TRAINING AND QUALIFICATION OF RUSSIAN PROFESSIONAL ENGINEERS

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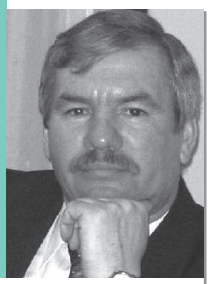
Only professional engineers can provide modernization of the national economy. These engineers should possess not only high professional skills but also the initiative, creative approach to decision making and high responsibility for the results of their engineering activity. In order to train such graduates the university programs have not only to meet the requirements of the Federal State Educational Standards but also increase it significantly in the field of orientated development of the graduates'competences under conditions of systematic interaction with employers to implement training competence model for future engineers. The socio-professional accreditation of such an educational programme, which is carried out in accordance with worldwide criteria, gives a graduate an opportunity to be licensed as a Professional Engineer at National or European Engineer Certification Centers.

Key words: professional engineer, educational program, accreditation requirements, professional standard, curriculum, oriented development, certification.



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What is a Professional Engineer?

To set up the discussion on the issues concerning professional engineer training and certification in Russia, it is essential to gain greater insight into the category of Professional Engineer, specifically to figure out what this concept means. In Soviet system of higher education, the graduates of technical institutions were awarded diplomas specifying their qualification as production engineer, design-engineer and mechanical engineer in any given industry. In other words, a soviet graduate was frequently termed by such slang expression of the time as "specialist with a diploma". In the meantime, the same graduates were categorized by manufacturing enterprises, which were the main 'consumers' of the soviet educational system, based on their level of knowledge and skills. At a later stage, they were qualified in accordance with their experience background and personal features; however, in most cases employee's qualification was strongly dependent on the presence of vacancies in the staffing pattern of an enterprise. Besides, some graduates were indeed engaged in so-called engineering work, i.e. design, construction and technology development, while the rest became the heads of manufacturing departments, engineering or economical services and even human resources department within two or three year period. As a rule, these engineers were to discharge carefully their typical duties in accordance with the job description or definite engineering task without considering the application of their ideas, as well as initiative and creative thinking. At the time the engineers were often called "performers" who were not encouraged to personal growth and showed no concern to the development of the company whose technical policy was restricted by definite ministerial special-purpose programs fulfilled through the strict obedience to the instructions of a chief engineer. It is obvious that such system, along with the absence of

competition, could hardly contribute to developing creative potential not only of a particular engineer but also of the whole enterprise. What actually happens is that the absence of the possibility of making independent engineering decisions as well as lack of interest in creativity results significantly decreased engineers' motivation for self-development, which in its turn became the reason for further degradation of an "Engineer's Degree".

The development of private ownership was manifested with the establishment of numerous small and medium-sized enterprises which also manufactured technical products. The implementation of various small-scale and large-scale engineering projects, as well as open competition in goods-producing and service industries prompted a greater demand for highly-qualified engineers capable of not only handling any technological problem but also working independently in project implementation or as a part of a team and what is more important it is the ability to assume responsibility for the results of their engineering activity. It is just this capability of working autonomously or as a part of a team, taking responsibility for any technological decision with due regard to the most contemporary engineering studies and up-to-date information technologies that makes the difference between "Professional engineer" and "Engineer-performer". Ability to create new analysis-based solutions, strong interpersonal skills and initiative, self-development and personal capabilities that form a foundation for effective work are the main characteristics of an employee, awarded the degree of "Professional Engineer". The requirements for training of "Engineers with diploma" were categorized as follows: knowledge, skills and experience. Today, in order to figure out the requirements for "Professional engineer" training, it would be useful to refer them at least to those described by Benjamin Bloom in his work "Taxonomy of Educational Objectives: the Classification of Educational Goals" (1956):

- knowledge – define, identify, reproduce;
- comprehension – interpret, distinguish, extend, explain;
- application – operate, apply, implement, relate;
- analysis – differentiate, characterize, comply;
- synthesis – generate, create, compile, reconstruct;
- evaluation – recheck, relate, control, test.

Although the above-mentioned competences and skills do not completely describe the "competence model" of a "professional engineer", however it is obvious that they differ significantly from the training requirements that were imposed on "engineers with diploma" in higher technical establishments. Besides, a "professional engineer" differs from an "engineer with diploma" by the relevant working experience and certificates awarded by various public and administrative professional establishments to prove a high level of an engineer's knowledge and skills.

As we have outlined with some degree of certainty the subject of our research, it is time to examine the following question: how and where a "professional engineer" could be trained? How and where a "professional engineer" could be certified?

What is known about "professional engineer" training and certification?

