Experience of implementation in NRNU MEPhI of the education program focused on training of specialists for “Proryv” project

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Abstract. The educational program “Nuclear power technologies of new generation” was created at the National Research Nuclear University MEPhI with the goal of selecting talented youth and organizing targeted training for specialists for Rosatom’s strategic project “Proryv”. The “Proryv” project is dedicated to the development of technologies for the transition to a two-component structure of nuclear energy based on thermal and fast reactors with a closed nuclear fuel cycle. The article discusses the experience of implementing this training program at the National Research Nuclear University MEPhI, educational technologies, and statistics on student enrollment and graduation. The possibility of extending existing experience to other universities implementing similar training profiles is also shown.

1. Introduction
The academic department “Technologies of the closed nuclear fuel cycle” of the National Research Nuclear University MEPhI (NRNU MEPhI) was established in 2014 for implementation of magister training upon the principal educational program “Nuclear physics and technologies” in the discipline “Nuclear power technologies of new generation”. In course of development of the new technological platform for nuclear power industry, it is necessary to transfer the accumulated experience and sophistication to the rising generation. The education program should solve the problem of training the graduates who possess the whole body of knowledge, from neutron physics to economy of the closed nuclear fuel cycle (CNFC), i.e. have the idea of all processes which take place in CNFC and understand the general task and objective.

Today, after three graduates of magisters, we may summarize the first results of the education program implementation, the results of the gained experience transfer in Seversk Technological Institute of NRNU MEPhI (STI NRNU MEPhI), evaluate decisions taken at its creation and its possible further extension for training of the staff for “Proryv” project.

2. Experience in implementation of the education program in NRNU MEPhI (Moscow)
According to the standards for the training program “Nuclear physics and technologies”, the following is implemented in the education program: the core courses of NRNU MEPhI; the special courses corresponding to the education program specialization; advanced courses in the CNFC technologies. The core courses are the following: technical English, special chapters of advanced mathematics,
nuclear physics, scientific knowledge methodology. The special courses corresponding to the educational program specialization: neutron transport theory, scientific basis of nuclear power, radiochemistry, engineering analysis of nuclear power units. Among the special courses in CNFC technologies, there are: neutronics of fast neutron reactor cores and the closed nuclear fuel cycle, spent nuclear fuel reprocessing, fast nuclear reactors, nuclear fuel cycle economics.

Now, the education is based on the modular technology [1]. The principle of the method is that the whole educational process is divided into the separate modules which include one or several themes. The didactic task is set which monitors the degree of training “to know - to can - to possess” fully completing hereby the technological cycle of education. One module may include several disciplines, also one discipline may include several modules. The example of such implementation is given in figure 1. Thus, the discipline “Management of innovative projects” includes slightly interrelated modules. After learning of the module “Management of innovative projects in nuclear industry”, the students get acquainted with types of strategies and place of project in the business management, learn how to structure the project, to analyze risks and uncertainties, master job network planning, evaluation and cost control methods. At learning of the module “Intellectual property and intellectual rights management”, the students learn the main principles of intellectual rights management, learn how to perform the patent information retrieval. The modules are united into one discipline by the fact that all examples used by the teachers are referred to the best experience of the State Atomic Energy Corporation “Rosatom”. Unlike the example above, the module “Nuclear Reactor Physics” solves the problem of teaching neutron physics of nuclear reactors, conditions of reactor neutronics selection, physics of fuel reproduction and transmutation of actinides to the students. It was divided into two different disciplines, because the course “Neutron transport theory” has classic theoretical character, and the course “Fast neutron reactor core neutronics and closed nuclear fuel cycle” is directly relevant to the CNFC.

Figure 1. Examples of module technology implementation.
The most interesting and massive implementation of the module technology is the complex of disciplines “Radiochemistry and nuclear fuel cycle”. Cooperation with key employers is the most important element of the educational process. Usually, it is implemented through engagement of external part-timers to the student teaching and entering into contracts for performance of research activities, practices and graduate qualification works by the students on the industrial enterprises, as it is shown in figure 1. At that, evolution of the higher education standards is consistently leans towards even-greater incorporation of professional industry standards, employer demands. The Federal Law “Concerning education in the Russian Federation” [2] (No. 273 - ФЗ dated December 29, 2012) allows implementation of educational programs in the network mode. At that, the requirements to the education program are assured by the resource pool provided by the organizations involved in its implementation.

