UCLouvain

lmapr2430

2023

Industrial processes for the production of base chemicals

5.00 credits	30.0 h + 22.5 h	Q1

Teacher(s)	De Wilde Juray ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Main themes	The production of basic chemicals is addressed. In the first part of the course, an overview of the chemical industry is given. A second part of the course addresses the various unit operations typically encountered in a chemical process. Basic models for the design of chemical reactors are described in the third part of the course. Finally, some key processes are covered in detail, includingflow-sheets and aspects of reaction kinetics/catalysis, reactor design, separation and purification of reactants and products, energy needs and environmental impact and safety.
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **Contribution of the course to the program objectives** Referring to the LOs of the KIMA diploma, the following LOs are aimed at: • Axe 1: 1.1, 1.2; • Axe 2: 2.2, 2.3, 2.4, 2.5; • Axe 3: 3.1, 3.2, 3.3; • Axe 4: 4.1, 4.2, 4.4; • Axe 5: 5.3, 5.5, 5.6; • Axe 6: 6.1, 6.2, 6.3. **Specific learning outcomes of the course** **Disciplinary learning outcomes** At the end of this course the student will be able to: - Give an overview of the (petro)chemical industry, the most important processes and their interactions. - Give the typical refining schemes and the processes involved. - Provide an overview of the various unit operations used in the chemical processes: • Types of unit operation (reaction, separation, heat exchange, ') • Technology (ies) used for the different unit operations - Make or interpret a flow-sheet incorporating different unit operations. - Calculate mass/species balances and energy balances for chemical processes taking into account the different unit operations - Model and design chemical reactors • Well-mixed, in batch or continuous operation • Plug flow - Take a variety of measures to increase the energy efficiency and to reduce the environmental impact of a chemical process. - For the following production processes: • Steam cracking : ethylene, propylene, butadiene • Steam reforming : syngas and hydrogen, ammonia, methanol • Catalytic reforming : benzene,toluene, xylene,gasoline • Catalytic cracking: gasoline • Sulfuric acid • Nitric acid • Maleic anhydride - Describe in detail: • the process flow sheet (species and heat) and the interaction with other processes, • the process safety, • the feedstock and product requirements, • the process conditions, • the chemistry and reaction thermodynamics and kinetics, • the catalyst if used, • the reactor types used and their design, i.e. the appropriate reactor model(s), • the measures taken to increase the energy efficiency and to reduce the environmental impact

	Transverse learning outcomes At the end of this course the student will be able to: • Study independently the different aspects of a chemical process. • Present and explain the different aspects of a chemical process to a professional audience, in writing and orally. • Look up and use scientific and technical information from various sources, including reference text books and the web. • To use a corpus of scientific and technical knowledge, allowing to solve given problems in the discipline studied. • To analyze, organize and develop an engineering approach for process development responding to specific needs or a given problem, the analysis of a given physical phenomenon or a system. • To contribute, as a team member, to the realization of a project with a given discipline or multiple disciplines according to a well described approach. • To efficiently communicate by writing and presentation, in English or French, the results of a well-defined project. • To show a rigorous behavior and critical thinking in carrying out scientific or technical tasks with respect for ethical issues.
Evaluation methods	The students will be individually graded based on the objectives indicated above. The theoretical exam is with a written preparation and oral defense/discussion. It counts for 70% of the mark. An exercise is part of the exam. <u>Evaluation of the mini-projects</u> One/two mini-projects (defined in the section on Learning methods) are evaluated. They count for 15/30% of the mark.
Teaching methods	This course combines ex-cathedra teaching, exercise sessions and projects with tutoring. The theoretical courses are ex-cathedra. The students are encouraged to ask questions. In the context of the course, a number of scientific papers have to be read and analyzed. The exercises focus on performing mass/species balances and energy balances for different processes, the safety analysis of a process, the modeling and simulation of well-mixed reactors (batch and continuous) and plug flow. Apart from exercise sessions, two mini-projects are planned to train students in the study and understanding of different aspects of a chemical process independently. <u>Example mini-project 1</u> : "Simulation of a commercial reactor for steam cracking of ethane" allows students to apply reactor modeling concepts in particular for plug flow reactors, reaction kinetics and numerical methods to a practical case of great industrial importance. With the developed simulation code of simulation, a sensitivity study is be performed. The coupling reactor - furnace must be considered in the analysis of the results. <u>Example mini-project 2</u> : "Sulfuric acid production: design of the global process and thermodynamic study of the oxidation of SO2 to SO3" allows students to study the mass and energy balances of an industrial process and to identify thermodynamic constraints of conversion. In addition to developing students' technical skills, the mini-projects also aim to teach students how to report a technical study scientifically and concisely, both writing and orally, in front of an audience.
Content	Main themes: The production of basic chemicals is addressed. In the first part of the course, an overview of the chemical industry is given. A second part of the course addresses the various unit operations typically encountered in a chemical process. Basic models for the design of chemical reactors are described in the third part of the course. Finally, some key processes are covered in detail, including flow-sheets and aspects of reaction kinetics/catalysis , reactor design, separation and purification of reactants and products, energy needs and environmental impact and safety. Content: • Refining and (petro) chemical industry • Unit operations • Material and energy balances • Analysis and design of chemical reactors : • Batch Reactors • Plug flow reactors • Well-mixed Reactors • Introduction to heterogeneous catalytic reactors (fixed bed and fluidized bed) • Safety of chemical processes • Environmental aspects and energy efficiency • Key Processes I: • Steam cracking: ethylene, propylene, butadiene & • Steam reforming hydrogen, ammonia & methanol • Catalytic reforming: benzene, toluene & xylene, high-octane gasolines • Catalytic cracking: petrol / C3-C4 olefins & isobutane • Maleic anhydride • Key Processes II: • Sulfuric acid • Nitric acid

