Worldwide trends in the development of education and academic research, 15 - 18 June 2015

Integration of Universities and Industrial Enterprises as a Factor of Higher Vocational Education Development

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Abstract

The paper deals with integration of higher education institutions and machine building enterprises using the example of Petrozavodsk State University, Petrozavodskmash OJSC and AEM-technology OJSC. In development of such integration, an important part is played by the initiatives of the Russian Federation Government and the Russian Federation Ministry of education and science aimed at enhancement of innovative interaction of universities and industrial enterprises. It has been demonstrated that joint work of higher education institutions and industrial enterprises not only considerably raises the professional level of scientists, developers, pedagogues, postgraduate students of the university but also promotes higher quality and demand for professionals graduated by the university who are ready for efficient work in high-tech organizations of the real sector of the economy. Preconditions are created for the development of scientific research and innovation developments of young scientists and professionals, and the connection of academic and scientific process of the university with the production and commerce activity of the enterprise is consolidated.

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Keywords: high technology production; innovations; intellectual property; competencies; studying for master's degree; scientific research

1. Introduction

In innovation economy, the most important resource of economic entities is the intellectual property which cannot be implemented without the economic entity having an efficient system of formation, protection and
implementation of innovation developments based on intellectual property (Shegel'man, Kester & Vasil'ev, 2012). It is no mere chance that in the recent years there has been active search for approaches to forming and implementing the technological and non-technological innovations both in Russia and abroad.

With regard to this, an essential part is to be played by sharing knowledge and competencies between universities, scientific organizations and Russian machine building enterprises. For Russia, such sharing is of a special importance because disintegration processes accompanying the market transformation of Russian industry entailed liquidation of most organizations of branch science that used to be created for solving the applied scientific problems of industrial enterprises. As it is known, it is only during the time span from 1990 to 1995 that the quantity of engineering organizations reduced 2 times, that of design and design and exploration organizations – almost 2,9 times, and scientific and technical units at industrial enterprises – 1,4 times.

This resulted in a critical shortage of qualified engineering staff and the enterprises had to look for new performers of applied scientific and research work and development efforts (R&D). As the foreign institutes cannot fill the resulting gap due to significant differences in technologies, approaches, systems of technical standards, and the innovation breakthrough objective that the Russian industry is facing is virtually unattainable without the applied science, the state began to develop the scientific potential of Russian higher education institutions, following the experience of the West (Salmi, 2009; Creation of world-class universities is essential, 2008; Building World-Class Universities in China: From the View of National Strategies, 2012).

Under these conditions, the universities of Russia gain a special significance transforming into educational scientific and innovation structures (Voronin, Shegel'man & Shchukin, 2013), which is promoted by the initiatives of the Russian Federation Government and the Ministry of Education and Science of the Russian Federation aimed at enhancing the innovation interaction of universities with industrial enterprises. In particular, the main directions of the interaction are the following:

- fundamental and applied R&D jointly with or to orders of industry;
- forming and protecting of intellectual property by universities for its commercialization by industrial enterprises, as well as for increasing stability;
- joint developments of universities and industrial enterprises as their strategic partners with grant support from the RF Ministry of Education and Science according to Resolution of Government of the Russian Federation No. 218.

In interaction with industrial enterprises, universities have to undertake the function of generating technological and non-technological innovations, including the intellectual property, its protection and commercialization.

2. Objectives, methodology and research design

The goal of this work is to study and evaluate the influence of integration of universities and machine building enterprises on the development of higher vocational education – a case study of Petrozavodsk State University (PetrSU). The university has an impressive experience in the sphere of intellectual property formation and protection and cooperation with machine building enterprises, IT-companies and engineering structures.

Such integration experience was obtained by PetrSU during implementation of two comprehensive projects.

The first project "Creation of resource saving production of environmentally friendly transport and packaging set for transporting and storage of spent nuclear fuel" was brought to life jointly with open-type joint-stock company "Petrozavodskmash" (2010-2012) within implementation of Resolution of Government of the Russian Federation No. 218 dated 09.04.2010 "On measures of state support for the development of cooperation among Russian higher education institutions and organizations implementing integrated projects of creating high-technology production".