It is known that since the inception of the Bologna Process (2003) and up to the present day, i.e. the State Law on Education adopted by the State Duma, the higher educational policy in Russia is focused on the integration of higher educational establishments into education world community. By introducing the two-level educational system (Bachelor's degree and Master's degree), the Government of the Russian Federation makes it possible to divide Russian graduates into two groups in accordance with the foreign education system seeking the recognition of Russian diplomas

of higher professional education abroad. Without weighing in on the debate over the efficiency of such reforms and expending our time in sliding into reverie over Soviet higher educational system, we want to state that the employees in higher educational institutions and the leaders of engineering community should not only hold the current level of engineer training but also to improve it assuring the formation of the basic professional engineer's competences. Moreover, it is highly required to launch certification programs for engineers and as we are dealing with a "professional engineer" it is urgent to provide favorable conditions for encouraging the mobility of engineering graduates and professionals at international level.

It has long been known that there are various certification groups and associations for engineering education accreditation in European Union and the Washington Accord countries. Due to these professional certification groups, the certification process is accurately defined, the number of engineers is monitored and qualification requirements are constantly upgrading. The European Federation of National Engineering Association / Fédération Européenne d'Associations Nationales d'Ingénieurs that unites national engineering associations from 29 countries including Russia is one of the above-mentioned professional certification groups. In the United States, Accreditation Board for Engineering and Technology (ABET) is recognized as the worldwide leader in assuring quality and stimulating innovation in applied science, computing, engineering, and engineering technology education.

The European Network for Accreditation of Engineering Education (ENAEE) authorizes quality assurance and accreditation (engineering educational) agencies within the European Higher Education Area. Quality standards in engineering educational programs, which were developed by ENAEE the EUR-ACE Project, are universally acknowledged. The EUR-ACE standards being complied with the Standards and Guidelines for Quality Assurance for the Higher Education Area and developed by ENQA, are proved to be the standards for evaluating educational programs in the framework of the Bologna Process [1]. For registration as "European engineer", it is required to complete the educational program accredited in accordance with the EUR-ACE standards.

As for Togliatti State University, there are only three educational programs, i.e. Specialist degree programs in welding technology, mechanical engineering and industrial power supply, which have been accredited by RAEE in compliance with "EUR-ACE" international criteria. However, the transition to the two-level educational systems has prompted the necessity for a new accreditation of Bachelor's and Master's programs.

What problems should be solved in order to make a "professional engineer" training possible within Russian conditions?

The development of educational programs, both the Bachelor's and Master's degrees, is the first and the most important problem without considering business demand for such specialists. It can be explained by the fact that current educational program, on the one hand, could hardly comply with the suggested time limit and, on the other hand, does not correspond to the main purposes of an engineer training.

The Bachelor's and Master's program requirements presented in the 3rd generation of Russian State Educational Standards are fairly formal, while the suggested Bachelor's and Master's educational programs are just rough samples. Unfortunately, both mentioned documents could hardly be described as a conceptually new approach toward a "professional engineer" training. The structure and content of the 3rd generation of Russian State Educational Standards, concerning the Bachelor training degree, principally, did not change in any item, with the exception of the following fact – the

term "classroom hours" was changed into "credits", while "knowledge, skills and experience" into "competences". Structure requirements to the basic education programs remain the same, i.e. it includes the same following subject-blocks: humanitarian and socio-economic, mathematic natural science, scientific and professional. In other words, the situation is as follows: the economic society parameters have sharply changed; the volume of different processing information has drastically increased; and the requirements to the education process results have also changed, while the higher professional education model for future graduates, as well as educational programs and teaching quality assessment are still the same within the previous framework.

