REFERENCES

1. Antonenko S., A new generation of engineers: the lost generation? // Kachestvo obrazovaniya. – 2014. – № 3. – P. 7-13.
2. Zelenskiy V.E. Process engineering – a basic tool to modernize food and related technologies // Food Processing Industry. – 2012. – № 10. – P. 8-12.
3. Kim I.N. Towards the necessity to develop education program "Production Facilities and Technological Processes of Fish-Processing Industries" / I.N. Kim, T.I. Tkachenko // Rybnoe khozyaystvo. – 2013. – № 2. – P. 16-18.
4. The concept of fishery industry development of the Russian Federation for the period until 2020 [Electronic resource]: approved by the Government decree, dated 2 Semptember, 2003. № 1265-p // website of the Ministyr of Agriculture of the Russian Federation. – M., 2002–2015. – URL: http://www.mcx.ru/documents/document/show/6409.191.htm, free. – title from the screen (reference date: 17.06.2015).
5. Bachelor's/master's degree education program of Higher Professional Education 151000 "Production Machines and Facilities", specialization "Production Facilities and Technological Processes of Fish-Processing Industries": 2 vol. / I.N. Kim, S.V. Lisienko, T.I. Tkachenko [et al.] – Vladivostok: Dalrybvtuz, 2012. – V. 1. – 262 p.; V. 2. – 114 p.
6. Prakhova M.Yu. Master training in engineering: Russian model / Prakhova M.U., Svetlakova S.V. // Vysshee Obrazovanie v Rossii (Higher Education in Russia). – 2014. – № 1. – P.118-124.
7. The project of innovative development of the Russian Federation for the period until 2020 [Electronic resource] // Ministry of economic development and trade of the Russian Federation: official site. – M., 2015. – URL: http://economy.gov.ru/minec/activity/sections/innovations/doc20101231_016, free. – title from the screen (reference date: 17.06.2015).
8. Saprykin D.L. Engieering education in Russia: history, concept, perspectives // Vysshee Obrazovanie v Rossii (Higher Education in Russia). – 2012. – № 1. – P. 125-137.
9. Khachin S.V. Experience of Tomsk Polytechnic University in teaching engineering business / S.V. Khachin, V.M. Kizeev, M.A. Ivanchenko // Mir obrazovaniya – obrazovanie v mire. – 2012. – № 4. – P.137-143.
10. Khurshudyan S.A. History of food technology and food industry development in Russia / S.A. Khurshudyan, Ts.R. Zaychik. – M.: DeLi print, 2009. – 296 p.

ENGINEERING EDUCATION 17'2015

UDC 378:62

On the Key Problem of Engineering Education in Machine-Tool Industry

Rybinsk State Aviation Technical University
K.A. Kapitonova

K.A. Kapitonova

The article considers the necessity and opportunity to develop a system mechanism model as an academic process reorganization basis for engineer training in the machine-tool industry.

Key words: mechanism, function, structure, subject of apprenticeship research.

During many years of education reforms experts in philosophy, psychology, pedagogy, information did great amount of work on principle issue of educational methods and techniques in our country including – engineer professional training. However, broad debates on the issues of engineering education virtually leave open the questions of its **professional content.** It is impossible to educate a specialist outside the limits of professional expertise and this or that subject area in the engineering industry. Besides, content and arrangement of teaching material, intensity and quality of academic process, as well as anticipating character of an engineer training should be defined. In the condition of modern cognitive technique application the basis for educational framework is the modern knowledge system in the industry.

In the content of engineering knowledge of any sphere one can distinguish two main constituents: an engineering facility of the industry (in machine tool industry at the initial stages it is a mechanism) and **process** of its development. The effectiveness of engineer professional training is defined, first of all, by content and structure of basic ideas of the study object, i.e. **accepted original model** of the object. The accepted knowledge model of engineering facility defines **the subject** of the educational process in engineering training [1].

The stage of original model development and knowledge in some engineering spheres accumulated today can be divided into sufficient time period. During the harmonious process of engineering development its achievements can be applied (under the condition of feedback) to correct continuously the initial concepts. In real engineering knowledge development processes there is no such correction. Obsolescence of basic assumptions on the object, their inconsistency with potential modern cognitive and information techniques is typical, to some extent, for all industry branches depending on their age. Machine-tool industry is one of the oldest engineering branches, hence, it is particularly illustrative.