The practical significance of the results obtained consists in creating in Russia a competitive production of an extra capacity transport and package container for transporting and temporary storage of spent nuclear fuel, with subsequent manufacturing and supplying of them to enterprises-consumers, as well as in enhancing the environmental safety of transport and package containers, entrance of Russian machine building enterprise, Petrozavodskmash OJSC, with its competitive products to the international market (Shegelman, Romanov, Vasiliev & Shchukin).

The second project was "Creation of high-technology production of gate and wedge stamp and welded valves for
enterprises of nuclear, heat power industry and oil and gas industry using nanostructured protective coating”. The project was initiated by "Engineering company "AEM-technology" OJSC, the head contractor being the Federal state budget-funded educational institution of higher vocational education "Petrozavodsk State University“ (PetrSU). The project was aimed at mastering the production of pipeline accessories for ensuring the development of the system of major pipeline transport, of nuclear power industry of the Russian Federation and the complete meeting of needs in gate and wedge stamp and welded valves in the domestic market of heat power plants (HPP) and nuclear power plants (NPP), as well as at export supplies. The project was implemented proceeding from the use of advanced modern branch technologies ensuring a high level of reliability, industrial and environmental safety.

We put forward the following hypothesis: joint integration activity of the university, an industrial enterprise and an engineering company produces a noticeable effect on enhancement of educational activity level at the university, higher quality of knowledge and competencies of both teachers and students, and better readiness of students to practical activity.

The methodologies implemented involved evaluating the efficiency of engaging the professors and teachers of PetrSU, young scientists and students in performance of the projects.

The analysis has shown that when performing comprehensive projects as a result of integration of the machine building enterprise and the university, the staff of PetrSU possessing profound theoretical knowledge got an opportunity to apply them in practice. An important result consists in enabling the university teachers to take a glance at the level of knowledge and competencies obtained by students during their study at the university, to reveal strong and weak sides in the students training. The other important result is that both professionals and management of the machine building enterprise have gained the opportunity to influence the students training process and select their potential employees from the number of the most promising students.

We also evaluated the influence of the university, machine building enterprise and engineering company integration processes on obtaining of competencies and knowledge for forming the new patentable objects of intellectual property.

Research has confirmed our hypothesis of efficiency of such influence on the quality and level of the students' obtaining knowledge and competencies. In particular, within the first project, over 10 new intellectual property objects were created, seven of which were handed over under an exclusive license to Petrozavodskmash OJSC. Within the second project, jointly with AEM-technology OJSC, two new technical solutions were patented, and nine patent requests more were submitted in relation to inventions and useful models that are currently under consideration at the Federal Institute of Industrial Property (FIPS) – an organization dealing with registering and issuing patents within Russia. Importantly, it is using the experience obtained during performance of the projects that the university pedagogues adjusted the work programs of academic disciplines as appropriate. Of no little interest is their greater focus on students' obtaining knowledge and competencies in order to increase their being in demand at the labor market.

3. Discussion of the research outcomes

The joint creative team of PetrSU scientists and AEM-technology OJSC professionals are active in the sphere of nuclear power industry aiming their efforts at creating innovation technical solutions in ensuring the environmental safety when creating the industrial objects in the industry.

The joint developments with AEM-technology OJSC belong to the direction approved as the priority one by the Russian Federation Presidential Commission on upgrade and technological development of economy of Russia. This work not only considerably enhances the professional level of scientists, developers, pedagogues, postgraduate students of the university, but also promotes higher quality and demand for the professionals graduated by the university who are prepared for efficient work at high-tech organizations of the real sector of the economy. Preconditions are created for development of scientific research and innovation developments of the young scientists and professionals, the connection of academic and scientific process of the university with the production and commercial activity of the enterprise is consolidated.