The effective implementation of the discipline module with the conventional name “Radiochemistry and nuclear fuel cycle” required to engage human as well as material resources of the partner organizations wherefore the corresponding contracts were made with the UCTR named after D.I. Mendeleev, ARSRICT JSC for network implementation of the education program.

As it is shown in figure 2, the discipline module is implemented within three semesters with increasing volume. The course “Radiochemistry” is given during the first semester in the UCTR named after D.I. Mendeleev; it is the levelling course for the magisters entered from different universities. The main purposes of the course are learning of the book knowledge by students in the area of the general and applied radiochemistry, transfer of skills of working with radioactive substances to the students. The knowledges gained by the students during learning of the course “Radiochemistry” are demanded further in the course “Radiochemistry (special chapters) which is also given on the base of the UCTR named after D.I. Mendeleev in the quantity of five class-room based hours per week including laboratory works. The course is aimed at learning of the theoretical basis of radionuclide concentration, extraction and separation procedures used both for environmental medium analysis and for analysis of process solutions and their products. At the third semester, the module “Radiochemistry and nuclear fuel cycle” is already given in two disciplines. The UCTR named after D.I. Mendeleev gives the course “Radioactive waste handling technologies”. Its main objective is to learn the basic principles of radioactive waste (RW) handling, production processes of RW immobilization, disposal methods. The course “Spent nuclear fuel reprocessing” is given by the leading specialists of ARSRICT JSC on the basis of this institution. The course objectives includes: learning of industrial implemented and advanced technologies of spent nuclear fuel (SNF) reprocessing; reprocessing characteristics of SNF produced by fast neutron reactors and thermal neutron reactors; insight into requirements to the final products of SNF reprocessing.

The skills learned during the first two semesters are developed during learning the course “Technology and equipment of the nuclear fuel cycle enterprises”. Currently, the course is organized in the following way. The students leave for Seversk CATU where they receive theoretical training six hours in a day during the first week in the Seversk Technological Institute of NRNU MEPhI. The second week is devoted to the introduction practical training in “Siberian Integrated Chemical Plant” JSC including visiting the radiochemical plant, the sublimation plant, the isotope separation plant, the industrial reactor and the chemical and metallurgical plant. Just at the site of the “Siberian Integrated Chemical Plant” JSC, the pilot and demonstration power supply package is under building consisting of the fast neutron reactor plant “BREST-OD-300” with near-by closed nuclear fuel cycle including production of uranium and plutonium nitride fuel (fuel fabrication) and also nuclear reprocessing with production of the secondary uranium and plutonium nitride fuel (fuel refabrication). The students may have a look at the construction progress and, currently, at the manufacturing technology of fuel and fuel assembly with nitride fuel. Hereafter, it is planned to transfer the course on the CLP4NET remote platform in the amount of 4 hours per week with a single-week intramural practical training in “Siberian Integrated Chemical Plant” JSC.
Figure 2. Example of implementation of the discipline module “Radiochemistry and nuclear fuel cycle”.

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The network form does not cancel entering into the contracts for organization of the student practical training on the enterprises and engagement of the teachers, external part-timers form the institutions involved in “Proryv” project. There are the following such institutions, besides the above mentioned, for the program “Nuclear power technologies of new generation”: State Atomic Energy Corporation ‘Rosatom’, “Proryv” ITCP PI, ARSRICT JSC, SICP JSC, LIPPE RF SSC JSC. The teachers from STI NRNU MEPhI (Seversk) and from IATE NRNU MEPhI (Obninsk) are involved for giving of separate courses on the basis of intra-network mobility.

Beginning from 21014, the enrollment was 10-13 people, the graduating class was 7-10 magisters. For the first time, the primary enrollment was the bachelors of NRNU MEPhI and the specialists working on the enterprises of State Atomic Energy Corporation ‘Rosatom’, but, with establishment of the education program, the enrollment geography changed a bit. The specialists are disappeared, the bachelors of NRNU MEPhI is about half of a group and the other students are the bachelors of other universities, for example, MPEI, PGSPRU, TPU.