In Russia key assumptions about machines and mechanisms have developed on their disciplinary base by the end of the 19th century. At the initial stage such fundamental disciplines of professional education as following were chosen: "Descriptive Geometry and Graphics", "Theoretical Mechanics", "Material Resistance", "Theory of Mechanisms and Machines" "Machine Parts", "Material Science" and others. At the initial stage of engineering education development theory issues were of particular importance. The theoretical bases of courses were taught to develop abstract thinking of future specialists. During the further development, engineering knowledge itself was improved and new disciplines appeared. For example, "Limits and Fits" is a discipline dealing with issues of part size precision, as well as disciplines associated with friction issues. There are a lot of other examples. A long-term tendency towards development of applied industrial science emerged [2] at the turn of 19th-20th century. During the subsequent development stages (in accordance with the international tendency of scientists' growing pragmatism [3] or economy-centralization [4]) the engineering knowledge enhanced mainly due to private research results of separate research projects. The objective of **knowledge system** development was not set for engineering science. At the moment, knowledge of mechanisms and machines involves mainly specific, poorly ordered information. The amount of information is like a snowball. In this conditions, the knowledge systematization, their scientific structuring has become a challenging education problem. Today, this common problem is formulated narrowly as a problem of overcoming interdisciplinary limits. In addition, it is the disciplinary knowledge developed over the years that was taken as a basis for the existing education standards in the machine-tool industry regulating the content of engineers' training (for example, [5]).

A narrower statement of a general problem leads to attempts of private solutions. For example, the textbooks of general professional disciplines: "Theoretical Mechanics", "Material Resistance", and "Machine Parts" are formally united under one cover with the title "Engineering Mechanics" [6]. In this case, separate disciplines are considered as parts of one textbook. The manual of the same title [7] consists of such chapters as: "Basis of Mechanisms and Machine Theory", "Material Resistance" and "Machine Parts and Basis of Design". At present, the issues of machine, mechanism and their parts precision are dealt with in a special discipline without connection with the issues of mechanism maintenance. For example, in the textbook "Metrology, Standardization and Certification" [8]. In this book the chapter dealing with issues of mechanism precision is referred to as "Basis of Interchangeability". Such a title reflects the conditions of the first five-year plans, when interchange was the key requirement to unit precision in the mass production development during the industrialization stage. Modern system knowledge suggests functional-structural models of engineering devices, the precision of which is one of permanent and significant features of mechanism's operation. Since the error of hundredth or thousandth of millimeter can result in the destruction of a whole mechanism, the priority task of precision science in machine-tool industry is optimal (from the standpoint of mechanism operation and economy) standards for parameters precision of parts in device design. To overcome the interdisciplinary limits it was suggested [9] to unite informally (with development of common concepts) two interconnected content disciplines "Theory of Mechanisms and Machines" and "Machine Parts" into the course "Theoretical Basis of Machine-tool Engineering". Such a decision could be considered as a half-measure, however, excluding possible solution of the problem in general, although it involves definite expenditures and time. The opportunity of synergetic is also taken into account (for example, [10]) to develop the knowledge structure in education. However, such a modern approach does not eliminate the problem of a more in-depth study in objects at the level of logical thinking intertwining with the development of learners' cognitive abilities.

In the chapter "Necessity to review the content of general scientific and general engineering disciplines" [11] the lagging of basic assumption from the modern practice, particularly in student design-engineering training is pointed out. In work [12] it is noted that in the existing education standards the matrix of specialist competence correspondence to the sections of training material is based on initial disciplinary structure of knowledge. But in the correspondence matrix the competences themselves are developed randomly, without task-oriented and consistent organization of the academic process. The author suggests abandoning the correspondence matrix and taking activity-based logic of academic process organization as a basis for the educational content. One can also notice that the division of competences and development of interdisciplinary modules accepted in standards increase the degree of randomness in the content and organization of academic process itself.

The division of basic assumptions on mechanisms and machines into definite disciplines leads to the fact that the **conceptual framework** of the branch has not formed yet. It means that the **subject** of academic process in machine tool industry has not been defined as an integrated whole and there is no integrated model of mechanism at present. In these conditions a student is given a chance to grow an integrated "tree" of assumption in the profession [1]. That task was not coped with by the whole branch science in machine-tool industry up to the moment.

In such circumstances, it is obvious that one needs to return to the beginning of science and review the basic assumptions on **an object** in the branch from the point of view of modern opportunities for its determination. In this case, the primary target of reorganization in professional academic process can be considered the development of the modern mechanism model. General necessity of new reality model development more corresponding to the potentials of modern cognitive and information technologies is underlined in the science about information, i.e. informatics [13].

The task of integrated mechanism model development is described in [14]. As a result of research, a functional-structural (system) model of mechanism is proposed, and, on its basis, a scheme of academic process of a fundamental course "Principles of Mechanism Construction and Operation".

The functional-structural model deals with a mechanism as a system of contact chains of part interactions performing its functions. The main functional chain in mechanism connecting its input and output, as well as sequence of derived functional chains of different order, forms an integrated structure. Any chain or its link can be considered on the basis of models of different completeness: size, static, kinematic, dynamic, and stochastic. Besides, an integrated operating structure can be revealed as a "mechanism-part-surface" chain to determine the principle scheme of parts and surface operation in-situ. The idea of "mechanism-part-surface" chain is consistent with the concept of integrated error of mechanism accepted in [15].

Based on the accepted system mechanism model, the sections of training material on fundamental course are designed in accordance with structural groups of the system. Since the first days of study at university a student is suggested one practical research project of mechanism structure (using virtual prototypes, carton board models, 3D-images). Such an arrangement of training material provides a student with an opportunity to observe the field of professional knowledge in general event at the initial training stage. Besides, students are taught to define practical problems of the subsequent order.

