

Table of Contents

- 1. Course (module) Description
- 2. Course Instructor(s) and Tutor(s), Contact Information
- 3. Prerequisites
- 4. Course (module) Outline
- 5. Assessment
- 6. Attendance Policy
- 7. Required Course (module) Participation
- 8. Facilities, Equipment and Software Annex 1. Example of Questions to the Exam Annex 2 Example of Self-Study Assignment

Course (module) Guide Innovation in Refining Processes

1. Course (module) Description

1.1. Course (module) overview

The course of Innovation in Refining Processes provided a curriculum of postgraduate program 02.00.13 Petroleum Chemistry. Innovation in Refining Processes is an extensive course where overview of the modern, integrated petroleum refinery will be analyzed. Each refining process is presented covering configuration, operating description and conditions, feedstock and catalyst selection, stream yields and properties, process parameter relationships and their effect on unit performance and yields. The impact of each process on environmental regulations and pollution control is also discussed. Crude oil properties and assays are reviewed. Current and anticipated future worldwide fuel product specifications are presented.

The effects of changes in crude oil source and supply, in particular bitumen and shale oil, as well as shifting product demand and import/export balances on future refinery operation will also be discussed.

The course Innovation in Refining Processes forms a scientific approach to subject areas associated with crude an oil analysis and processing. The graduate students get the ability to set and solve problems in the scientific and processing fields. Strong motivation for self-development and professional development are develop by the special design of the course. The exceptional attention is paid to the formation of ability to conduct independent research, teaching and expert consulting activities.

1.2. Special features of the course

- Scientific, social and practical aspects of refinery industry are tightly integrated in the teaching on the course;
- In addition to conventional lectures the course offers a range of other learning opportunities in which students actively participate. Moreover, students will be involved in cases and tests;
- Provides broad technical information on refining processes and petroleum products, enabling a rapid immersion in the refining industry;
- Detailed course material with a glossary of the main technical terms used in the refining industry. New trends in market structure and

product characteristics to European and worldwide scale. Up to date refining schemes including the production of petrochemical intermediate products;

 Refinery employees and scientists will be participated in educational process. It allows students to be kept in the loop of modern trends and challenges which are the core for petrochemistry.

1.3. Course aims

- to explain the chemical basis of processes that are realized by petroleum industry;
- to develop understanding and skills related to the recognition and interpretation of modern trends and challenges in petrochemistry;
- to design schematic diagrams of different existing refinery processes as well as to develop flow schemes of innovative chemical processes;
- to provide a knowledge which allow to estimation environmental impacts of the petroleum refining industry.

1.4. Course objectives

- to explain the different chemical reactions occurred during innovative refining processes;
- to classify students innovative secondary refining processes;
- to provide students with the designing of refinery's basic schematic diagrams;
- to familiarize students with different kind of pollution and refining industry accidents.

1.5. Learning outcomes of the course (module)

By the end of the course, students will be able to:

- analyze the chemical processes and phenomena according to the main theoretical schools, approaches, concepts for solving problems in the field of chemical technology of oil refining;
- determine topics of investigations within research areas for oil refining and petrochemistry;

- use modern achievements on areas of technology development in the oil and gas industry and chemical and technological processes of oil refining;
- exploit the professional knowledge about the technological modes and chemistry of the primary and secondary oil refining processes, based on the existing ideas about the physical and chemical basis of the processes;
- develop innovative approaches to the modernization of hydrocarbon processing with the receipt of products that meet modern requirements.

2. Course Instructor, Contact Information



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3. Prerequisites

Master's degree in Petroleum Engineering, Engineering, Chemistry, Environmental Sciences or equivalent (transcript of records), good command of English (certificate or other official document).

4. Course Outline

4.1. Course (module) requirements

4.1.1. Required text(s)

1. Modern Chemical Enhanced Oil Recovery: theory and practice / J.J. Sheng - Amsterdam: Elsevier, 2007. - 316 c.

2. Modeling and simulation of catalytic reactors for petroleum refining / Ancheyta J, S. l: John Wiley & Sons, 2011. - 260 c.

3. Hydroprocessing of Heavy Oils and Residua / J Ancheyta, J. G. Speight - Boca Raton: Taylor Francis Croup, 2007. - 280 c.

