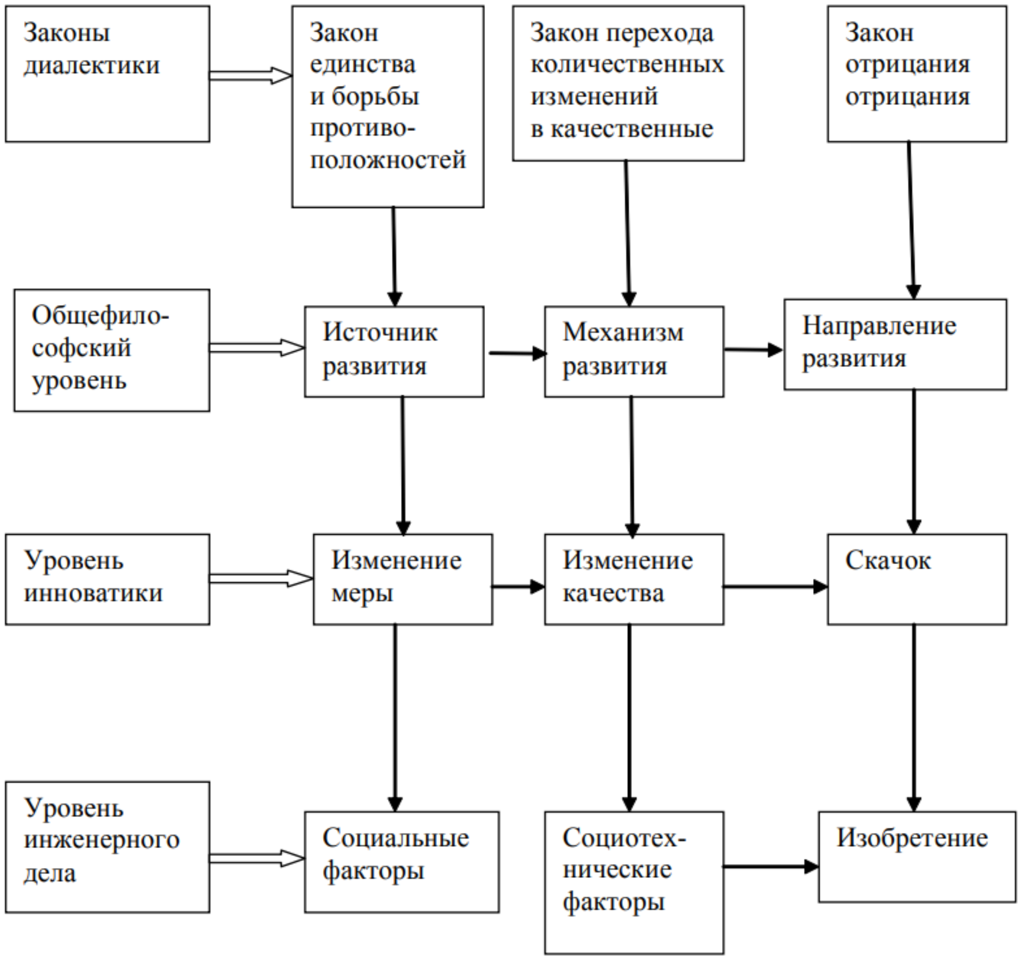


Figure 6. Engineering, innovation processes and the laws of dialectics

It should be noted that the dialectical approach to the analysis of technical sciences is being developed by both domestic and foreign philosophers. Moreover, all works emphasize that "a truly systematic approach to solving technical problems has not yet become a reality..." At the same time, even in specialized literature aimed at a narrow circle of professionals, social-innovative processes are touched upon, which inevitably bring the authors to the level of dialectical thinking. Returning to Figure 7, which shows three levels of the epistemological approach - general philosophical, innovation and engineering - it is necessary to clarify the following positions more clearly:

about the epistemological and ontological approach. In contrast to the level of general philosophical knowledge and the level of categories of innovation, the level of philosophy of technology is determined by the subject of activity itself - scientific and technical thinking. Since the end result of the activity is the development of material, technical objects or knowledge about them, even if this happens at the level of abstraction, the engineer is faced with the concepts and realities of a purely concrete, material world. Developing and mastering the possibilities of most fully satisfying the requirements requested by society for the consumer properties of products, he is forced to rely on concepts considered at the ontological level. Of course, we can take a position of scientific snobbery (at the heights of epistemological truths), but in this case we will not be able to solve a single issue related to substantive practical activity. Figure 8 shows the "circulation" of concepts, designated as a single conceptual cycle "concrete - abstract - concrete". The content of the figure consists of terms, without mastering which it is difficult to understand the relationships and interdependence of the processes of a systematic approach and assessment of product quality. In the center of the figure there are purely philosophical categories, on the left and right - branches of systemic-dialectical analysis.