During the project implementation, system distance seminars and review sessions are conducted in development of large size shutoff valves for NPP, HPP and major pipelines with participation of AEM-technology OJSC and
Brainstorms are conducted involving professionals from the production and scientific workers of PetrSU for search of solutions for scientific and technical problems arising during development of new equipment. Among the problems under consideration, special attention is paid to ones of emergence of corrosion, ensuring the reliability of operation, preventing the emergencies and ensuring of the equipment operability in emergency conditions.

The results of the project were presented at all-Russian and international exhibitions-conferences. For instance, the results of this comprehensive project performed jointly with AEM-technology OJSC were presented at VUZPROMEXPO 2014 exhibition in Moscow. At the same time, the project results were reported at republic-scale scientific and practical conferences "Problem-oriented research: theory and practice" (2014), as well as "Boundary region: science and innovations" (2014).

Jointly with AEM-technology OJSC, the comprehensive project was presented at the production site of Petrozavodskmash OJSC to vice-prime minister of Government of the Russian Federation, D.O. Rogozin, in October 2014.

The interaction is up in implementation of intellectual property at production sites of AEM-technology OJSC. So, in the current accounting period, 6 license contracts were registered in Federal Intellectual Property, Patent and Trademark Service under which AEM-technology OJSC receives exclusive rights for the results of intellectual activity created by the staff of PetrSU.

Moreover, within the cooperation with AEM-technology OJSC and Petrozavodskmash OJSC and the branch of chair of the National Research Nuclear University "Moscow Engineering and Physics Institute", a master class was given in the area of development and protection of intellectual activity results.

PetrSU interacting with machine building enterprises, with Petrozavodskmash OJSC and AEM-technology OJSC in particular, broadens the opportunities of the university in conducting experiments, practical classes for students and opens up new ways for joint R&D efforts in adjacent areas, thus ensuring the innovation activity and implementation of their projects on major production sites of the enterprises. The professionals of the enterprises obtain an opportunity to influence the academic process for selecting the professional staff required for the enterprise.

It is important that such cooperation promotes higher qualification of staff of PetrSU as well as the degree of preparation of its graduates, intensification of development of new intellectual property objects. So, for instance, in 2014, when working on technical solutions ensuring lower impact of mechanic action on the surface of the valve in stamp and welded gate valves in opening and closing, the problem of mechanic action on the surface of the valve in stamp and welded gate valves in opening and closing was analyzed, the direction of developing the technical solutions was selected and backed up, and variants of technical solutions were developed.

It has been found that the main ways of reducing the wear of sealing surfaces "valve-saddle" of the gate valve are: reducing the friction force between the rubbing surfaces by supplying the grease in the area of friction of the coupled surfaces "valve-saddle", reducing the friction force between the rubbing surfaces due to smaller force of pressing of the gate valve to its saddle during progressive motion of the gate valve conditioned by one-side action of pressure on the part of working medium flow, and higher wear resistance of contacting working surfaces due to selection of the material and technological process of their manufacturing. To counteract high wear of sealing surfaces of the valve and the saddle, nine promising intellectual property objects were developed and described in detail that ensure reduced mechanical impact on the gate valve surface in stamp and welded gate valves during opening and closing. The structures of technical solutions feature novelty and are distinguished by the possibility of being made in metal in machine building enterprises of Russia. Patent requests were submitted for the new intellectual property objects to the Federal Intellectual Property, Patent and Trademark Service of the Russian Federation.

Joint activity of the higher education institution and a large Russian machine building enterprise is conducted under the Agreement on strategic partnership between Petrozavodskmash OJSC and PetrSU in the areas of education, science and innovations.

