Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Head of the Phystech School of Aerospace Technology
S.S. Negodyaev

Work program of the course (training module)

course:	Beam-Plasma Technologies. Part 2. Environmental Technologies/Пучково-плазменные технологии. Часть 2. Природоохранные технологии
major:	Applied Mathematics and Physics
specialization:	Beam-Plasma Systems and Technologies/Пучково-плазменные системы и технологии
	Phystech School of Aerospace Technology
	Chair of Logistics Systems and Technologies
term:	2
qualification:	Master

Semester, form of interim assessment: 4 (spring) - Grading test

Academic hours: 60 AH in total, including:
lectures: 30 AH.
seminars: 30 AH.
laboratory practical: 0 AH.

Independent work: 30 AH.

In total: 90 AH, credits in total: 2

Author of the program: M.N. Vasilev, doctor of technical sciences, full professor

The program was discussed at the Chair of Logistics Systems and Technologies 09.02.2022

Annotation

Known applications of plasmas in “green” technologies are the course subject. Among them:

- Hydrogen energetics including hydrogen production
- Clean conventional fuels burning
- Biofuels production
- Cleaning of power and industrial plants gaseous exhausts
- Gaseous hydrocarbons conversion
- Wastes recycling
- Water cleaning and disinfection
- Medical products and devices sterilization

The basic concepts of plasma physics and plasma chemistry are given in the context of engineering solutions for techniques and equipment for environment technologies. Resource saving technologies based on electron beams, thermal and non-equilibrium plasmas, as well plasma-based hybrid methods are considered from both the point of view of scientific fundamentals and practical realizations.

1. Study objective

Purpose of the course

Demonstrate how basic principles of plasma physics and plasma chemistry are used in the environment saving at present and can be used in future.

Tasks of the course

Familiarize students with known plasma-based approaches to development “green” technologies for industry, fossil and renewable resources usage, natural organic raw materials processing.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Gain fundamental scientific knowledge in the field of physical and mathematical sciences	Gen.Pro.C-1.1 Apply fundamental scientific knowledge in the field of physical and mathematical sciences
	Gen.Pro.C-1.2 Consolidate and critically assess professional experience and research findings
	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional settings
Gen.Pro.C-2 Acquire an understanding of current scientific and technological challenges in professional settings, and scientifically formulate professional objectives	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form within professional communication
Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results	Pro.C-1.1 Locate, analyze, and summarize information on current research findings within the subject area
	Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model
	Pro.C-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- fundamental concepts of applied plasma physics and plasma chemistry;
- methods for estimation of ecological characteristics of industrial setups of various types.
- principles of plasma chemical setups design
- modern problems of environment protection and “green” technologies
- typical designs of plasma generators applicable for “green” technologies.

be able to:

- estimate ecological efficiency of plasma-based techniques and equipment,
- use their knowledge to suggest technical decisions for environment savig technologies based on plasmas,
- to analyze advantages and disadvantages of beam-plasma technologies for environment protection and resource saving,
- estimate the by-side effects of the electron beams and plasmas application from the point of view of their action on environment.

master:

- skills of mastering a large volume information;
- skills of independent work in the laboratory and the Internet;
- culture of setting and modeling physical, chemical and environment problems;
- skills of competent multifactorial analysis of beam-plasma technologies.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Introduction to the subject. General concepts of “green technologies”	2	2		3
2	General concepts of “green technologies”	2	2		3
3	Fundamentals of plasma physics and plasma chemistry in context of “green technologies”	2	2		3
4	Plasma chemistry in hydrogen production	3	3		1
5	Plasma chemistry in conventional fuels burning	3	3		2
6	Plasma chemistry in fuels production	3	3		3
7	Plasma chemistry in cleaning of power and industrial plants gaseous exhausts	3	3		3
8	Plasma chemistry in hydrocarbons conversion	3	3		3
9	Plasma chemistry in wastes recycling	3	3		3
10	Plasma chemistry in water cleaning and disinfection	3	3		3
11	Plasma chemistry in medical products disinfection and devices sterilization	3	3		3
AH in total		30	30		30
Exam preparation		0 AH.			
Total complexity		90 AH., credits in total 2			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 4 (Spring)

1. Introduction to the subject. General concepts of “green technologies”

Green economy. Green technologies. Estimation of ecological characteristics of industrial, power and medical technologies. Electron beam setups and electron-beam plasma chemical reactors. by-side effects of the electron beams and plasmas application from the point of view of their action on environment.