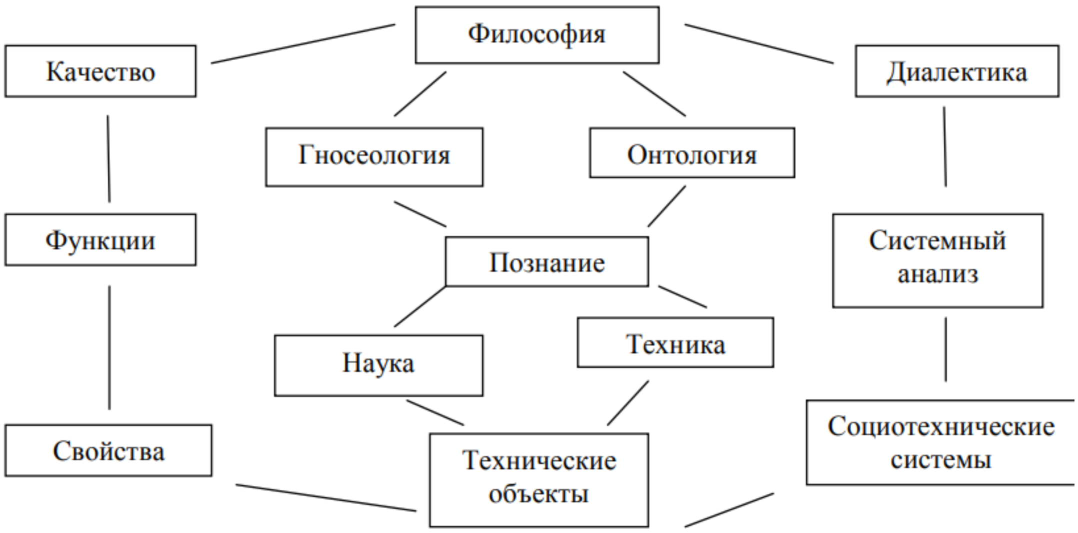


Figure 7. Conceptual cycle "ascent from abstract to concrete"

I would like to answer one more fundamental question: why was it necessary to talk about the laws of dialectics in such a brief, incomplete form, when there are professionally valuable works in this area? The fact is that the connection that is associated with the presentation of philosophy in relation to technology is made, as a rule, by professional philosophers only from the position of philosophy. And this is correct, since it guarantees methodologically correct coverage of the issues under consideration. But this, relatively speaking, is the external side of the problem. An engineer who is "inside" his task needs a philosophical understanding of what is happening. Therefore, such a concept as "philosophy of technology" or "philosophy of engineering" was introduced. Just as there is a philosophy of history, a philosophy of culture, a philosophy of science, etc., with its own subjects, structure and history, so a philosophy associated with engineering has actually already developed. However, to present it for a "technical audience" at the level of classical philosophy courses means dooming the whole matter to misunderstanding. Therefore, the authors believe that, by analogy with various introductory courses such as "Introduction to a Specialty," it is necessary to present the fundamentals of engineering thinking, constantly and purposefully leading the student to master the fundamentals of a systems approach. There is a fairly common misconception that a system for assessing the quality of a finished product and assessing the quality of production of this product can exist independently of each other. Failure to understand the essence of the existence of a single life cycle for any product of human (and, as a derivative, technical) activity has led and continues to lead to the release of low-quality goods. Using a systems approach radically changes the situation. Entrepreneurs in industrialized countries (the USA and Germany) were the first to understand that the success of production is inevitably associated with the development of general theoretical concepts for analyzing the patterns of technology development. This has led to the emergence of theoretical and practical universal developments, the originality and value of which lies in the fact that they are not related to a specific subject area and at the same time are necessary for the successful activities of any manufacturer. Let us note that the emergence and development of methods and techniques of technical creativity is evidence of the urgent need to develop "mechanisms and tools" for transferring the "general" - social, economic and technical development trends - to the "particular" - a specific engineering or scientific research task. In essence, this is what, since the time of Hegel, in philosophy has been called the ascent from the abstract to the concrete. This process is the turning of theory to real specifics and reflects the content-constructive development of theoretical thought.

If in these works system analysis is considered primarily from the perspective of optimizing a technical solution, then in the second half of the last century many works appeared that reached the sociotechnical level of problem solving. Specialists from Japanese companies were the first to not only sense, but also implement this approach. For example, the son of the founder and head of the Omron corporation, in the afterword to his father's book "The Eternal Spirit of Entrepreneurship," writes: "In the meantime, I am doing everything in my power to guide Omron along the path of humanism... Previously, we gave priority degrees of education, now, along with "excellent students" in their studies, we also accept those who have proven themselves in other areas, for example, in sports or such unique fields of knowledge as the Chinese language or astronomy. We are happy to hire simply erudite people, people who know a little bit about everything. For us, the main thing is talent as such, regardless of the sphere of its manifestation."

It seems to us that the above transition from the purely technical to the "human" characterizes the main trend of reform activities not only in the sphere of education, but also in the sphere of production. Scientists and businessmen both in the USA and in Europe quickly understood the essence of what was happening, as evidenced by a number of fundamental works from the point of view of scientific research. Despite the fact that each of them examines an area of specialized knowledge - labor productivity, economics, management, marketing - it is emphasized throughout that high quality can only be ensured through the understanding of the problems by the performer himself - the person. The most advanced technology without such training of the worker is unable to provide sufficient quality. An example is the level of quality of products produced on foreign equipment in Russia.

