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Engineering Education and Engineering in Russia: Problems and Solutions

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The article analyzes the global challenges that influence Russian engineering education and engineering in general. The information on current situation of engineering education and engineering in Russia provided by the experts of the Russian Association for Engineering Education is presented. The authors suggest measures that can contribute to positive changes in Russian engineering education and engineering.

Key words: *engineering education, engineering industry, Engineering Education Doctrine, international accreditation of educational programs, certification of engineering qualifications.*

The Russian engineering education has a 300-year history and is rich in traditions. Since the times of Peter I who established the School of Mathematics and Navigation Sciences and to our days the traditional Russian engineering education system has been developing and has become more entrenched. These traditions were based not only on the Russian mentality (curiosity, inborn wit, determination to achieve desired results, willingness and talent "never do things by halves"), but also on the government support in questions of engineering education.

The impact of engineering education on the country's economic development, level of population engineering and technological culture and provision of its economic and process safety are crucial. The dramatic proof of which can be highlighted in the events of the past 100-150 years: development of domestic aircraft engineering, exploration and development of mineral deposits and mineral resources (especially Siberia), electrohydraulic power development, atomic power engineering, space development and so on and so on. This would have been impossible without such talented graduates of Russian higher technical education institutions as N.E. Zhukovski, S.P. Korolev, N.A. Dolezhal, M.K. Korovin, I.V. Kurchatov, M.L. Mil, A.P. Tupolev, N.I. Kamov, V.N. Schukin, N.V. Nikitin and millions and millions of rank-and-file engineers who were involved in the design, production and operation & maintenance of that unlimited diversity of equipment, facilities and technology, and who concentrated in one's hands all the profound engineering ideas and brilliant engineering problem-solving.

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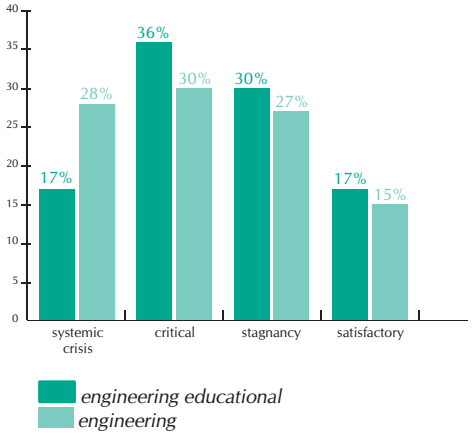
Unfortunately, it should be noted that, in the period of new Russian history, there are new tendencies indicating the breakaway of professional communities and governmental authorities from the age-old traditions of Russian engineering education. The whys of it are in the untoward response of this or that side to external environment challenges of communities and authorities. During the last few years, Russian engineering education has been stumbling over a wide range of challenges, both global and domestic, the most urgent of which are the following:

- Adoption of specialist training in accordance with the principles of the Bologna Declaration.
- WTO accession of Russia, competitiveness within the global engineering labour market; a sharp decline in the prestige of engineering professions and engineering activities.
- Lack of general qualification requirements for specialist in the engineering and technology domain, professional standards embracing the adoption of level-program training of specialists.
- Controversy between previous specialist training system and modern employer's requirements to engineer- graduates; between aging infrastructure and human resources.
- Limited number of modern-equipped enterprises providing high-quality internship of future engineers and university faculty staff.

The result pattern of engineering activities in Russia is characterized by universal and rapid replacement process of domestic engineering development to imported engineering development. The activity results of Russian engineers are in less and less demand within one's own country. During the last 10-15 years, most consumer goods, machinery, equipment and hi-technology used in Russia have been imported, including computers, mobile – satellite-conventional telephones, televisions, fridges, washing-machines, automobiles, medical equipment, high-accuracy machines, boat engines, civil planes and others. The fact is that many Russian engineers, living and working abroad, have been involved in various engineering development projects, and, this of course, "warms our soul", but it neither stabilizes the situation nor adjusts present working conditions to the revolutionary changes in engineering in Russia.

According to the data of the Association of Engineering Education in Russia and based on the results of expert seminars in 2011-1012 [1], the status of engineering in Russia is the following: systemic crisis- 28 %, critical - 30%, stagnancy - 27% and only 15% -satisfactory. Analogous situation concerns the engineering education in Russia.

Moreover, strange as it may be, the majority of experts evaluate the



training level of domestic engineers as rather satisfactory.

The experts distinguished the following factors to evaluate the status of engineering in Russia:

- fraction of high-tech and innovative engineering products in the Russian export structure;
- demand of Russian engineers in the domestic industrial sector;

- rank of Russian engineering development projects in the international top list of engineering solutions;
- fraction of Russian engineers, certified to international engineering requirements;
- fraction of engineering product import;
- scope of patent engineering solutions;
- "brain-drain";
- social position of an engineer.

Failure of relevant and prompt response to global challenges resulted in the existing critical situation of domestic engineering education. To a certain extent, this is the result of the crisis in the domestic engineering itself, i.e. those products acquired through different engineering activities- projects, technology, facilities, machinery, devices, equipment and their operation and maintenance.

Factors conforming to today's society demand in engineering activities are classified as general and specific.

The first general factor includes the lack of appropriate conducted systemic analysis of the engineering situation itself. In this case, the transition process of the country to imported techniques and technology and their mass production developed unnoticed. Consequently, this resulted in the further training of engineer-graduates (more than 200 thousand engineers annually) in accordance to previous standards and/or updated standards which do not even guarantee professional training of these engineer-graduates to existing market economy. Therefore, deprivation within the competitive market of engineering solutions and engineering products, low level of technological culture administering huge economic losses due to failure of high-cost engineering equipment, and even, tragic consequences for the people which, in its turn, could have been promoted by changes in the school education system itself and prestige decline of engineering professions within the society.