4. Purification of laboratory chemicals [Electronic resource] / Wilfred L. F. Armarego, Christina L. L. Chai. - Electronic text data (20,1 MB). - Amsterdam: Butterworth-Heinemann, 2003. - 634 p. - Ver. with the title. screen. - Electron. version of the printer. publication.

5. Organic chemistry [Electronic resource] / J. Clayden. - Electronic text data (33,9 MБ). - [S. l. : s. n.], 2001. - 1490 р

6. Polymers a Property Database [Text]: monograph / ed .: B. Ellis, R. Smith. - 2nd ed. - London: CRC Press, 2009. - xxii p. : tabul. - Name and Synonym index: p.1089-1106.

7. Petroleum Refining. Tehnology and Economics [Text] / J. H. Gary, G. E. Handwerk, M. J. Kaiser. - 5th ed. - Boca Raton; London: CRC Press; London; New York: Taylor & Francis Group, 2007. - 463 p.

8. Essentials of Petroleum. A Key to Oil Economics [Text]: monograph / P. H. Frankel; foreword by M. A. Adelman. - London: Frank Cass, 2005. - xiii, 188 p.

The list of information and telecommunication resources required for mastering the discipline (module) is available via Internet network

1. www.eLIBRARY.RU - Scientific electronic library. Access mode is free.

2. www.sciencedirect.com - Elsevier Database. Access mode is free.

3. www.nature.com - Scientific journal Nature. The access mode is free.

4. www.scopus.com - Scopus peer-reviewed literature database. Access mode is free.

5. www.springerlink.co - Springer Database.

6. www.isiknowledge.com - Web of Science Database. Access mode is free.

4.1.2 Web page of the course (module)

You can receive the whole information about the postgraduate program 02.00.13 Petroleum Chemistry and about the course in SibFU website: www.e.sfu-kras.ru. You must be logged in to access this course. Course materials and required reading materials are available at the course web-page.

4.1.3. Course (module) materials (seminar notes, assignments for classroom activities and sessions)

Prior to attending the lections some preparation can be very valuable. Consultation on the Innovation in Refining Processes module is carried out by electronic resources that are associated with the SFU or face-to-face. There are various materials for self-preparation, for seminars or practical classes, which are available a week before the class on the web page of the discipline provided by My SFU Resource. The materials can be in form of simple text documents while others may be audio or video files, or online exercises. Most of them are supplementary intended for independent study and are not supposed to replace the practical sessions. The great benefit is that you can return and revisit them when you want. Home assignments involve printed reports, oral or visual presentations.

4.1.4 Required feedbacks

The supervisor might use the web page of the subject as a communication channel. It is important that you become familiar with checking and accessing it regularly. Make sure that you have access to the correct module pages, and get in touch with your lector or programmer administrators in any other cases.

4.2. Course (module) Structure

	T-4-1	Semester	
Learning activities	credits (academic hours)	4	
Total	4 cr. (144 a. h.)	4 cr. (144 a. h.)	
Lectures	0,67 cr. (24 a. h.)	0,67 cr. (24 a. h.)	
Practice sessions / Seminars	-	_	
Self-study of the students:			
Study of the theoretical course (including preparation for final attestation)	2,33 cr. (84 a. h.)	2,33 cr. (84 a. h.)	
Final Attestation	Exam (1 cr., 36 a. h.)	Exam (1 cr., 36 a. h.)	