In all fairness it has to be added that there are also positive changes concerning the development of new professional educational programs that have been recently taking place in Russian scientific community. For example, the "Methodological Guidelines" [2] on educational program development in accordance with the Federal State Education Standards has been published where the draft of the overall structure of new educational program has been figured out. The authors point out (See "Methodological Guidelines", Chapter 2) that "the curriculum content of compulsory subject-blocks in overall educational programs is only partially regulated by the legislation bodies". And further: "The overall higher professional educational program that is to comply with the Federal State Education Standards within a definite specialization is developed in response to a number of fundamental factors. First and foremost, it is the logics of competence approach which is applied as the basis of the Federal State Education Standards concerning higher professional educational program and the implementation of which involves not only preservation of the current module-based structure but also the development of student-centered, integrated and multidisciplinary educational setting". It is obvious that a competence model of a graduate elaborated not only in accordance with the Federal State Education Requirements but also and mainly in compliance with the professional standard should serve as the basis for educational program development. Indeed, the analysis of the suggested draft of the general educational program discussed in Chapters 2 and 3 has shown that the basic characteristics of a graduate's professional work are related to the professional standard. However, even here the correction "if such characteristics exist" is introduced. In our opinion, the elaboration of the competence model of a graduate based only on the requirements of the Federal Sate Education Standards without considering professional standard requirements will lead to the development of the certainly obsolete educational programs. To prove this point of view, one can consider the following example: United Aircraft Corporation developed its own professional standard for graduates of a number of Russian Aviation Institutes. However, all educational programs failed to provide the achievement of clearly stated outcomes [3]. Besides, the obligation to consider a professional standard while developing the general educational program within a definite specialization must optimize the interaction between higher education and business communities, which in turn will definitely contribute to the economic development of the country. The encouraging thing is that there are also some changes in a professional standard development within the automobile production and manufacturing. A number of seminars were organized and held in 2011 under the auspices of the Ministry of Industry and Trade. The representatives of higher education and business communities were involved in the discussion aimed to figure out standard requirements toward professional activity and engineer qualifications in Russian automobile production and manufacturing.

As for other accompanying documents of the general educational program, they are also undergoing

some of the changes which, however, are deeply rooted into the content and structure of the previous educational programs. For example, a curriculum is suggested to be of two types. The first is competence-based curriculum which is focused on the correlation of all graduate professional requirements, i.e. competencies, with the courses and subjects being taught in a definite time sequence. In other words, competence-based curriculum (definite disciplines, courses, vacation training) is focused on the outcomes (competencies) that are linked to workforce needs, as defined by employers and the profession. This type of curriculum forms an innovative statement in higher professional education in that it allows a competence model to be integrated into education even better than before. The second type is a traditional time-based curriculum within which training is understood as a series of subject-block rotation (humanitarian, social and economic, mathematical, professional blocks as well as natural science) with the idea that a student acquires this or that competency from each one at a different time period.

Unfortunately, the overall structure of the proposed educational program draft developed in compliance with the Federal State Education Standards is divided into paragraphs (See "criteria" as State Accreditation of general educational program is carried out in accordance with criteria) which, though resembling the international criteria developed within EUR-ACE Project, are significantly different from them.

In the meantime, there are definite criteria and technologies being well-known both in Europe, and Russia which are intended for the development of educational programs and curricula considering the needs of professional community (competence model), learning result assessment and training arrangement. These criteria have been developed by Russian Association for Engineering Education (RAEE) and they can be easily correlated with the accreditation program requirements within ENAEE framework standards (ABET Criteria 2000).

We intentionally provide here again the accreditation criteria developed for the quality assessment of educational programs and a well-known dual-mode process of educational program development as it is just these documents a general educational program should comply with (Fig.1) [4].

Notes:

1 – requirements set by the parties concerned;

2 – developing objectives of educational program;

3 – insurance of target attainment;

4 – determination of learning objectives and attainment targets;

5 – developing implementation strategy for learning target attainment;

6 – developing a strategy for learning outcome assessment;

7 –determination of result achievement indicators;

8 – learning process development.

More detailed step-by-step procedure of a new educational program design in accordance with RAEE criteria and various stages of development, i.e. organizational, preliminary and basic, is described in the works of A.I. Chuchalin and V.V. Eltsov [4,5].

A further variant of engineering education program design (Fig.2) which also considers FEANI –ENAEE criteria and corresponds to the above-mentioned scheme is discussed in the work of E.D. Alisultanova [6].

Both ABET dual-mode model and the process of educational program development presented in Fig 2 involve almost the same stages with only differences occurring in titles. For example, the 4th stage of both mentioned models implies the development of a graduate's competence model. The 8th (Fig. 1) and the 7th (Fig.2) stages are considered to be the most important in the development of educational program within higher professional establishment framework. The 8th stage implies the

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Fig.1. Fundamentals of New Educational Program Development Based on ABET Dual-Mode process (model).

1 – educational program objectives;
2 – educational program content;
3 – students and learning process;
4 – higher-education teaching personnel;
5 – focus on job performance;
6 – material and technical facilities;
7 – information and analytical support;
8 – finance and management;
9 – alumni.