The more interesting question is distribution of the students by the places of their graduate qualification works. The statistics for such distribution beginning from the enrollment of 2014 is given in the figure 3. The places of performance of research activity by the students is shown for the enrollment of 2017. It is apparent that all works were performed in favour of “Proryv” project in the first year of education program implementation, but the student distribution became more various just beginning from the second year. The statistics of the graduate qualification works in favour of “Proryv” project is the following: 2014 – 100 %, 2015 – 89 %, 2016 – 43 %, 2017 – 13 % (preliminary, according to the research activity places). The experience of students’ distribution by the research managers testifies increasingly frequently that the employers of “Proryv” project stream are less and less seeking for the magister graduates. Perhaps, this is stipulated by decrease of research engineering part and proceeding to design and engineering works. In this case, the educational program of the academic department should be refocused according to the employer demands.

Figure 3. Distribution of students.
3. Implementation of the education program in STI NRNU MEPhI (Seversk)

In 2017, STI NRNU MEPhI began training of magisters in the similar discipline in the academic department “Chemistry and materials technology of the modern power industry”. The program has its own particular characteristics associated with the STI discipline, and with the geographic proximity of UGR PDF OJSC, SICP JSC enterprises, “BREST” PDFK site, but it maintains the basic principle of multidisciplinary and extensive engagement of external recourse. During 2017-18, STI NRNU MEPhI received the license and was certified successfully for training of magisters in the discipline 14.04.02.

The advantages of magister training in STI NRNU MEPhI:

- Construction of the pilot and demonstration power supply package on the SICP JSC site consisting of the fast neutron reactor plant “BREST-OD-300” with near-by closed nuclear fuel cycle including production of uranium and plutonium nitride fuel (fuel fabrication) and also nuclear reprocessing with production of the secondary uranium and plutonium nitride fuel (fuel refabrication). This allows to combine the theoretical training of graduate students in STI NRNU MEPhI with the practical training at the production site directly;
- STI NRNU MEPhI in cooperation with the SICP JSC has the experience in training of highly skilled professional engineers in the disciplines 18.05.02 - Chemical engineering of materials in the modern power industry, and 14.05.04 - Electronics and automatics of physical installations; and also has modern educational, laboratory scientific and research facilities, highly professional teaching staff;
- capability to organize network training of magisters with engagement of top-level scientists and teaching staff of NRNU MEPhI, S&R TPU, S&R STU, ARSRICT JSC and other research and educational institutions cooperating with STI NRNU MEPhI for a long time;
- the geographic proximity of many leading Siberian and Urals institutions of State Atomic Energy Corporation “Rosatom” - MCC (Zheleznogorsk), ECP (Zelenogorsk), AIECP (Angarsk) and other potential consumers of magisters for which STI NRNU MEPhI trains specialists at the present time.

4. Conclusion

Implementation of the education programs in NRNU MEPhI is based on decades of the university experience, its personnel and material resources. The key requirements to the graduate competence are taken into account by engagement of the leading professionals in the industry as the external part-timers and establishment of the practical training on sites as well as by the network, joint implementation of the education program.

State Atomic Energy Corporation “Rosatom” develops rapidly different staff teaching methods. Thus, the State Atomic Energy Corporation “Rosatom” has the license for additional training and education programs since 2013. The enterprises of the State Atomic Energy Corporation “Rosatom” rapidly develops compliance-training programs. Herewith, only academic institutions (universities) have the full range of certified training programs. There is no doubt that the experience and resources of the academic institutions in coordination with the State Atomic Energy Corporation “Rosatom” are required for organization of staff training for “Proryv” project and establishment of the center of competence in Seversk.

References

[1] Shutikova M I 2015 Organization of educational process in an academic institution on the basis of the modular system “Concept”, research and methodological electronic journal 13 pp 3941-3945
[2] Federal Law dated December 29, 2012 No.273-FZ “Concerning education in the Russian Federation” http://base.garant.ru/70291362/#ixzz5LPIQ50G9.