4.2.1 Internal education

4.3 Time schedule course (module) and course (module) outline

			Learning Activities				
		week,	(lecture, lab, class			Salf strider	
№	Topic		assignments,		Hours	Sen-study	Reading
		JN⊇	assessme	assessment and		Assignments	
			othe	er)			
1	Theoretical	1	Lecture 1.	Scientific	2	Exact topics for	The
	foundations		principles and	technology		self-study	literature
	and		of oil prep	aration for		assignments are	listed in 4.1
	processing		refining proces	sses.		depended on the	paragraph.
	technology of					line of	The articles
	primary oil					academicals	and
	distillation					research that is	materials are
	and refining					conducted by the	indexed by
						students.	Scientific
		2-3	Lection 2 - 3.	Theoretical	3	Exact topics for	Databases
			approaches	of oil		self-study	listed in 4.1
			distillation pro	cesses		assignments are	paragraph.
						depended on the	
						line of	
						academicals	
						research that is	
						conducted by the	
						students.	-
		3-4	Lection 3 -	4. Modern	3	Exact topics for	
			equipment for	r crude oil		self-study	
			and its	fractions		assignments are	
			distillation			depended on the	
						line of	
						academicals	
						research that is	
						conducted by the	
	T 1 · · 1			T 1 1		students.	rp1
2	Theoretical	5-6	Lection 5 - 6.	Technology	4	Exact topics for	The
	foundations		of the	rmocatalytic		self-study	
	and		processes for	petroleum		assignments are	listed in 4.1
1	technology of		reedstock proc	essing		aepended on the	paragraph.
1	secondary oil					line of	i ne articles
1	renning					academicals	anu motoriola are
	processes					research that is	indexed by
1						conducted by the	naexed by
						students.	Scientific

4.3.1 Internal education

		7 - 8	Lection 7 - 8. Technology	3	Exact topics for	Databases
			of catalytic heterolytic oil		self-study	listed in 4.1
			refining processes		assignments are	paragraph.
					depended on the	
					line of	
					academicals	
					research that is	
					conducted by the	
					students.	
		8 - 9	Lection 8 - 9. Theoretical	3	Exact topics for	•
			foundations and		self-study	
			technology of catalytic		assignments are	
			homolytic oil refining		depended on the	
			processes		line of	
					academicals	
					research that is	
					conducted by the	
					students.	
2		10-11	Lection 10 – 11. Hydro-	3	Exact topics for	The
			catalytic refining		self-study	literature
			technology		assignments are	listed in 4.1
					depended on the	paragraph.
					line of	The articles
					academicals	and
					research that is	materials are
					conducted by the	indexed by
					students.	Scientific
		12-13	Lection 11 - 12. Theo-	3	Exact topics for	Databases
			retical and technological		self-study	listed in 4.1
			foundations of the	,	assignments are	paragraph.
			production of lubricating		depended on the	
			oils		line of	
					academicals	
					research that is	
					conducted by the	
					students.	
4	Final	18	Exam			
	attestation					

5. Assessment

5.1 Form of assessment

Home assignment will involve some form of printed and oral reports, or downloadable file on the web page of the discipline within the specified period. The students must realize successfully not less than 6 oral reports during the course.

5.2 Grading scale

Grade policy for both home assignments and the final exam is:

- A (excellent work) 91–100 points
- B (above average work) 81–90 points
- C (average work) 71–80 points
- D (below average work) 50–70 points
- F (failed work) < 50 points

Students are assessed by results of practical work, tests, and a final exam. Progress assessment:

- 50 % home assignments;
- 50 % exam.

6. Attendance Policy

Students are expected to attend and participate in classes and should notify lecturer of excused absences in advance, where possible. Students who have an excused absence are expected to make arrangements with lecturer for alternative assignment.

Every topic has a home assignment work that should be done. The final mark will be made by the same grade policy as for a final exam.

7. Required Course (module) Participation

Students should be able to:

- defend the writing reports (50 points maximum),
- write an answer on 2 questions, demonstrate covered material (50 points maximum).

8. Facilities, Equipment and Software

The implementation of the course provides for the availability of lecture rooms (personal computers, printers, copier, projector, demonstration materials) with access to webpages of the E-learning SibFU through web site: www.sfukras.ru. The training process for this course uses standard Microsoft Office programs.

List of required software.

1. Windows XP or later operating system from Microsoft® Windows family.

2. Microsoft® Office Professional Plus 2010 Russian Academic OPEN No Level.

3. ESET NOD32 Antivirus Business Edition for 2750 users.

4. Adobe Acrobat Pro Extended 9.0 WIN AOO License IE Acrobat Pro Extended, License Certificate from Softline (10.12.2008, indefinitely).