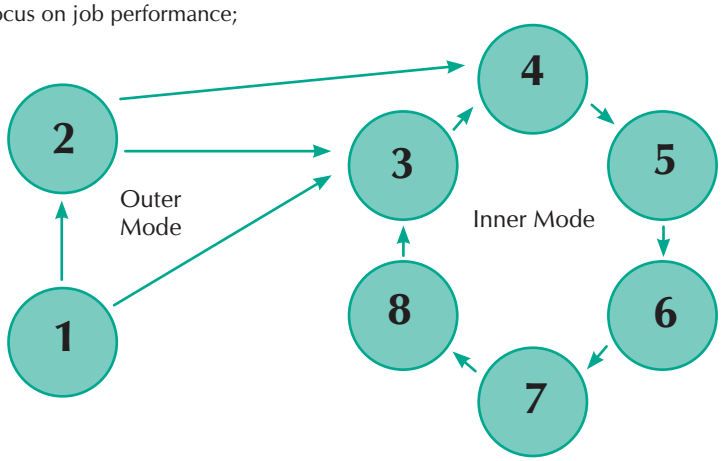
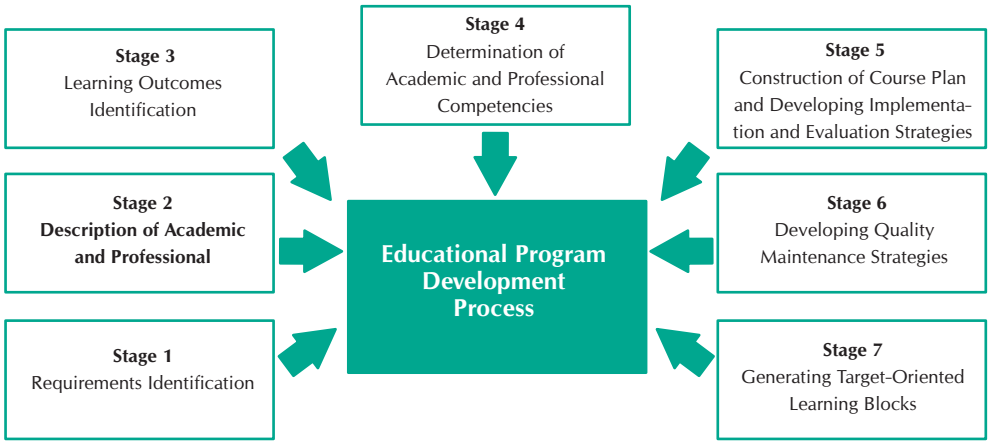


Fig.2. New Educational Program Development Process



arrangement of a learning environment in such a way that curriculum development becomes the most essential step, while the 7th stage of the second model is directly concerned with generating target-oriented learning blocks.

The achievement of this or those learning outcomes, which quality directly influences the formation of professional engineer's competencies, depends to a large extent on the curriculum structure and content. Therefore, the main task in arranging new educational environment is to develop such curricula or learning plans with the help of which it would be possible to create educational experiences in a variety of formats and tailored for the specific competency of a graduate.

However, this is far from being the case, as even well-distinguished and highly-regarded scholars still recommend in their works to apply the traditional time-based curriculum where

subjects being taught are categorized as humanitarian, social and economic, scientific, mathematical or professional blocks. The subjects are taught in a definite time sequence as before without considering the formation of this or that graduate's competency. It can be stated that a new type of curriculum, i.e. competence-based curriculum, should be recommended for so-called "advanced" university clusters [2].

Above all, the curriculum itself is developed not on the basis of a competence model elaborated in compliance with employer's requirements but as a series of subjects with some being defined as electives to create an allusion of target-oriented learning. The most forward-minded heads of the departments who are also one of the educational program developers try to introduce some definite subjects or courses into the curriculum, which would, in their opinion (influenced or not by an employer's needs), contribute to the development of a stated or required competency. All this could hardly contribute to the achievement of the main objective, i.e. a professional engineer training. It can be explained by the following reasons:

1. Curriculum is not developed in accordance with a graduate's competence model designed in compliance with employer's professional requirements;
2. Curriculum structure does not contribute to the development of the required competencies.

In order to move from the traditional time-based education toward a competency-based one aimed at achieving clearly stated competencies, a curriculum structure should include various learning units and modules with each module being linked to a definite competency acquisition within a graduate's competence model. A module is a learning segment with a specified educational or training purpose including a set of courses or subjects aimed at achieving required competencies. In this case, it is possible to develop learning modules not only based on already existing subjects but also involving absolutely new ones which have never been taught before but very essential for a successful competence model implementation. In addition to, once the "database of learning modules" is created, it is possible to modify learning process depending on the required outcomes. Besides, it should be noted that as almost all foreign universities apply module-based curricula, a certain degree of conformity and harmonization can be observed between Russian and foreign educational programs. The example of module-based curriculum development within a definite Bachelor's degree program is provided in our works "Bachelor's Educational Program Development Process Based on Competency-Based Approach" [7] and "Engineering Educational Program Development Process for Innovation-Oriented Specialists" [8].