Another factor is the so-called non-systemic, inappropriate and untimely measures initiated by line agencies in response to external environment challenges and changing conditions. Thus, after signing the Bologna Declaration in 2003 and transition to level-program training in engineering and technology, no actions were conducted to regulate the activities of Bachelor, Master graduates of technical universities. If previously, enterprise employers knew how to employ engineer-graduates, now they realized that they are not ready to employ today's graduate with a Bachelor and/or Master degree. Moreover, according to the opinion of different representatives from the industrial sector and even within the university community, such Bachelor and / or Master degree graduates are considered to be "untaught engineers". This fact promoted a further prestige enhancement of engineering professions within the society. Those professional standards for Bachelor and/or Master graduate education programs are being only now developed, i.e. in 2012 [2,3]!

Transition to training Bachelor and Master Graduates for the engineering domain is connected with the possible risk of losing the Russian engineering corps. The retardation of adopting laws in engineering profession and engineering certification hinder the further provision of essential regulatory acts for engineering activities. The existing system of organizing the engineering corps through certification of professional engineers in developed countries is very simple and comprehensible. The introduction of a national register of professional engineers in every country warrants the existence, maintenance and development of the engineering corps. Base for developing the engineering corps in these countries includes the Bachelor and Master community, trained in accordance to the requirements of labour market.

Lack of effective incentives of orientated and consolidated interaction between education, research and production infrastructure and communities significantly decreases the scientific provision level of engineering activities. Engineering firms established within state corporations are weakly bond with universities and research centers of state academies (RAS, RA, MS and others). In this case, many domestic concepts and engineering projects are frequently of high-demand abroad, but in Russia.

Lack of R&D centers and R&D institutes that existed once in the Soviet period significantly reduces the engineering activity performance.

One of the specific factors - the lack of human resources for engineering activities- is the conventionalism of existing university education communities, its inflexibility to the external environment challenges, tendency to retain passive education methods, deliberation in rejecting orientated education technologies.

An excellent illustration of this could be those facts of delayed affiliation of Russian engineering universities to CDIO, implementation of practical courses and technologies to shape creative and systematic engineering mentality, entrepreneurial competencies, ethical norms, ecological outlook, etc. This, in its turn, generates fallibility of self-conception, quality evaluation and inconsistency of the level of specialist training for different engineering activities. For example, 59% AEER experts, 80% of which are representatives of research communities, acknowledged that the training level of today's engineers is satisfactory, 25%- good and 2%- excellent. It should be mentioned that 83% of the experts stated that the state of engineering in Russia is unsatisfactory. In other words, the engineers are well-qualified, but the paradox is that they work badly, irrelevant of any causes.

One should highlight the fact of weak research base in most domestic engineering universities, i.e. lack of updated research equipment, incompetent participation of instructors in the research domain, concentration of narrow topics, tenuous university collaboration (or none) with academic communities in Russia and global leading research-education centers.

In view of above-mentioned facts, the procedures in changing the situation within the engineering education system and engineering itself in Russia have been formulated as follows:

1. Develop and adopt National Engineering Education Doctrine in Russia as a strategic document, regulating the engineering resource development of Russia.

2. Design an international-recognized engineering accreditation system in Russia and institute national register of engineer-professionals.

3. Develop and implement measurement system to enhance prestige of engineering professions within the society.

4. Expand and elaborate experience of National Research Tomsk Polytechnic University in elite specialist training and professional teams of international standards within the framework of priority development areas in science, engineering and technology.

5. Initiate systemic measures to enhance engineering susceptibility and reduction of innovation antagonism of the society to provide successful engineering activities.

6. Stimulate the organization of temporary teams within universities, academic institutes, engineering firms and production companies implementing the following model "idea- product sales".

7. Develop and implement measurement system stimulating those teams producing competitive Russian trademark products for global market.

8. Take actions in reducing the bureaucratization level in education, research and engineering organizations, especially, reduction of regulation level of these institutions and

develop conditions for academic freedom.

9. Adopt law of engineering profession.

Proposals in the law development of RF "Engineering Profession" are as follows. List of sections:

1. Definition of engineering profession, engineer status in Russia, his/her rights and responsibilities, warrant of rights exercise, liability of infringement of rights and responsibilities.

2. Definition of engineering activities, types, implementation mode and provision.

3. Role of state, public-professional organizations within engineering activities in Russia; agencies for oversight and compliance monitoring.

4. Requirements to universities and curricula in engineer training; public- professional accreditation of engineering programs, its legal basis, acknowledgement of accreditation results by state agencies; preference of accredited universities and programs.

5. Engineering accreditation, accreditation agencies, requirements, procedures, documentation, status of these documents; involvement procedure of certified engineers in public-professional accreditation of engineering programs and evaluation of engineering university activities.

6. Projects, requiring the participation of certified engineers; types, implementation regulations and evaluation; involvement procedure of certified engineers, salary rate.

7. International cooperation within legislation domain and organization of engineering activities.

Potential of the Russian engineering education system is competent to enhance the quality of specialist training in engineering and technology and change the situation within the engineering domain. In December 2012 the Russian Conference "Approaches in Reshaping the National Engineering Education Doctrine in Russia" held in Tomsk confirmed this concept. Recommendations of conference representatives [4], in the event of their implementation, would promote Russian engineering universities in facilitating specialists and engineer-professional teams for those enterprises solving new targets in the country's industrialization.

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