5. Ascon Compass-3D, License Certificate №E-08-000123 (11.09.2008); №E-7-00107 (12.12.2017, indefinitely).

6. AutoCAD, free software.

Annex 1. Example of Questions to the Exam

1. Collection and preparation of oil in the fields.

2. Desalination of oil at the refinery.

3. Theoretical foundations of the processes of distillation of oil and gases.

4. General information about the distillation and rectification of oil.

5. Methods for regulating the temperature regime of the rectification columns.

6. Selection of pressure and temperature conditions in the distillation column.

7. Features of steam distillation.

8. Classification of rectification columns and their contact devices.

9. Modern industrial installations for the distillation of oil.

10. Types of industrial installations.

11. Block for atmospheric distillation of oil - ELOU-AVT-6 units.

12. Block for stabilization and secondary distillation of AT gasoline.

13. Block for vacuum distillation of fuel oil - ELOU-AVT-6 units.

14. Features of the technology of vacuum distillation of fuel oil in the oil version.

15. Fractionation of hydrocarbon refinery gases.

16. Fundamentals of technology for the processes of selective purification of oil fractions and deasphalted materials.

17. Fundamentals of technology of processes of dewaxing of raffinates by crystallization, information about other processes of dewaxing.

18. Types and purpose of thermocatalytic processes.

19. Technology of modern thermocatalytic processes for processing petroleum raw materials.

20. Thermal cracking of distillate raw materials.

21. Installations for visbreaking of heavy raw materials.

22. Delayed coking units.

23. Features of the technology for the production of needle coke.

24. Processes of obtaining petroleum pitches by thermal condensation of residues.

25. Plants for pyrolysis of crude oil.

26. Production of petroleum bitumen.

27. Carbon black production.

28. Technological basis for the production of carbon materials

29. Theoretical foundations and technology of hydrogenation

catalytic processes for upgrading petroleum feedstock

30. Theoretical foundations and technology of hydrogenation

catalytic processes of refining petroleum feedstock.

31. Theoretical foundations of hydrogenolysis reactions of heteroorganic compounds of raw materials.

32. Catalysts of hydrogenation processes and their mechanism of action.

33. Basics of hydrogenation processes management.

34. Industrial processes of hydrofining of distillate fractions.

35. Catalytic processes of hydrocracking of crude oil.

36. Brief characteristics and classification of refineries.

Annex 2. Example of Self-Study Assignment

1. The vacuum residue residence time in the visbreaking furnace at A $^{\circ}$ C is B sec. What will be the residence time at 450 $^{\circ}$ C, if the conversion of the feedstock remains the same?

2. 11.67 kg/sec of vacuum residue and 2.36 kg/sec of recirculating residue enter the visbreaking furnace. The output of fuel oil in one pass is C %. Taking into account recirculation, determine the total yield of fuel oil.

3. The duration of heavy crude oil cracking at 450 $^{\circ}$ C is 240 s. What will be the time of the process at 425 $^{\circ}$ C, if the same amount of gasoline is obtained? Take the temperature gradient equal to 12.9.

4. Determine the coefficient of unconverted feedstock recirculation, if the mass flow of gasoline in one pass is 4.1%, and with recirculation - 5.34%.

5. 18.05 kg/sec of mixed feed, consisting of straight-run residue and the recirculate flow, are going to the cracking furnace. The utilization rate coefficient is 1.25. Determine the amount of recycle fed to the oven.

Basic Information

This is a course, which contributes to postgraduate educational program 04.06.01 Chemical Sciences, specialization is 02.00.13 Petroleum Chemistry.

Course period	From February 1st till May 31st, 4 semester (15 weeks)
Study credits	4 ECTS credits
Duration	144 hours
Language of instruction	English
Academic requirements	 M. Sc degree in Petroleum Engineering, Engineering, Chemistry , Environmental Sciences or equivalent (transcript of records), good command of English (certificate or other official document)

Course Description

The course of Innovation in Refining Processes provided a curriculum of postgraduate program 02.00.13 Petroleum Chemistry. Innovation in Refining Processes is an extensive course where overview of the modern, integrated petroleum refinery will be analyzed. Each refining process is presented covering configuration, operating description and conditions, feedstock and catalyst selection, stream yields and properties, process parameter relationships and their effect on unit performance and yields. The impact of each process on environmental regulations and pollution control is also discussed. Crude oil properties and assays are reviewed. Current and anticipated future worldwide fuel product specifications are presented.

The effects of changes in crude oil source and supply, in particular bitumen and shale oil, as well as shifting product demand and import/export balances on future refinery operation will also be discussed.