The second problem to be solved within a professional engineer training is the problem of educational program accreditation.

Within the framework of higher professional education, state accreditation is closely connected with the State Educational Standards of Higher Professional Education in the Russian Federation, which prescribe the minimum requirements concerning curriculum content and graduates' training level within a definite program or degree. As for Europe, there are no any State Educational Standards, except for Germany. Therefore, evaluation of university performance in Russia significantly differs from that abroad. In Russia, State Educational Standards serve as the basis for outlining general educational environment and facilitating student academic mobility. As Russian Higher Professional Educational System is focused on the to integration to the All-European higher education environment, State Educational Standards of Higher Professional Education must be considered as just so-called "frames" within which universities can independently develop educational programs

depending on the peculiarities of the region. Besides, these "frames" must not set the limits in correlation of Russian and foreign higher education curricula. Therefore, both Russian and European accreditation systems of engineering educational programs must be accorded with the national accreditation agencies working within concerted standards. It is obvious that the criteria and methods applied in these accreditation agencies must be set out within "EUR-ACE" framework. In this case, if accreditation is carried out by one of the EUR-ACE-authorized agencies, it can be qualified as European "EUR-ACE" accreditation. Professional accreditation in engineering education offered by RAEE Accreditation Center is the most prominent example.

The third problem concerns the qualifications of engineering graduates within first cycle and second cycle degrees.

This problem is critical not only for Russian Higher Professional Education but also for the representatives of engineering companies, i.e. any employer who is a potential "consumer" of a graduate. It is obvious that the problem could be solved only by a concerted effort of academic and professional communities. Detailed requirements for various state and private businesses have been set out in the Recommendation to the Parliament Proceedings "Contemporary Engineering Education as an Integral Part of Technological Modernization of Russia" held in the Committee of the Council of the Russian Federation on 13th May, 2010. The main issue of the proceedings was as follows: "It is necessary to discuss with the representatives of the professional communities the possibility of establishing regional centers providing professional qualification certification". As the result, Russian Center of Certification and Registration of APEC Professional Engineers was established in 2010 upon an initiative of Russian Union of Scientific and Engineering Organizations and RAEE agreement.

As a response to these events, a series of seminars and conferences uniting academic representatives and engineers of the above-mentioned automobile production and manufacturing was organized by the Ministry of Industry and Trade in 2011. We cannot but hope that the same changes will take place in other industries, which in turn will contribute to the development of competence models (professional standards) within the two-level education system and prompt the Ministry of Education and Science of the Russian Federation to develop new educational standards considering Parliament proceedings and competence models (Fig.3).

Special attention should be given to the fact that the Recommendations to the Parliament Proceedings were prepared in May, 2012. Therefore, we are dealing not with the 3rd generation of Russian State Educational Standards, but with the standards "...aimed at facilitating graduate job performance...".

Thus, it can be stated that the problem of engineering graduate qualification within first cycle and second cycle degrees, as well as acquiring qualifications of "Professional Engineer" or "European Engineer" is still to be solved. In the meantime, this problem is already a stumble block in the modernization of Russia's economy, announced by the President and the Government of the Russian Federation. There are already many examples of this. Many foreign companies which are involved in the implementation of any technical project in Russia have no rights in accordance with the regulative documents to recruit Russian engineers to the leading positions as they have no qualification of a "Professional Engineer". To solve the problem, the companies have to invite European engineers for extra charge. Such situation which can be termed as "second-rate" could hardly contribute to the development of either Russia's economy, or engineering community.

Conclusions.

1. Training and Qualification of Russian Professional Engineer is an integral part of the modernization of Russia's economy.

2. The current engineering educational programs, including those developed in accordance with the 3rd generation of Russian State Educational Standards do not completely correspond to the quality requirements of "Professional Engineer" training.

3. State accreditation system does not provide Russian engineers with the required conditions to be qualified as "European Engineer" (Professional Engineer").

4. New educational program developed in accordance with international "EUR-ACE" quality criteria and including outcomes-oriented and module-based curriculum with further accreditation by the public professional agency is the main condition for Russian engineering graduates being qualified as a "Professional Engineer" ("European Engineer").

Рис. 3. Text passage from recommendations of parliament proceedings (Council of the Russian Federation in Education and Science

3. Министерству образования и науки Российской Федерации:

1. Обеспечить разработку и введение в действие федеральных государственных образовательных стандартов профессионального образования, ориентированных на формирование готовности выпускника к профессиональной деятельности и обеспечивающих повышение свободы образовательного учреждения в формировании образовательных программ с учетом запроса реального сектора экономики.

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