Al-FARABI KAZAKH NATIONAL UNIVERSITY
FACULTY MECHANICS AND MATHEMATICS
Educational program on specialty «050603-Mechanics»

Approved
at the meeting of Academic Council
of the faculty of Mechanics and Mathematics

Protocol №___from « ____»_______ 2015
Dean of the Faculty ______ Kydyrbekuly A.B.

PHYSICOCHEMICAL HYDRODYNAMICS

SYLLABUS

4-th year bachelor students «050603-Mechanics»,
Spring semester, 3 credits

Lecturer/Labs Teacher: Yerzhan Belyayev, Master of Sciences
Office phone: 8 (727) 377-31-93
Office #: 102
e-mail : Yerzhan.Belyaev@kaznu.kz

Activities under the program of the course is set in the form of lectures. Practical fastening of the lecture materials is carried out in a laboratory studies and ISWT (independent work of student with a teacher) in accordance with the schedule and the program. Tasks for ISW (independent work of student) and verification of ISW is carried out by lecturer. Midterm exams takes Labs teacher.

Aim of the course. To teach students the fundamentals of Physicochemical Hydrodynamics on the base of Physics of Combustion Process, the basic research methods of modeling of combustion, to teach them to understand the basic equations and to introduce the fundamental axioms, hypotheses and modern approach in modeling of chemically reacting flows. The purpose of discipline is familiarize students with the basic reacting flows, which are covered with practical applications. Concept of the course is based on the book "Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation" by J. Warnatz, U. Maas, R.W. Dibble. As a result of studying the course, students should know the basic laws and characteristics of Physicochemical Hydrodynamics, to be able to recognize and simulate problems in Physicochemical Hydrodynamics.

Objectives of the course. To teach students to build mathematical models, to understand the basics of Physicochemical Hydrodynamics, namely Combustion Processes such as flame and fuel types, thermodynamics and chemical kinetics, ignition and soot formation, etc. and instill skills to recognize specifically behavior of that effects during solving chemically reacting flow problems. Reacting flow are one of the main types of flow encountered in many practical problems. As it is well known, experimental studies of combustion processes, in particular at high Mach number are costly and unwieldy. So today it is popular to use methods of CFD (Computational fluid dynamics). The main problem in modeling this kind of flow is the numerical solution of nonlinearity: convective, turbulent and combustion terms in the system of equations for compressible viscous gas. In order to understand all of these issues it is need a basic theoretical knowledge of the program of Physicochemical Hydrodynamics, which will be taught in this course.

Learning outcomes. Necessary knowledge in the basics of gas dynamics and skills to solve the problems of compressible flows.

General competence:

- instrumental – the ability to assess the methodological approaches to carry out their critical analysis;
- interpersonal – ability to independently develop and deepen their knowledge and acquire new skills in a professional manner; knowledge of a foreign language in an amount sufficient to communicate freely in arbitrary topics;
- system – the ability to plan the steps of solving professional problems and implement them in time; demonstrate independence and original approach to problem solving, the ability to justify and make decisions.

Subject specific competences: owning a deep fundamental theoretical knowledge in the Physicochemical Hydrodynamics, modern Combustion problems.

Prerequisites: “Fluid Mechanics”, “Continuum Mechanics”, “Differential Equations”, “Mathematical Physics”, “Thermodynamics”, “Chemical Kinetics”, “CFD”.

Post requisites: “Physicochemical Hydrodynamics”, “Thermodynamics”, “Combustion Theory”, “CFD”, “Chemically Reacting Flows”.

STRUCTURE AND CONTENT OF THE SUBJECT

Week	Title of the theme	Hour	Grade
1	**Lecture 1.** Introduction, Fundamental Definitions and Phenomena. **Lab.1.** Basic Flame Types. Types of Fuel. **ISW 1.** Experimental Investigation of Flames.	4 2	25
2	**Lecture 2.** Mathematical Description of Premixed Laminar Flat Flames. **Lab.2.** Laminar premixed Flames. Zeldovich’s Analysis of Flame Propagation. **ISW 2.** Laminar Nonpremixed Flames.	4 2	25
3	**Lecture 3.** Thermodynamics of Combustion Processes. **Lab.3.** Methods of Quantifying Fuel and Air Content of Combustible Mixtures. **ISW 3.** Determination of Heating Values.	4 2	25
4	**Lecture 4.** Transport Phenomena. **Lab.4.** Fick’s Law. **ISW 4.** Ignition Processes.	4 2	25
	1st control test	**1**	**100**
	Midterm exam	**1**	**100**
5	**Lecture 5.** Chemical Kinetics. **Lab.5.** Simplified Model of Combustion Chemistry. **ISW 5.** Reaction Mechanisms.	4 2	25
6	**Lecture 6.** The Navier-Stokes-Equations for Three-Dimensional Reacting Flow.	4	