2. General concepts of “green technologies”

Principles of “Green chemistry” and “Green energy”. Modern state of art of “Green technologies”. Conventional approaches to diminish negative effect of industry, agriculture, power production and medicine on environment.

3. Fundamentals of plasma physics and plasma chemistry in context of “green technologies”

Plasma generation: thermal and non-thermal plasmas. Equilibrium and non-equilibrium plasma chemistry. Plasma catalysis. Electron-beam plasma generation at various pressures. Hybrid plasmas. Advantages and disadvantages of beam-plasma technologies in context of “green technologies”. X-ray protection of electron-beam plasma setups.

4. Plasma chemistry in hydrogen production

General Features of Plasma-Assisted Production of Hydrogen. Plasma activation of gases techniques. Plasma processing methods for hydrogen production.

5. Plasma chemistry in conventional fuels burning

Plasma assisted combustion. Automobile and aircraft fuels ignition and burning stimulated by electric discharges and electron beams.

6. Plasma chemistry in fuels production

Syngas production in plasma chemical reactors. Plasma-assisted processes in biofuel production. Plasma-assisted coal gasification.

7. Plasma chemistry in cleaning of power and industrial plants gaseous exhausts

Exhausts cleaning from SO2 and NOx. EBARA-processes. Plasma-assisted mercaptans destruction. CO and CO2 conversion.

8. Plasma chemistry in hydrocarbons conversion

Methane conversion. GTL-processes. Schemes and designs of plasma chemical reactors for methane conversion and GTL processes.

9. Plasma chemistry in wastes recycling

Lignin recycling. Sawdust recycling. Plastics recycling. Syngas production from industrial and municipal wastes.

10. Plasma chemistry in water cleaning and disinfection

Plasma in liquids and solutions. Electron-beam plasma of aerosols. Active oxygen production in plasma chemical reactors.

11. Plasma chemistry in medical products disinfection and devices sterilization

Ozone production in plasmas. Surface sterilization by active oxygen, nitrogen oxides and X-ray radiation. Plasma generators for ozone, oxygen and nitrogen oxides production. Basic principles of the Plasma Medicine in the contexts of medical products disinfection and devices sterilization.

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Necessary equipment for lectures and practical exercises: computer and multimedia equipment (projector, marker board, Internet connection). Laboratory plasma generators: gas discharge systems, electron-beam and hybrid plasma generators.

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

1. Alexander Fridman, Plasma Chemistry, Cambridge University Press (2008).
2. Alexander Fridman, Lawrence A. Kennedy, Plasma Physics and Engineering, CRC Press (2011).
3. Nonthermal Plasma Chemistry and Physics, Ed. JurgenMeichsner, Martin Schmidt, Ralf Schneider, Hans-Erich Wagner, CRC Press (2013).
4. Green Chemistry, Theory and Practice, Anastas P., Warner J.C., Eds.–Oxford University Press: Oxford, 1998.
5. Clark J., Masquarrie D. Handbook of Green Chemistry and Technology. – Blackwell Science: Oxford, 2002.
6. Mohd Firdaus Yhaya, Husnul Azan Tajarudin, Mardiana Idayu Ahmad Renewable and Sustainable Materials in Green Technology. Springer. 2018.
7. Igor Matveev Plasma Assisted Combustion, Gasification, and Pollution Control: Volume 1. Methods of Plasma Generation for Pac. Outskirts Press, 2013.
8. Igor Matveev. Plasma Assisted Combustion, Gasification, and Pollution Control: Volume 2. COMBUSTION AND GASIFICATION. OutskirtsPress, 2015.

Additional literature

1. Jerzy Mizeraczyk and MariuszJasiński Plasma processing methods for hydrogen production. Eur. Phys. J. Appl. Phys. (2016) 75: 24702
2. P. Nikolaidis, A. Poullikkas, A comparative overview of hydrogen production processes. Renew. Sust. Energ. Rev. 67 (2017) 597-611.
3. H. Zhang, X.D. Li, F.S. Zhu, K.F. Cen, C.M. Du, X. Tu, Plasma assisted dry reforming of methanol for clean syngas production and high-efficiency CO2 conversion, Chem. Eng. J. 310 (2017) 114-119.
4. A. Gutsol, Warm discharges for fuel conversion. In Handbook of combustion; Lackner, M., Winter F., Agarwal A. K., Eds.; Wiley-VCH: Weinheim, Germany, 2010.
5. Encyclopedia of Renewable and Sustainable Materials. Ed. In chief Salem Hashmi and Imitaz Ahmed Choudhury.CcienceDirect, 2020.

