MASTER PROGRAMME "CRYOGENIC ENGINEERING" OF BMSTU (ECDEAST PROJECT)

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ABSTRACT

This paper describes a master programme “Refrigeration, cryogenics and life support systems” designed during implementation of an ECDEAST Tempus project. Key programme outcomes are presented. Curriculum structure is shown. Described the assessment methods, criteria for admission and for successful master thesis defense. Specific interest is paid to the evaluation of the programme by an international expert committee for compliance with EUR-ACE standarts.

INTRODUCTION

According to the Bologna Process Russia uses a two-tiered training: Bachelor's and master's degree. The Bologna process main objective is to prepare specialists who are able to work in a rapidly changing labor market, at the junction of the various activities in labor migration, to continue as a learning process [1]. If earlier the training main objective was that students receive a certain amount of knowledge, at the present time - get learning outcomes (competencies) that allow to implement its objectives. Thus, early education center was a teacher, and now - the student. The modern master Russian state educational standards meet these requirements in many ways, although there are some differences against the European educational standards.

BMSTU is an educational research university, designed to prepare highly qualified graduates. It is therefore necessary to create a master's program for training of both domestic and foreign masters. This programme must meet the requirements of the federal state educational standards of Russia and satisfying the requirements of the Bologna process. It made the master's programme "Cryogenic Engineering" in the framework of the TEMPUS 511121-TEMPUS-1-2010-1-DE-TEMPUS-JPCR «ECDEAST - 511121-TEMPUS-1-2010-1-DE-TEMPUS-JPCR «ECDEAST Engineering curriculum design aligned with the EQF and EUR-ACE STANDART" and Federal State Educational Standards 141200 “Refrigerated, cryogenics and life support systems” [2].

The project official coordinator is Hochschule Wismar (Germany). In addition to BMSTU Russian project participants are two Russian universities - Tomsk Polytechnic University and St. Petersburg Polytechnic University. KTU – Kaunas University of Technology (Lithuania), LBUS – Lucian Blaga University of Sibiu (Romania), SEFI – Société Européenne pour la Formation d'Ingénieurs, ENAEE – European Network for Accreditation of Engineering Education are also involved in the project. The main European partner of BMSTU is Kaunas University of Technology.

1. THE PROJECT DESCRIPTION

1.1 Programme objectives

Master's Programme in Cryogenic Engineering is aimed at teaching students to meet modern science and industry demands. Learners should be able to carry out theoretical, computational and practical work in the field of cryogenic engineering. The study programme enables industry- and research-oriented graduates to be able to make analysis, design, manufacture and use machinery, plants, equipment, and devices of cryogenic engineering. The programme also allows professionals to investigate processes in cryogenic systems and plants and have an access to the doctoral school.

The seven main Programme objectives formulated as follows:

- conduct activities with research and development (R&D) related to the innovation techniques tor alculation and design and to the experimental study of low-temperature plant facilities and related industries;
- conduct manufacturing, R&D, and innovation activities to create new CAD-based and environmentally safe cryogenic facilities;
- perform value engineering of research and industry projects including multidisciplinary ones;
- carry out consulting and expert activities, analyze and compare and generalize research and industrial outcomes, prepare presentations and publications including those of in foreign language;
- show skills to organize and manage different profile specialists’ teamwork from different countries;
- carry out research and teaching activities both in the secondary schools of physics and mathematics and HEIs;
- upgrade professional knowledge and skills, including further studies at doctoral school.

1.2 Key programme learning outcomes (competencies)

Federal State Educational Standards 141200 “Refrigerated, cryogenics and life support systems” numerous competencies grouped into twelve core competencies. These competencies are divided into two parts - professional and universal.

Eight professional competencies are divided into five main parts according to the EUR-ACE STANDART:

Knowledge and understanding:

P1. Show sound knowledge of physical processes in machines, apparatus, and plants of cryogenic engineering; identify challenges and demands of the industry in terms of cutting-edge technology achievements and world tendencies;

Engineering analysis:

P2. Apply physicomathematical tools, theory- and computation-based methods of analysis, mathematical and computer modeling to design machines, apparatus, and plants of cryogenic engineering.