For fulfilling the Agreement, Petrozavodskmash OJSC and PetrSU have taken the following steps. Coordination board for development of prospective and annual plans of joint work, analysis of results of the joint work has been created. Actions in career guidance and awareness-building work with students are coordinated and employment of
the higher education institution graduates is promoted. Youth engineering department has been created along the profile of work of Petrozavodskmash OJSC, with performance of initiative projects and works on orders of Petrozavodskmash OJSC, diploma and course papers, as well as dissertation studies, production practices for students being provided for on the basis of the department. The expedition of launching new specialties in PetrSU to cover the needs of Petrozavodskmash OJSC is under consideration. The target audience of students in the profile of activity of OJSC is being formed and measures for supporting the branch of PetrSU chair created at Petrozavodskmash OJSC are being determined. Career guidance for students and schoolchildren on the profile of work of Petrozavodskmash OJSC is conducted and young professionals, graduates of PetrSU, are selected for work at Petrozavodskmash OJSC. There is a day of "Petrozavodskmash at PetrSU" event. Joint applied R&D are conducted, preconditions for development of scientific research of the young scientists and professionals are created, and the connection of academic and scientific process of PetrSU with the production and commercial activity of Petrozavodskmash OJSC is consolidated, and so on.

Meanwhile, Petrozavodskmash OJSC has undertaken to forecast needs in engineering and technical personnel for the purposes of the enterprise and to make up requests for PetrSU to prepare certain specialties staff on this basis, to annually arrange a contest for 3 and 4 year students of PetrSU for selected the talented ones for their further preparation for work at Petrozavodskmash OJSC with a special scholarship fund allocated for them, to suggest relevant topics of diploma projects and master's works to PetrSU for the university students and to provide advisors for performance thereof, to promote high quality organization of practical classes and training during professional education of students and postgraduate students in the directions of work of Petrozavodskmash OJSC, to form the topics range of initiative and business contract R&D to be performed by PetrSU professionals, to participate in support of applications for grants of Russian and foreign foundations, contests etc. prepared by PetrSU according to directions of work of Petrozavodskmash OJSC, to ensure job placement for production and diploma practice of PetrSU students, conducting the R&D, to aid PetrSU in organization of excursions and laboratory classes in the units, to foster consolidation of the material base of PetrSU, including the creation of Youth engineering department, and to promote employment of students and graduates of PetrSU.

An example of efficient integration interaction of universities and machine building enterprises is also the project of development of master's degree program of the National Research Nuclear University "Moscow Engineering and Physics Institute" (NRNU Mephi) aimed at ensuring of training the staff for the nuclear industry. Within the project, several objectives are achieved at the same time, among them the integration of science and education, transfer of technological innovations into the production, development and implementation of new educational technologies, advance training of engineering staff of enterprises of the state corporation (SC) "Rosatom".

For achieving the objectives under the strategic partnership agreement between the machine building division of Rosatom SC – Atomenergomash OJSC and NRNU Mephi, chair No. 76 of "Power generation machine building" of NRNU Mephi was created based on the division enterprises, Machine building plant "ZiO-Podolsk" OJSC and Petrozavodskmash OJSC, in November 2011. The chair is a part of the Institute of Master's Studies of NRNU Mephi and prepares masters in the direction "Engineering and technological support of machine building productions" for the enterprises of Rosatom SC (currently, the workers of ZiO-Podolsk OJSC, Petrozavodskmash OJSC and Kursk nuclear power plant are studying for their master's degree).

The educational program suggested by the chair of NRNU Mephi is aimed at expansion of the basic preparation in both humanitarian and natural scientific knowledge and advanced vocational training in the area of power generation machine building enjoys a great popularity with the staff of the enterprises participating in the project.

This program allows studying for a profile master's degree on the job, in a training mode that takes into account the interests of enterprises as much as possible, at the basic industry one and at one of the leading universities of Russia. Within the program, one is free to choose a topic for one's master thesis paper directly related to solving complex practical problems within the sphere of vocational responsibilities of students.

Studying for master's degree takes two years with partial off-job training, using full-time intensive classes directly at NRNU Mephi, lectures and practical classes with teachers of NRNU Mephi on the premises of enterprises on a regular schedule in video conference communication mode, independent studying of the material, and personal consulting with a teacher via e-mail.

The current control of the academic progress is provided by such assessment means as defense of course projects,
online testing, business games, essays etc. The results of the term are drawn up by distance taking of credits and face-to-face exams.