In academic process the research in solids interactions in mechanisms can be added by the study in interactions of solids with liquids, gases, granular, etc. in machines in the framework of general structure. Such an addition allows the subsequent transition from mechanism model to more complicated machine model. The **process** of machine design and operation (construction and engineering design, production, testing, operation) is proposed to be studied in terms of the order of accepted real procedure. The stages and procedures of this process are to be forestalled by the necessary and sufficient theoretical justification. Such a parallel connection of theory and practice enables

ENGINEERING EDUCATION 17'2015

a deeper understanding the concept of procedures and intensification in the academic process.

The accepted system of assumptions allows a thorough structural analysis of mechanism, i.e. the links of any part surface with the surface of another part, and, above all, with the mechanism function. Today, such potentials in machine tool industry are estimated by some experts as redundant – in practice, this branch has developed a wide range of template solutions for design and engineering conditions. However, from the standpoint of knowledge arrangement and formalization as well as application of information technologies, the accepted assumptions provide significantly new opportunities in machine-tool practice. In particular, to justify the optimal standards of part size precision, the development of module technologies are based on template operational part structures and their surfaces, etc.

Mechanism functional-structural scheme can also serve as a basis for academic process improvement in machine-tool engineer training. The scheme of academic process suggested in [14] includes hands-on professional experience from the first day of study in university, not academic, but practical professional training and organic solutions of most problems in branch professional education: practice-oriented, problem-oriented, developing, advance training, and a number of other requirements for modern academic process.

The author is fully aware of the fact that actual system organization of the academic process requires involvement of many independent experts of different fields. First of all, it is necessary to discuss potentials and versions of suggested model in the professional community involved in the academic process. In the author's opinion, such an appropriate community, can include university teaching staff attending upgrading courses. The advantage of such an "educational board" is the involvement of a wide range of experienced professionals and their qualified view on the problem. Relative independence of teachers-researchers from their management and dictation of authorities is also of great importance. Taking into account amended corrections and comments it will be possible to arrange the academic process for several pilot groups within the leading universities of the country at the initial stage of transformations.

Therefore, it can be concluded that

- The key problem at the modern stage of professional education reforms in the machine-tool industry is to define a subject of academic process in the branch – development of modern system mechanism model.
- Probable system organization of academic process can serve as a basis for the solution of most mentioned problems of reforming professional education in the branch (at all its levels).
- Quality of basic object model in the branch is associated with the opportunities in the of information technologies in the branch, ecology of knowledge, as well as saving students' and working specialists' intellectual labor.

REFERENCES

1. Karyakin Yu.V. On coming fundamental transformation of future image of national education // Alma-mater. – 2014. – № 1. – P. 28-31.
2. Saprykin D.L. Engineering education in Russia: history, concepts, perspectives // Vyssheye obrazovaniye v Rossii. – 2012. – № 1. – P. 125-137.
3. Vodop'yanova Ye. et al. The other science. Order of innovative society // Svobodnaya mysl'. – 2007. – № 4. – P. 126-140.
4. Ovchinnikov G.K. On the question of strategy in higher education dvelopment // Alma-mater. – 2013. – № 1, P. 13-14.
5. HPE FSES in major "Construction-engineering supply of machine-building production". Bachelor degree. № 151900.
6. Movnin M.S. Bases of engineering mechanics: Textbook / 6-th edition. – Saint-Petersburg: Polytechnika. – 2013. – 286 p.
7. Volosukhin V.A. et al. Engineering mechanics: Manual. Moscow: RIOR: INFRA-M, 2011. – 384 p.
8. Dimov Yu.V. Metrology, standardization and certification: Textbook. 4th edition. Standard of the third generation. – Saint-Petersburg: Piter, 2013. – 496 p.
9. Gutyrya S.S. Development of the course "Machine parts" in the framework of modern machine-building problems // Proceedings of the All-Russian scientific-engineering conference "Machine science and machine parts". – Moscow: MSTU press, 2008. – P. 244-248.
10. Divisilov V.A. Synergism and transdisciplinary in education. Alma-mater. – 2013. – № 2. – P. 95-97.
11. Zubarev Yu.M. Modernization of machine-building depends on the specialists' training level // Vyssheye obrazovaniye segodnya. – 2011. – № 5. – P. 5-9.
12. Sosnin N.V. On the structure of education in competence model // Vyssheye obrazovaniye v Rossii. – 2013. – № 1. – P. 20-23.
13. Kolin K.K. Philosophy of information and fundamental problems of modern informatics // Alma mater. – 2010. – № 1. – P. 29-31.
14. Kapitonova K.A., Gurevich A.I. Structure of basic assumptions and content of professional education in machine-building industry // Research-methodical manual. – Rybinsk. – 2010. – 46 p. Electronic resource: [URL]: http: //web. snauka.ru / issues/2012/07/15822.
15. Kalashnikov N.A. Bases of theory of real mechanisms and their application in practice. – M. ЦНИИТМАШ, 1942. – 130 p.