However, we do not find either in educational or scientific literature a clear explanation of the "joining" of two stages of the life cycle - production and consumption. Perhaps only in the work of K. Ishikawa are clear formulations given. The author writes: "I never tire of repeating that quality management begins with personnel training and ends with personnel training... In the West, it seems, they emphasize the production aspect of training in order to develop in workers certain skills that can be used by a particular company. In my opinion, we must turn the workers into well-educated people. We have to teach them to think and then direct their thinking in the right direction." In the modern situation, no one will argue with this thesis. But one fundamental question remains, and the success of the matter depends on its resolution: what needs to be taught to think? This is where the term "engineering thinking" that we introduced comes in handy. In fact, as a rule, we are offered two options for use: either the theoretical concept of production analysis, or the economic approach. Let's look at them using specific developments as examples. One of the most successful and fundamental implementations of the first option is the work of the Polish scientist V. Gasparsky.

"Praxeological analysis of design and construction developments." At the same time, praxeology is understood as the science of the effectiveness of actions, i.e. a science that deals with the study and development of rational and effective actions based on a comprehensive analysis of consumer or beneficial effects. The author quite rightly believes that materials, energy, tools are only the means by which "actions" are performed, i.e. technologies. "By comparing different technical objects with each other, we are actually comparing their suitability for meeting our needs. A comparison of the individual characteristics of these objects is nothing more than a way of assessing certain qualities of objects in relation to satisfying certain needs."

An example of a fairly successful implementation of the second option - economic and practical - is the methodology for planning and forecasting durable goods, set out in a domestic publication. Of interest to us is the classification of consumer properties introduced by the author. Table 3 shows the structure of consumer properties, which, in our opinion, can be extended to most products manufactured in Russia.

Table 3. Structure of consumer properties of durable goods

Classification	Composition and characteristics of consumer properties

View	The main properties that distinguish these durable goods from the general world, formulate the base of consumer value, causing the emergence of a qualitatively new need and a qualitatively new production
Group	Leading properties that determine qualitative diversity, significant differences in products that embody the properties of the species and cause development, an increase in the needs embodied in these products, as well as major changes in production
Class	Significant properties that complement the main and leading properties, expanding and differentiating the needs for products of a given type and its constituent groups; their implementation places special demands on production
Type	Levels of properties (main, leading, significant) - numerical values obtained as a result of calculations, measurements, tests, or identified by expert methods, determining the degree of development of the need and the degree of its satisfaction; ensuring these levels is an inherent task of production
Model	The embodiment of the main, leading, significant properties in compliance with the levels corresponding to the type, in unity with private auxiliary properties that determine the completeness of a particular thing

So, in any case, the necessary steps in determining consumer properties are:

system analysis of the process; selection of quality assessment criteria.

It is obvious that analysis is unthinkable without selecting appropriate criteria. The following consideration may help in understanding this choice. Whatever the degree of complexity of the product manufacturing process, the following sequence of actions is inevitable: obtaining raw materials or semi-finished products, manufacturing products, selling products.

If you start moving not from the supplier to the customer, as is usually explained in the classroom for the simple reason that the production cycle of the product is structured this way, but from the consumer to the raw materials, then it becomes clear how the consumer properties of the product should be formulated and what specific criteria will be effective. The starting point is the consumer's request, on the basis of which consumer properties—product quality—are formulated. Then the properties of the finished product must be converted into quality requirements for semi-finished products and raw materials, which will make it possible to clearly and clearly formulate the properties of both semi-finished products and starting materials. Then the task of developing a control methodology that should be followed is simplified: from output control to production control and incoming control. Let us note the most significant thing in this matter.

The most "subtle" point is the need to translate consumer properties from the language of the consumer into the language of the manufacturer (technical and economic engineering language). Moreover, the main thing is that in the process of such a transition the properties of the product that determine the performance of its main functions are not lost. Violations of this rule occur everywhere when, in order to improve manufacturability, in the pursuit of savings on production, they completely lose sight of the final goal of the entire production process.

No less complex is the procedure for transferring consumer properties to each previous operation of the technological process, right down to the properties of the starting materials. The rule should apply here: each subsequent operation is needed not in itself, but to perform the next one.

The basis for solving such problems, a kind of guiding star for an engineer, should be the following thought: the essence of any technological process is to transform the properties of materials (raw materials) into the properties of the finished product.

A huge number of publications are devoted to the issues of assessing product quality. Their topics range from deep theoretical research reaching the level of fundamental science to GOSTs, OSTs and similar regulatory documents. We are interested in the relationship between quality and consumer properties. Before moving on to consider these connections, we will examine several cases from practice. As a typical situation, I remember an incident that occurred while the authors were working as part of a factory commission assessing a machine for the "Quality Mark". When checking the finished part, a significant "runout" was discovered - the eccentricity of the outer surface - up to 0.3 mm, which is unacceptable even for machines from blank shops. And we were dealing with equipment designed for finishing. After a long search, a completely absurd thing became clear - the position of the tailstock of the machine was not checked, the displacement of the center of which determined the delay in the work of the commission of twelve people.