Engineering Design:

P3. Design low-temperature systems and machinery to meet the requirements for their maximum performance and durability, safety of life.

P4. Apply CAD-systems to design componentry for cryogenic machines and systems.

P5. Elaborate a feasibility study to design competitive ecologically safe cryogenic machines and plants.

Research:

P6. Display new contemporary methods and tools to carry out thermo-physical and mechanical investigations, analysis, and processing of cryogenic machines, plants and equipment.

P7. Demonstrate skills in running the modern cryogenic machines and plants, integrating innovative approaches, to ensure their high performance, cost-effectiveness and health and environment safety.

P8. Advise cost-engineers, designers, technologists and examine the theoretical and experimental cryogenic engineering work in terms of science and technology.

Four universal competencies (personal skills) are as follows:

P9. Have a good command of Russian and foreign languages with the ability for appropriate business communication, correspondence, documents circulation and for making presentations and papers, writing articles and reports.

P10. Apply basic principles of social, humanitarian, and economic sciences to solve social and professional problems and follow legislation in activities.

P11. Use practical experience and skills to manage professional activities of an individual, a team worker and an international team's leader of specialists with different profile.

P12. Upgrade a qualification independently through life-long learning, hold studies for students at different levels both in cryogenic engineering, and in physics and mathematics.

1.3 Curriculum structure

The curriculum consists of four main parts: General sciences, Professional subjects (Majors), Practical trainings and research activities and Final thesis (master's thesis defense). General sciences and Professional subjects parts consist of two main section: Core subjects and a Minors. The Minors contains the elective modules.

№	Code	Title of subject / module	credits	Prere-quisites
	GS	**General Sciences (GS)**	26	
	GSB	*Core subjects/modules (GSB)*	8	
1	GSB01	Foreign Language (special course)	5	
2	GSB02	History and Philosophy of Science and Technology	3	
	GS	*Minors (GSV)*	18	
3	GSV01	Strategy and innovation management	4	
4	GSV02	Mathematical modeling and Similarity methods	4	

5	GSV03E	Elective №1	3	
6	GSV04E	Elective №2	3	
7	GSV05E	Elective №3	4	
	PS	**Majors (PS)**	48	
	PSB	*Core subjects (PSB)*	13	
8	PSB01	Cryogenic systems: special chapters of thermodynamics	3	
9	PSB02	Cryogenic facility design engineering	4	PSB01
10	PSB03	Cutting-edge cryogenic systems and plants	3	PSB01 PSB02
11	PSB04	Computational gas and fluid dynamics, heat and mass transfer	3	PSB01
	(PSV)	*Minors (PSV)*	35	
12	PSV01	Cryogenic systems	4	
13	PSV02	Mathematical modeling of cryogenic systems	4	PSB01 PSB02 PSB03 PSB04
14	PSV03	Emergency Protection	3	
15	PSV04	Contemporary superconducting devices	6	PSB01PSB02 PSB03 PSB04
16	PSV05S	Elective №1 (“Cryogenic transport systems”)	6	
17	PSV06S	Elective №2	6	
18	PSV07S	Elective №3	6	
	PR	**Practical training and Research activities (PR)**	31	
19	SC01	**Final state attestation** (Master's thesis defense)	15	

1.4 Teaching/learning methods

Lectures, tutorials, laboratory and field works, group design project, case studies, presentations, practical trainings, and theses. IT and web, textbooks, periodicals, patents, etc.

Lectures to cover design and product development principles. In-company practical training to give the students an understanding of the industrial context of their work. A group design project focusing on an aspect of new and renewable energy engineering. This assignment will develop the student's knowledge of the implementation and management of the design process and their team-working skills. The assessment of this assignment will involve an element of student peer assessment. The mark will be made up from a team component and an individual component. Examinations to assess knowledge, understanding and application.