	Lab.6. 1D Combustion Modeling. **ISW 6.** Combustion of Liquid and Solid Fuels.	 2	25
7	**Lecture 7.** Turbulent Reacting Flows. **Lab.7.** Turbulent Nonpremixed Flames. **ISW 7.** Turbulent Premixed Flames.	4 2	 25
8	**Lecture 8.** Formation of Hydrocarbons and Soot. **Lab.8.** Low Temperature Oxidation, Engine Knock. **ISW 8.** Formation of Nitric Oxides.	4 2	 25
	2nd control test	**1**	**100**
	Exam		**100**
	TOTAL		**(1CT+2CT)/2*0.6 +0.1*MT+0.3*EXAM**

LIST OF LITERATURE

Main:

1. J.Warnats, U. Maas, R.W. Dibble Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation // 3rd Edition, Springer 2006, ISBN-10 3-540-25992-9, ISBN-13 978-3-540-25992-3, P. 378.
2. Ю. Варнатц, У. Маас, Р. Диббл Горение: физические и химические аспекты, моделирование, эксперименты, образование загрязняющих веществ // Москва «ФИЗМАТЛИТ» 2003, С. 351.
3. Sara McAllister, Jyh-Yuan Chen, A. Carlos Fernandez-Pello Fundamentals of Combustion Processes // Springer USA, ISBN 978-1-4419-7942-1, P. 302.
4. В.Г. Левич Физико-химическая гидродинамика // Москва ФИЗМАТЛИТ 1959, С. 699.
5. Ronald F. Probstein Physicochemical Hydrodynamics: An Introduction // Second Edition John Wiley & Sons, Inc. 1994, P. 210.

Additional:

1. Ю. В. Лапин, М. Х. Стрелец Внутренние течения газовых смесей // Москва «Наука» 1989, С. 366.
2. П. Либби, Ф. Вильямс Турбулентные течения реагирующих газов // Москва «Мир» 1983, С. 325.

GUIDLINES

All the assignments must be completed until due date. Students, who could not earn 50% out of 100% during first or second midterm and final, will be able to work off during an additional term. Late assignment is not accepted except for extenuating circumstances (e.g. field trip, hospitalization). Student, who failed to meet all kinds of work, is not allowed for passing an exam. In addition, the assessment takes into account the activity and attendance of students during class.

Be tolerant and respect other people's opinions. The objections should be formulated in a correct manner. Plagiarism and other forms of cheating are not allowed. Cheating is not accepted during independent work of student (IWS), midterm and final exam, copying solved problems from others, passing the exam to another student are not allowed also. Student convicted of falsifying any information about the course, any unauthorized upload to the “Intranet” using cheat sheets, will be graded with a final grade «F». For advice on the implementation of IWS, submitting and defending, as well as additional information on the studied material and all the other issues that arose upon studying the course, contact the instructor during his office hours.

Letter grade	Numerical equivalency	% (percentage)	Grading in a traditional way
A	4,0	95-100	Excellent
A-	3,67	90-94	
B+	3,33	85-89	Good
B	3,0	80-84	
B-	2,67	75-79	
C+	2,33	70-74	Satisfactory
C	2,0	65-69	
C-	1,67	60-64	
D+	1,33	55-59	
D-	1,0	50-54	
F	0	0-49	Unsatisfactory
I (Incomplete)	-	-	«The course is incomplete» (this isn't taken into account when calculating the *GPA)*
P (Pass)	-	-	«Passed» (this isn't taken into account when calculating the *GPA)*
NP (No Pass)	-	-	«Not passed» (this isn't taken into account when calculating the *GPA)*
W (Withdrawal)	-	-	«the course is withdrawn» (this isn't taken into account when calculating the *GPA)*
AW (Academic Withdrawal)			Withdrawn because of academic issues (this isn't taken into account when calculating the *GPA)*
AU (Audit)	-	-	«Audit» (this isn't taken into account when calculating the *GPA)*
Att.		30-60 50-100	Attested
Not att.		0-29 0-49	Not attested
R (Retake)	-	-	Retaking the course

Considered in department meeting
Protocol № __ from «__» ___________

Head of the department of Mechanics _____________________ A. Kaltayev

Lecturer _____________________ Ye. Belyayev