The second example is from the process of debugging a new generation machine with program control at the pilot production of a large research institute. The machine support did not move after switching on. The engine is powerful, the system is in order. After a futile search conducted by the adjuster and the lead designer, we turned to the chief of scientific work. He said: "Well, sometimes science can come in handy," he went to the workshop. What happened next was ridiculously simple. "Turn off the engine," the chief said. "Try turning the feed screw by hand." It turned out that a colossal amount of effort was required. "Disassemble the screw-nut pair." And what? There was a felt O-ring there, which the fitter installed "very conscientiously." It's hard to blame him. After all, he carefully sealed the screw pair, protecting it from contamination. If he had thought about the main, and not the auxiliary, function of this node, then this would not have happened. And finally, let's look at another feature of low quality.

In this case, the situation is typical for the production of things with adhesive joints. An example from the shoe industry. The boots were made using proprietary foreign equipment, and yet, under our production conditions, for some reason they fell apart. A representative of the company analyzed the production process and demanded a sharp increase in payment for the operation "coating the soles with glue." The marriage disappeared. The fact is that this operation was performed manually, was considered primitive and was paid according to one of the lowest categories. Therefore, either trainees or temporary workers were assigned to carry out this operation. From the point of view of the complexity of execution, this operation is the simplest, but from the point of view of future consumer properties, it is the main one.

What is the real, root cause of marriage in the above and similar cases? In the first of them (the center of the machine) - the distribution of responsibility for one task simultaneously among several performers, i.e. lack of responsibility; in the second (sealing) - the assembler's lack of understanding of the functional purpose of the unit; in the third (applying glue) - an error by the production management engineer in assessing the significance of the operation. The analysis of such situations was the reason for the emergence of the now world famous "quality circles" in Japan. Many specialists, getting acquainted with the methods of their work, are quickly disappointed - their activity seems very elementary, even primitive. Let's try to approach this issue from an engineering perspective.

Regardless of what this production does, the following scheme of its "circulation" remains valid (Figure 8). The initial data for understanding the design process are materials and design, for the manufacturing process - the technological process and equipment, for the operating process - the operating conditions, storage and transportation of the finished product. In colleges (nowadays most of them have become academies and universities, which makes this material even more necessary due to its universality), the specialization of faculties occurs, as a rule, according to the above scheme. To understand the technological process, they train technologists, to understand the operation of equipment - mechanics, to calculate all stages of production - economists, for the design stage - artists (designers), to sell products - merchandisers. The names of specialties for each university, of course, have their own characteristics, but in general the approach described above remains the same. The stages of the production cycle shown in the figure also determine a set of special disciplines: materials science, mechanics, strength of materials, theory of mechanisms and machines, machine parts, etc. Obviously, each stage is responsible for the quality of future products. But how exactly?

In the center of Figure 8 there is a triangle - quality control. In fact, it has a dual nature: technological and constructive. Two triangles arise, which determine the sources of future quality.

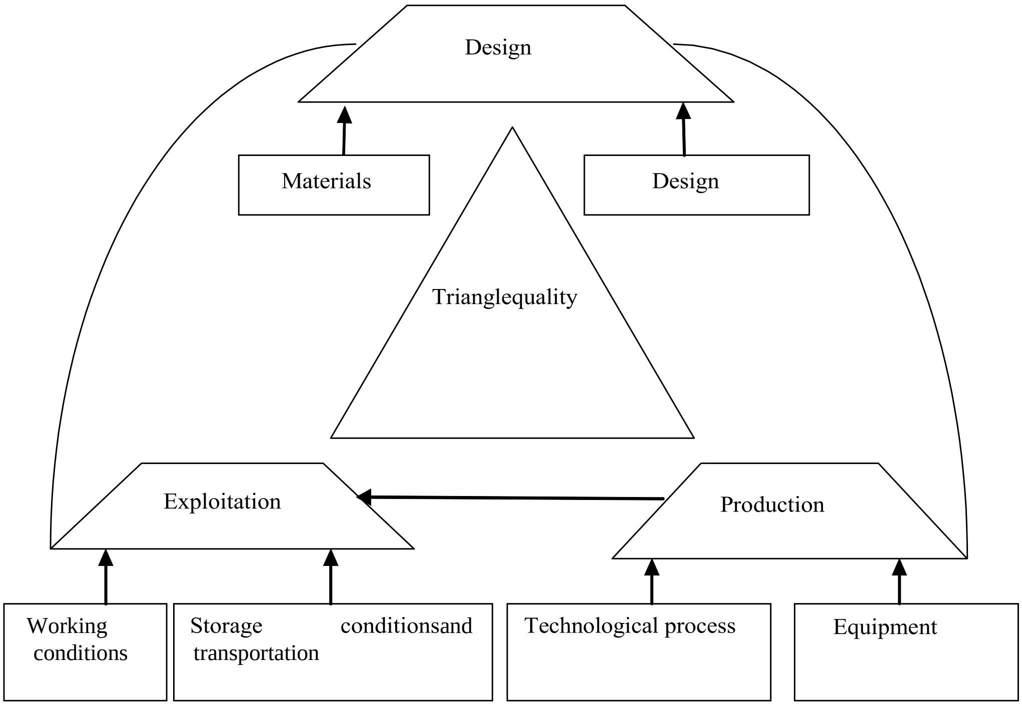
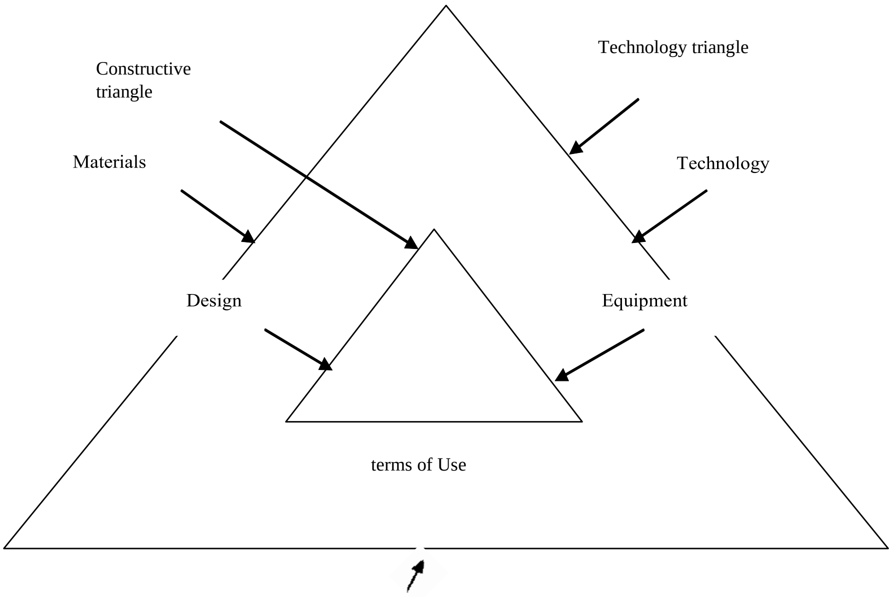