7. List of web resources that are necessary for the course (training module) mastering

Not used

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

Microsoft Office. Internet access.

9. Guidelines for students to master the course

Successful mastering of the course requires significant self tuition of the student. Self tuition includes:
- reading and taking notes of the recommended literature;

- study of educational material (based on lecture notes, educational and scientific literature);
- solving problems offered to students at lectures;
- preparing to self tuition and tests.

The guidance and control over the student self tuition is carried out by the analysis of the self tuition results, tests, and individual consultations.

SUPPLEMENT

Assessment funds for course (training module)

major:	Applied Mathematics and Physics
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term:	2
qualification:	Master

Semester, form of interim assessment: 4 (spring) - Grading test

Author: M.N. Vasilev, doctor of technical sciences, full professor

1. Competencies formed during the process of studying the course

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	Gen.Pro.C-2.2 Assess the relevance and practical importance of research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form within professional communication
Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems and obtain new scientific results	Pro.C-1.1 Locate, analyze, and summarize information on current research findings within the subject area
	Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model
	Pro.C-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- fundamental concepts of applied plasma physics and plasma chemistry;
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- skills of competent multifactorial analysis of beam-plasma technologies.

3. List of typical control tasks used to evaluate knowledge and skills

Current control is carried out in the form of independent work or written tests on each topic.

The management and control of the student's independent work is carried out as a result of the analysis of the results of control, independent work, as well as individual consultations.

4. Evaluation criteria

1. Principles of “Green technologies”, “Green chemistry” and “Green energy”.
2.Thermal and non-thermal plasma generation in the context of “Green technologies”.
3. Plasma-assisted fuel combustion: processes and engineering realization.
4. Hydrocarbons conversion in plasmas: processes and engineering realization.
5. Wastes recyclingin plasmas: processes and engineering realization.

The mark is excellent 10 points - given to a student who has shown comprehensive, systematized, deep knowledge of the curriculum of the discipline, who is interested in this subject area, who has demonstrated the ability to confidently and creatively apply them in practice in solving specific problems, free and correct justification of the decisions made.

An excellent mark of 9 points is given to a student who has shown comprehensive, systematized, in-depth knowledge of the curriculum of the discipline and the ability to confidently apply them in practice in solving specific problems, free and correct justification of decisions made.

An excellent grade of 8 points is given to a student who has shown comprehensive, systematized, in-depth knowledge of the curriculum of the discipline and the ability to confidently apply them in practice in solving specific problems, the correct justification of the decisions made, with some drawbacks.

A good score of 7 points is given to a student if he firmly knows the material, expresses it competently and to the point, knows how to apply the knowledge gained in practice, but does not adequately substantiate the results obtained.

A good score of 6 points is given to a student if he firmly knows the material, expounds it competently and to the point, knows how to apply the knowledge gained in practice, but makes some inaccuracies in the answer or in solving problems.

A good score of 5 points is given to a student if he basically knows the material, expresses it competently and to the point, knows how to apply the knowledge gained in practice, but makes a large number of inaccuracies in the answer or in solving problems.

The mark is satisfactory 4 points - given to a student who has shown a fragmentary, scattered nature of knowledge, insufficiently correct formulations of basic concepts, a violation of the logical sequence in the presentation of the program material, but at the same time he has mastered the main sections of the curriculum necessary for further education and can apply the acquired knowledge in sample in a standard situation.

The mark is satisfactory 3 points - given to a student who has shown a fragmented, scattered nature of knowledge, makes mistakes in the formulation of basic concepts, disruptions in the logical sequence in the presentation of program material, poorly knows the main sections of the curriculum necessary for further education and hardly applies the acquired knowledge even in standard situations.

The score is unsatisfactory 2 points - given to a student who does not know most of the main content of the curriculum of the discipline, makes gross errors in the formulation of basic principles and does not know how to use the knowledge gained when solving typical problems.

The mark is unsatisfactory 1 point - given to a student who does not know the main content of the curriculum of the discipline, makes gross errors in the formulation of the basic concepts of the discipline and generally does not have the skills to solve typical practical problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

To pass an oral differential test the student is given 60 minutes for preparing and 15 minutes for presentation. The discussion on the student presentation should not exceed 15 minutes.

When preparing differential testing, students can use the discipline program, lecture notes and any other information excluding on-line Internet resources.