1.5. Assessment

Student performances are assessed by applying grading criteria that indicate what level a student has achieved while taking examinations and tests, analyzing investigation results, doing course papers and projects, completing theses and making conference reports, analytical papers, presentations, and essays. Student ability for critical evaluation of different activities, holding debate, interpreting and applying results is of significance in assessment.

2. MASTER'S PROGRAM IMPLEMENTATION

2.1. Criteria for admission to graduate program

Master's programme "Cryogenic Engineering" applicants can be both Russian citizens and foreign nationals. Foreigners coming to study in the framework of international agreements and treaties between BMSTU and foreign universities, institutes and companies. Applicants must have a bachelor's or engineering degree (qualification), preferably low-temperature engineering or the other engineering such as: power engineering, thermal physics, thermal engineering.

Entrance exams are conducted in accordance with Federal State Educational Standards 141200 “Refrigerated, cryogenics and life support systems”. As an admission test is used exam. The examination ticket includes four questions: three general specialty questions and one applicant master's thesis questions. Three specialty questions are consisting of the curriculum courses of bachelor 141200 “Refrigerated, cryogenics and life support systems”: "Cryology fundamentals", "Theory and analysis cycles of cryogenic systems", "Fundamentals of heat and mass transfer theory" and master thesis question. Overall assessment of the results is obtained by the answers.

2.2 Resources

Eight full-time teachers and ten part-time teachers of "Refrigerating, cryogenics and life support systems" Department are involved in master's program implementation.

Laboratories of the "Refrigerating, cryogenics and life support systems" Department, Russian and foreign companies specializing in low-temperature engineering are used for Practical training, Research activities and Master's thesis.

2.3 Master's thesis

Implementation of Master's thesis is the final stage of training. It summarizes the development of the educational program of the master. Protecting his master's thesis serves to control the student acquired knowledge, skills and competencies for the entire period of study at the University.

The purpose of Master's thesis implementation is identification and development of the creative and performing qualifying potential graduate, his abilities and inclinations to specialised types of scientific, engineering, organizational and managerial activities, the development skills of independent solutions of complex engineering problems.

Implementation of Master's thesis focused on the creation of a project or study for their practical application. During the public defense of Master's thesis the student demonstrates his ability, based on the knowledge, skills, common cultural and professional competence.

Master's thesis topic must correspond the modern scientific, technological and / or technical requirements. It must be the actual, as close to the solution of real problems and contain elements of research, which are oriented to achieve a new result.

Master's thesis topic is given for admission to graduate. It should be an independent and logically complete work related to the problem solving activity, which is preparing to graduate student (research, scientific, educational, design, development, experimental design, technological, etc.).

The sources of his master's thesis topics include direct booking academic and industrial organizations, commercial firms, etc. specializing in cryogenic engineering; research themes

"Refrigerating, cryogenics and life support systems" Department staff; research interests, including the development of the search head master. Master's thesis should consist of the following parts: setting tasks of the research or engineering project; review the current state of the matter with the justification relevance of the topic; implementation of theoretical and / or experimental research; generalization of the results and formulation of conclusions and specialized recommendations on the basis of these results; justification of master's thesis intended result effectiveness.

2.2. The interest of students and employers

Seven students-masters successfully continue their studies in this program. None of the students have not stopped learning. Students Master's theses topics of are associated with the direct labor for factories and research centers.

The program is popular among students. It is expected to take 13 budget form students for the first course in September 2013. CRI "Course", JSC "Cryogenmash", JSC "Holodhimmash", LLC "Air Liquide", JSC "Institute of HOLODMASHHOLDING"are interested in preparing programme "Cryogenic Engineering" students - master's. These companies have written letters to the BMSTU about the need for the preparation of such masters.

2.2. Publications about the master program and presentations at conferences

"Cryogenic Engineering" programme first version was reported in July 2012 at the Second International Conference " International Cooperation in Engineering Education" in St. Petersburg Polytechnic University. The article about this Master's programme is placed in the conference proceedings [4].