Figure 8. The stages of the production cyclological triangle are nothing more than a line of properties that determines the function of the future product, and the constructive triangle is the organization of its structure in space and time (Figure 9).

In the future, we will specifically discuss such a concept as "constructive-technological analysis". Here we note that placing the constructive triangle inside the technological triangle is not accidental. This emphasizes the primacy of technology. Just as in inventions there can be many devices that implement one method, so the same technology can be implemented using different equipment. Let us try to identify the sources of origin of the category "quality", which, by philosophical definition, should express the essential certainty of the object. These sources are based on two concepts, which we will conventionally designate as "I want" and "I can". Let's reveal their contents. As already mentioned, on one side of the production process there is the consumer - "I want it this way", and on the other - the production process - "I can do it this way". What the buyer wants can be determined through marketing - market research. What production can do is clarified with the help of management - the management of people carrying out the production process.



Consumer properties
Figure 9. Quality triangle

There is always a discrepancy between these "I want" and "I can". The task of reducing the degree of this mismatch falls on the shoulders of the engineer. What can help him? Of course, knowledge. But knowledge not only about the subject area of his activity, but also an understanding of the entire circuit of relationships shown in Figure 9. Awareness of the origin of the sources of quality - production capabilities, standard of living, value orientation - enables the engineer to use not only the stock of knowledge in the specialty, conventionally designated " technology", but also make it necessary to use data from sociology, HTT. With such a scheme of reasoning, which essentially implements a systematic approach, the engineer has a chance to "float" to the "surface" of quality, leaving the problems of both technocratic and social reasoning at lower levels. Only in this case will he be able to create a quality product, in the totality of whose properties the contradictions between "I want" and "I can," between the consumer and production will be eliminated. Then we can talk about engineering as an art, since with this approach the category "quality" acquires its primary scientific and philosophical meaning - the ability to express a certain degree of human knowledge of objective reality. Knowledge of technology, i.e. the ability to transform the properties of source materials into consumer properties is the main part of the content of an engineer's knowledge. It is for this that he needs to know physical and chemical laws and effects, and it is for this that he needs to master the mathematical and economic apparatus. To truly master the art of engineering, he needs to enter the "supersystem" of socio-psychological aspects associated with the formulation of consumer properties and production conditions. In practical work, the situation is as follows. Each specialist has his own idea of the concept of "quality". And at meetings devoted to production issues, long discussions arise, which can ultimately be reduced to the question: what is good and what is bad? As mentioned earlier, there are numerous instructions regulating the quality of products in production and giving a clear answer to this question. But the complexity of the situation is that no instructions can provide for a change in the situation in real conditions. The need to make local decisions depending on the requirements of today and production capabilities at the moment makes thick volumes of publications such as KSUKP (integrated product quality management system) ineffective. This is especially evident at the present time, since the prospect for the development of Russian industry is associated with the denationalization of large enterprises and the need to organize numerous independent joint-stock, private, joint and similar industries. Scientific and technical workers and managers need to make operational decisions to develop successful strategies and tactics for their enterprises. And, of course, it's not just a matter of the abstract concept of "product quality." The fate of both the enterprise and the people working at it depends on what exactly is manufactured and with what consumer properties. Therefore, the responsibility of providing the decision maker with data that reflects the situation as objectively as possible falls on the shoulders of the engineer who is thinking through what and how to do. These considerations become even more important when assessing development prospects, when the development of a new object associated with innovation processes throughout the organization is required.