Innovation in Refining Processes. Syllabus

The course Innovation in Refining Processes forms a scientific approach to subject areas associated with crude an oil analysis and processing. The graduate students get the ability to set and solve problems in the scientific and processing fields. Strong motivation for self-development and professional development are develop by the special design of the course. The exceptional attention is paid to the formation of ability to conduct independent research, teaching and expert consulting activities.

Special Features of the Course

- Scientific, social and practical aspects of refinery industry are tightly integrated in the teaching on the course;
- In addition to conventional lectures the course offers a range of other learning opportunities in which students actively participate. Moreover, students will be involved in cases and tests;
- Provides broad technical information on refining processes and petroleum products, enabling a rapid immersion in the refining industry;
- Detailed course material with a glossary of the main technical terms used in the refining industry. New trends in market structure and product characteristics to European and worldwide scale. Up to date refining schemes including the production of petrochemical intermediate products;
- Refinery employees and scientists will be participated in educational process.
 It allows students to be kept in the loop of modern trends and challenges which are the core for petrochemistry.

Course Aims

- to explain the chemical basis of processes that are realized by petroleum industry;
- to develop understanding and skills related to the recognition and interpretation of modern trends and challenges in petrochemistry;
- to design schematic diagrams of different existing refinery processes as well as to develop flow schemes of innovative chemical processes;

 to provide a knowledge which allow to estimation environmental impacts of the petroleum refining industry.

Course Objectives

- to explain the different chemical reactions occurred during innovative refining processes;
- to classify students innovative secondary refining processes;
- to provide students with the designing of refinery's basic schematic diagrams;
- to familiarize students with different kind of pollution and refining industry accidents.

Learning Outcomes of the Course

By the end of the course, students will be able to:

- analyze the chemical processes and phenomena according to the main theoretical schools, approaches, concepts for solving problems in the field of chemical technology of oil refining;
- determine topics of investigations within research areas for oil refining and petrochemistry;
- use modern achievements on areas of technology development in the oil and gas industry and chemical and technological processes of oil refining;
- exploit the professional knowledge about the technological modes and chemistry of the primary and secondary oil refining processes, based on the existing ideas about the physical and chemical basis of the processes;
- develop innovative approaches to the modernization of hydrocarbon processing with the receipt of products that meet modern requirements.

Course Outline

Week	Topic Lections / Practice session / Assignments		Hours ¹
		,	(Internal education)
		Lecture 1. Scientific principles and	2
		technology of oil preparation for refining	
	Theoretical	processes.	
	foundations and	Lection 2-3. Theoretical approaches of oil	3
	processing	distillation processes	
1-7	technology of	Lection 3-4. Modern equipment for crude	3
	primary oil	oil and its fractions distillation	
	distillation and	Self-study assignments. Exact topics for	28
	refining	self-study assignments are depended on	
		the line of academicals research that is	
		conducted by the students.	
		Lection 5-6. Technology of thermocatalytic	4
		processes for petroleum feedstock	
		processing	3
		Lection 7-8. Technology of catalytic	
		heterolytic oil refining processes	
		Lection 8-9. Theoretical foundations and	3
	Theoretical	technology of catalytic homolytic oil	
	foundations and	refining processes	
5-14	technology of	Lection 10–11. Hydro-catalytic refining	3
	secondary oil	technology	
	refining processes	Lection 11-12. Theo-retical and	2
		technological foundations of the	5
		production of lubricating oils	
		Self-study assignments. Exact topics for	56
		self-study assignments are depended on	
		the line of academicals research that is	
		conducted by the students.	
15		Final attestation (Exam)	

¹ Hours designed for Classroom sessions, Web-sessions, Home Assignments etc. Innovation in Refining Processes. Syllabus

Lecturer and Contact Information



Fedor A. Buruykin

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Tel: +7 391 254-54-43, FBurykin@sfu-kras.ru

Assessment

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- 50 % home assignments;
- 50 % exam.

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Web page of the course

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Core reading

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2. Modeling and simulation of catalytic reactors for petroleum refining / Ancheyta J, S. I: John Wiley & Sons, 2011. - 260 c.

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8. Essentials of Petroleum. A Key to Oil Economics [Text]: monograph / P. H. Frankel; foreword by M. A. Adelman. - London: Frank Cass, 2005. - xiii, 188 p.