Article of the master's programme "Cryogenic Engineering " was published in the Vestnik MGTU (Series ”Mashinostroenie”) in 2012 [5]. This article describes the basic steps for creating a programme and Federal State Educational Standards 141200 “Refrigerated, cryogenics and life support systems” and EUR-ACE Standards competences comparison.

"Cryogenic Engineering" programme final version was reported at the International Conference "European approaches to improve engineering education", which took place in the BMSTU in June 2013.

3. THE PROGRAMME EVALUATION AGAINST EUR-ACE STANDARDS

3.1. The main activities to evaluate the programme

Evaluation Master's program "Cryogenic Engineering" major work was carried out during visits to the main partner Kaunas University of Technology (September 2011 and May 2012). It was conducted familiarity with master's programmes in the field of "Mechanics" and a detailed discussion of the master's programme BMSTU during these visits.

The first general discussion of the "Cryogenic Engineering" programme was held at the project «ECDEAST Engineering curriculum design aligned with the EQF and EUR-ACE STANDART" " meeting in the Lucian Blaga University of Sibiu (Romania) in October 2011. The main observations were a large number of competencies and discrepancy between this curriculum main parts number of credits and European requirements.

Master's programme "Cryogenic Engineering" work was reviewed during the monitoring of the project by the National Tempus Office of the Russian Federation (December 2011). During monitoring it were discussed the following key issues: the results achieved; interest of the university in the project performance and mobility training, dissemination of project results and developments at the university and beyond; the availability of mechanisms to ensure the project quality; stakeholders participation; sustainability and the importance of the project.

The same evaluation of this programme was carried out during a visit to the Hochschule Wismar (Germany) (June 2012) and at this project conference in St. Petersburg (July 2012).

3.2. Evaluation of international expert committees for compliance with EUR-ACE standarts

The main assessment of the master's programme against European standards was carried out during a visit to BMSTU by international expert commission. Before the visit the Self-Assessment Report was made according ENAEE form.

The visit lasted two days. During the visit the members of international expert commission familiarized with the main works of the "Refrigerating, cryogenics and life support systems" Department, with the guidance documents and met with teachers and master students, listened to a report about the employment of the Department graduates, visited the labs and library.

3.3 Preliminary outcomes of the review

После визита международной экспертной комиссии были сделаны следующие выводы и рекомендации:

- there are seven students studying the programme, five of whom have graduated from Specialist Diploma programmes, and two form Bachelor programmes;
- the SAR included detailed Module Descriptors for all the taught modules but not for two important parts of the Programme, that is for Practical training and Research activities, and for the Master Thesis.
- the absence of specified Module Learning Outcomes for these activities means that their contribution to the Programme Learning Outcomes is unclear, that there is no indication how they are to be assessed, and that students will not have a formal statement of expectations;
- the assessment of each module was described only briefly, and there was no indication of how the proposed assessment would ensure that the Module Learning Outcomes would be achieved;
- University has a formal Quality Assurance procedure that ensures that there is a formal annual review of each programme, however this should be complemented by a procedure for obtaining feedback information from the students of each individual programme using questionnaires or any other appropriate method.

In general, international commission of experts noted that the “Cryogenics Engineering” Programme is established with a structure and syllabus that provides for possible future developments. Development, and with firm links to local industry. The documented and verbal evidence indicated that the Learning Outcomes of Programme are consistent with the Content and Level of the EUR-ACE Framework, and with the Russian Federal Standards. Accreditation by the AEER (Association for Engineering Education of Russia) would provide independent confirmation of the standard of the programme.

4. CONCLUSION

Master programme " Cryogenics Engineering " is one of the first BMSTU master's degree programs, which meets the requirements of both the Federal State Educational Standard and EUR-ACE standards. Resulting in the creation of this program experience is very important for the design of other master's programs in the BMSTU and other Russian universities.

international expert commission notes will improve the quality of this programme. Joint project work has given a lot of experience in Russian universities methodical work, allowed to establish close cooperation between universities - partners and the European institutions SEFI and ENAEE.

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