The methodology outlined below is a general tool that an engineer can use to solve a specific problem. The value and meaning of the following approach to assessing quality based on consumer properties lies in the fact that a specialist breaks out of the framework of instructions and regulations given to him from the outside and often contradict each other, and acquires the opportunity to "create quality" from the inside, i.e. according to his own ideas, relying on the capabilities of the production that he knows. First, we will consider the method of transition from general requirements related to the fulfillment of consumer properties to specific standards. Before talking about constructing a "properties - norms" diagram, it is necessary to analyze several levels of concepts related to the production process. The starting point for us is the structural-functional approach, the main provisions of which are based on the systems approach and FSA (functional-cost analysis). First of all, we are interested in the property level, which is a derivative of the functional level, as well as the constructive level, which is a derivative of the structural level. In turn, the technological level is determined by the level of properties, and the level of equipment is determined by the design level. Table 4 provides a semantic explanation of the above levels, and Figure 11 reveals their connection and subordination. There are three pairs of levels with corresponding relations of the two concepts, namely:

1. first level structure/function;
2. design/properties;

equipment/technology and two communication lines:

second level

1) function - properties - technology;

2) structure - design - equipment.

Although in practice the engineer has to deal with either technology (process engineer) or equipment (mechanical engineer), it should be clear that both technology and equipment are derived from previous levels. It should also be understood that a mistake at the upper levels (1 and 2 pairs) will cost immeasurably more than at the third level.

Table 4. The semantic content of various levels of the production process

Level name	Content
Functional	Defines all functions performed by a product from raw materials to the finished product. Functions are formulated on the basis of value orientation. The main function is primary
Structural	Defines the relationships between product elements from raw material to finished product. Connections are determined using a systematic approach and taking into account the analysis of subsystems
Properties	Determines the properties inherent in a product - from raw materials to the finished product. Properties are formed based on functions. Consumer properties are primary
Constructive	Determines the composition and relative arrangement of product elements - from raw materials to the finished product. The design option is determined based on the optimal organization of the structure from the point of view of its consumer properties.
Technological	Determines the composition and sequence of operations to ensure the properties that the product must have during the manufacturing process - from raw materials to the finished product. Technological operations, their sequence and modes are determined based on the level of properties
Equipment	Defines a set of tools, devices, mechanisms, machines necessary for implementation in a specific production environment with the appropriate technological level. Equipment is selected based on the need to ensure the relative position of elements in space and to give them certain properties

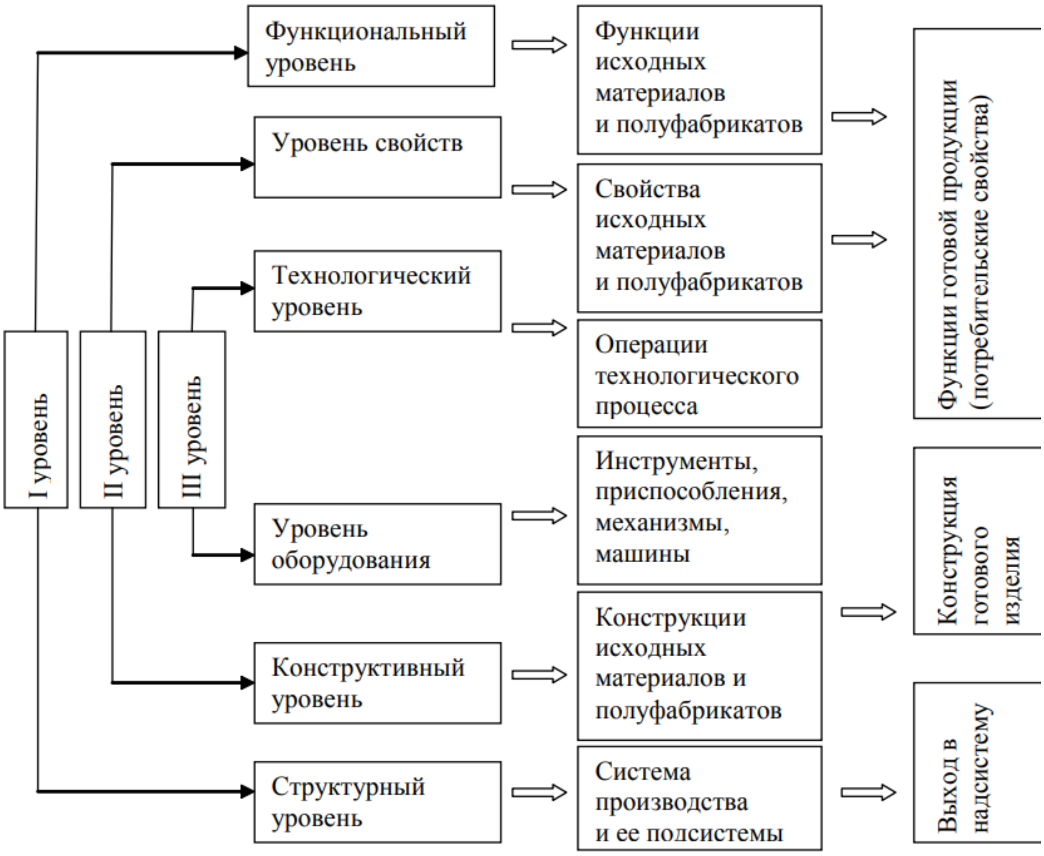


Figure 10. Connection and subordination of levels of analysis of the production of a given subject area of specialists.