2014 saw the awarding of diplomas to the first graduates of master's degree program – ten employees of enterprises taking part in the project. All topics of the master's thesis papers defended are relevant and have applied significance, being approved by heads of enterprise units where the masters work.

The successful experience of interactive teaching based at the chair of power industry machine building is expected to be used by NRNU MEPhI for teaching students of master's degree program at other basic chairs and at pre-master preparation programs. A further direction of this activity is engaging masters – employees of Petrozavodskmash OJSC – in implementing joint projects with MEPhI and PetrSU.

4. Conclusion

As a result of joint work of PetrSU with machine building enterprises, PetrSU students, postgraduate students and scientists obtain the unique experience of learning and working at the modern high-tech Russian enterprise and with its modern equipment. This allows broadening the opportunities of PetrSU in conducting experiments, practical classes for students and opens up new ways for joint R&D efforts in adjacent areas, thus ensuring the innovation activity and implementation of their projects at a large Russian machine building enterprise with subsequent commercialization of the projects. Joint scientific and practical research will result in creation of intellectual property with a high possibility of commercialization. Scientists and pedagogues of PetrSU engaged in R&D enhance their professional level gaining experience in advanced production while the professionals of Petrozavodskmash OJSC have obtained an opportunity to influence the academic process for selecting the professional staff required for the enterprise.

The objectives of intensive sharing knowledge and competencies, new knowledge and competencies formation cannot be achieved without organization change. With regard to this, massive access to databases of scientific and technical information is crucial, and, first of all, to databases of Russian and foreign patents, as well as systemic patent search, including one in grants of the RF Ministry of Education and Science. This access was provided owing to close interaction with the Federal Institute of Industrial Property (FIPS) under a contract with which the regional Technologies and innovations support center was created on the basis of the university. All this has allowed to organize high quality systemic patent search, including one in grants of the RF Ministry of Education and Science, etc.

The analysis performed has shown that the most important factors of organization change intensifying the formation and protection of intellectual property are the following: innovation atmosphere, training of staff and their mastery of methodology of resolving the inventor's problems, already formed scientific and innovation school, availability of a structure responsible for protection of intellectual property. Other important factors are participation in grants initiated by the RF Ministry of Education and Science (including ones performed under the Resolution of the Russian Federation Government No. 218), access to databases of Russian and foreign patents, accumulation of own databases proceeding from systemic patent search.

Among the crucial factors that ensure generating technological and non-technological innovations, their protection and commercialization in PetrSU, there are the formed innovation atmosphere and creation of innovation units of PetrSU. In the units, the most important place belongs to innovation and technical park (IT-park) of the university. Production sites in a number of machine building enterprises have been created and distributed according to areas. On the basis of PetrSU, regional representative office of the Foundation of support of smaller enterprises in scientific and technical sphere is active. Creation of new inventions, useful models, electronic resources (programs for PC and databases) and other intellectual property units are popularized, systemic work with inventors is conducted etc.

A significant factor is training of the university staff and students in methodology of inventor's problems solution and patenting skills. In order to achieve this objective, a new discipline "Protection of intellectual property" has been introduced into the academic process.

An essential factor of intensifying the invention activity is also the staff's mastery of the original methodology of functional and technological synthesis of patentable technological and technical solutions (Shegel'man, 2012).
It was the Federal Institute of Industrial Property (FIPS) that rendered considerable assistance to PetrSU in training in the sphere of intellectual property: with its support, a number of PetrSU employees completed distance learning courses at the Academy of the World intellectual property organization "Foundations of intellectual property".

No development of works in the sphere under analysis could be ensured without creation of a structure responsible for protection of intellectual property and manned with qualified staff. In PetrSU, it is the Department of protection of intellectual property and invention activity that has become a structure of this kind.

Acknowledgements

The work has been performed within the program of implementation of PetrSU strategic development for 2012-2016 and supported by the RF Ministry of education and science under contract No. 02.G25.31.0031 for implementing a comprehensive project "Creation of high-technology production of gate and wedge stamp and welded valves for enterprises of nuclear, heat power industry and oil and gas industry using nanostructured protective coating".

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