Teaching university students using special disciplines is preparation for work at the third level. The considered three-level analysis of the production process of the finished product allows us to move on to developing a methodology for assessing production from the position of forming consumer properties during the technological process. In reality, we are dealing with finished products (or their components), as well as with the means of production and control of these products. Between these two materialized objects there is a hierarchical system of transitional "concepts - steps". The content of each stage is clearly revealed using a diagram, in the center of which is the finished product, and on the periphery are control tools. In the most general case, consumer properties can be divided into technical, economic and aesthetic.

This makes it possible to work with a chart for certain sectors. Each sector of consumer properties may correspond to one to several evaluation criteria. Control methods may also be ambiguous, i.e. the same criterion can be assessed in different ways. The contents of circles - units of measurement and norms - are well known to any engineer. In each subject course, they are regulated by very specific units of measurement and a recommended range of tolerances. The entire production process, from the first to the last technological operation, is inherently characterized by a "ladder of transition" from the finished product to the means of control. Figuratively speaking, we are dealing with a whole range of diagrams sequentially transforming into each other in the production process. This system of diagrams is integrated into the production process and differentiated into individual operations of the technological process. How many internal sections of diagrams are needed depends on the technology and production conditions. Let us explain this situation. As a result of the technological process, properties are converted from the initial elements to the finished product. Each slice of the diagrams can correspond to a specific operation (stage) of the production cycle. An indispensable condition for the development of such diagrams is the following: the consumer properties of semi-finished products are determined based on the properties of the finished product. The analysis should begin from the end of the technological process to its beginning, right down to the starting elements. After such elaboration of the production process, a complete picture of possible requirements and conditions for their implementation for specific products appears.

Conclusion

The circumstances are such that you have to choose between a traditional and a new solution that promises increased efficiency and reduced costs. The choice, however, should be based only on preliminary testing. The young engineer's boss unexpectedly informs a group of colleagues that the recommendations must be substantiated within two days. At an engineering school, a young employee had the opportunity to research a new device, but now, in production conditions, there is no time for thorough research. Nevertheless, the device is promising. The engineering team agrees with the boss and recommends an old, proven device. The boss instructs a young employee on how to write a report praising an old device and recommending its use. The report should not contain a word about a new alternative. What should an engineer do?

Summarizing the above, it should be noted that against the backdrop of an increase in the number of publications devoted to certain aspects of engineering work, the scarcity of studies in which it would be considered as a spiritual and practical activity becomes noticeable. The creativity of an engineer has not yet been studied deeply enough in the sociological and philosophical literature. Scientific, technical and engineering activities as a cumulative source of technological innovation in a number of important aspects are outside the field of research. Therefore, the need arose not so much to optimize the processes of scientific and technical creativity and scientific and technical activity, but to develop a general concept for the further development of a system for training specialists with higher technical education and a methodology for managing this system. The creation of a new paradigm for the educational process has become not only a pedagogical, technological or environmental problem, but also becomes a philosophical and socio-economic problem, on the successful solution of which scientific and technological progress throughout the country depends. It should be noted that until now the process of both theoretical and practical understanding of the categories “engineering activity”, “engineering thinking”, “scientific and technical creativity” has developed in such a way that its psychological, logical and epistemological aspects have received the greatest development, and general sociological , in essence, have been studied very little and, as a rule, are in the nature of general recommendations that are difficult to actually implement in the socio-technical activities of an engineer. Therefore, it is natural that the public consciousness is dominated by the idea of scientific, technical and engineering activity as a special kind of spiritual activity, as if divorced from creativity in general and especially from art. Without accepting the limitations of such views, the author came to the conclusion that engineering activity should be considered as a dialectical unity of change in the object and subject of activity, as a constant divergent-convergent process of scientific and technical activity, including its subject, spiritual and organizational components. Engineering activity can be understood and revealed only through a specific historical study of socio-technical and socio-economic processes. Such an analysis makes it possible to understand the inextricable connection between the method of production and scientific and technological progress, scientific and technological progress and culture, the connection between engineering activity and art, with the moral values of a creative person. Modern highly industrialized and largely technocratic society is in dire need of such theoretical works that carry the potential of practicality and make it possible to harmonize the processes of scientific and technical activity with the help of technological innovations. It should also be noted that there has been a sharply increased public need to unite representatives of different scientific disciplines in solving technical problems.This is confirmed by the material incentives Japanese and American firms provide for scientists and engineers to obtain second and third degrees, including the study of foreign languages and non-technical sciences. The real embodiment of this trend is the synector teams in manufacturing performance analysis consulting firms. An example indicating the negative impact of differentiation of sciences is the division of engineering departments of a higher educational institution into departments for equipment and technology in the same branch of production. Such a separation, formally convenient for organizing the educational process and for compiling a range of specialties, led to a deep and long-term mutual alienation of the style of engineering thinking of process engineers and mechanical engineers, as a result of which many unsuccessful and ineffective decisions arose in the design and manufacture of technical objects. To give universal recommendations for changing the entire system of higher technical education is an unrealistic task. This work is only an attempt to fill the “blank spots” that have arisen between the socio-philosophical and subject-technical areas of training in the education system, with the help of concrete sociological and concrete methodological research.

Solving the problems posed in the work is complicated by the fact that during times of crisis many social contradictions appear that are inherent in the existing social system. Therefore, this study does not claim to solve all problems associated with scientific, technical and engineering activities. Considering the multifaceted nature of engineering activity in the light of the onset of a new period in the education system, conditioned by the need to develop students' systems and computer styles of thinking, the author puts forward the following thesis as a basic one: the process of development of natural intelligence should not be identified with the development of increasingly universal artificial intelligence systems, including including computerization. The author also does not agree with the statements that engineering activity will become art only when, on the basis of fully automated and computerized labor, the techniques and methods of scientific and technical technology are combined with artistic creativity. The emergence of value-based approaches to human activity is a long-standing humanistic tradition. Mythology is actually considered the beginning of humanitarian culture. Religion divided the world into material and immaterial (mystical, otherworldly, supernatural), which led to an awareness of the importance of the spiritual in this world, which can also be attributed to humanistic cultural studies. Philosophy develops a rationalistic picture of existence, based on the human mind and scientific achievements. The humanistic orientation of philosophical concepts is expressed in value systems developed by philosophy. As shown in this work, art, including technical art (techne), originating in the springs of myth-making, religious teachings, and philosophy, ultimately led humanity to the development of rationalism, which degenerated in the 20th century into technicism and technocracy. There has been a shift in the value system towards greater satisfaction of human material needs. In the history of its development, humanity has moved further and further away from truly humanistic ideals, moving away from the social-humanistic direction of progress towards scientific and technological progress. Frightened by the results of such a movement, which led to an ecological and moral catastrophe, the world community, at least its leading part, is trying to change the course of human development towards humanization. This process is most important for the education system. In the education system itself - to humanize the process of technical education. Using various sociocultural approaches (social, philosophical, systemic, structural-functional, general systems theory), we tried to formulate a technology paradigm for the formation of engineering thinking associated with the destruction of ideologies of utilitarian-pragmatic goals. We also tried to contribute to the work of streamlining the mass of recommendations, conglomerative in form and eclectic in content,introducing a sociotechnical approach to solving technical problems using NTT and innovative technologies. In contrast to the descriptive (descriptive) method of constructing humanistic concepts adopted in socio-philosophical works, the study proposes a constructive definition of the methodology for moving the system of higher technical education along the path of humanization. To reveal this approach, the present study raised issues of dialectics, ethics and aesthetics as necessary. Over the past decades, society's requirements for specialists have significantly transformed. In addition to being highly qualified in their field, workers in science, technology, and management must be capable of creative activity and self-improvement. Engineering activity began to have a planetary character, technogenesis became commensurate with natural scales, covering the entire territory of the earth. The humanization of scientific and technological progress to mitigate technocratic blows should be directed primarily towards the humanization of the process of education of engineers. Nowadays, the disciplinary paradigm of education continues to operate, fostering “chauvinism of special disciplines.”

Those who call for a shift in the training of engineers to a paradigm shift, to the introduction of a problem-based method, and the like, are right, in fact. The difficulty of such a transition lies in the fact that there are no simple and quick solutions leading to successful results in education. It is obvious that the transition period requires not only time, but also special techniques. During this period, an understanding should come of how to move from technical knowledge, how to move from technocratic thinking to sociotechnical knowledge, to humanistic thinking.

First of all, the purpose of education must be changed; it is not knowledge itself that is important, but the development of personality with the help of knowledge. Such goal setting requires solving the problem of teaching students creativity and self-improvement. It is not enough to call for internalist activities focused on self-education. Tools for this activity need to be developed. If this is successful, then both the student and the graduate engineer will be able to take advantage of the content and scope of knowledge that is already available in existing educational programs, using this knowledge to humanize technical activities. The stated position is the main goal of this work. It is to achieve this goal that it is shown how, with the help of a sociotechnical approach, using the diversity of such concepts as “consumer properties” and “result quality”, one can arrive at a full-fledged creative educational process. Therefore, in this work, significant attention is paid to the consideration of the transcendental in engineering activities, i.e. such categories as faith, intuition, imagination, fantasy, creativity, “working” for the humanization of engineering thinking. The introduction of such conventional concepts as “efficiency coefficient” is associated with the need for an instrumental and constructive description of innovative processes in engineering activities. The ability to operate with these concepts will enable the engineer not only to adapt to innovation, but also to actively participate in the creative process and master the art of solving real life problems. The tools that the NTT methodology has in its arsenal will help the engineer make the transition from a system of conceptual knowledge to a system of instrumental knowledge, and move on to real creativity.

The search for effective criteria for optimizing engineering activities is a fundamental point to which considerable attention is paid in the study. The anthropological aspect of performance results can be realized with a sufficiently in-depth analysis of the concept of "result quality". This will help in teaching to move from explanatory and illustrative methods to problem-search methods.

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