Inline resources	https://moodleucl.uclouvain.be/course/view.php?id=10005
Bibliography	Les notes de cours (en français et en anglais) sont fournies aux étudiants et disponible sur Moodle. Text book: Chemical Reactor Analysis and Design, 3th edition, Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, Wiley, 2010.

Other infos	This course requires basic knowledge in chemistry and chemical engineering (thermodynamics, kinetics and transport phenomena).
	Learning outcomes:
	Contribution of the course to the program objectives
	Referring to the LOs of the KIMA diploma, the following LOs are aimed at:
	• Axe 1: 1.1, 1.2;
	• Axe 2: 2.2, 2.3, 2.4, 2.5;
	• Axe 3: 3.1, 3.2, 3.3;
	• Axe 4: 4.1, 4.2, 4.4;
	• Axe 5: 5.3, 5.5, 5.6;
	• Axe 6: 6.1, 6.2, 6.3.
	Specific learning outcomes of the course
	Disciplinary learning outcomes
	At the end of this course the student will be able to:
	• Give an overview of the (petro)chemical industry, the most important processes and their interactions.
	• Give the typical refining schemes and the processes involved.
	• Provide an overview of the various unit operations used in the chemical processes:
	  • Types f unit operation (reaction, separation, heat exchange, …)
	  • Technlogy (ies) used for the different unit operations
	• Make or interpret a flow-sheet incorporating different unit operations.
	• Calculate mass/species balances and energy balances for chemical processes taking into account the different unit operations
	• Model and design chemical reactors
	  • Well-mixed, in batch r continuous operation
	  • Plug flw
	• Take a variety of measures to increase the energy efficiency and to reduce the environmental impact of a chemical process.
	• For the following production processes:
	  • Steam cracking : ethylene, prpylene, butadiene
	  • Steam refrming : syngas and hydrogen, ammonia, methanol
	  • Catalytic refrming : benzene, tluene, xylene, gasline
	  • Catalytic cracking: gasline
	  • Sulfuric acid
	  • Nitric acid
	  • Maleic anhydride
	• Describe in detail:
	  • the prcess flow sheet (species and heat) and the interaction with other processes,
	  • the prcess safety,
	  • the feedstck and product requirements,
	  • the prcess conditions,
	  • the chemistry and reactin thermodynamics and kinetics,
	  • the catalyst if used,
	  • the reactr types used and their design, i.e. the appropriate reactor model(s),
	  • the measures taken t increase the energy efficiency and to reduce the environmental impact
	Transverse learning outcomes
	At the end of this course the student will be able to:
	• Study independently the different aspects of a chemical process.
	• Present and explain the different aspects of a chemical process to a professional audience, in writing and orally.
	• Look up and use scientific and technical information from various sources, including reference text books and the web.
	• To use a corpus of scientific and technical knowledge, allowing to solve given problems in the discipline studied.
	• To analyze, organize and develop an engineering approach for process development responding to specific needs or a given problem, the analysis of a given physical phenomenon or a system.
	• To contribute, as a team member, to the realization of a project with a given discipline or multiple disciplines according to a well described approach.
	• To efficiently communicate by writing and presentation, in English or French, the results of a well-defined project.
	• To show a rigorous behavior and critical thinking in carrying out scientific or technical tasks with respect for ethical issues.

Faculty or entity in charge	FYKI

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Chemical and Materials Engineering	KIMA2M	5		🔍
Master [120] in Biomedical Engineering	GBIO2M	5		🔍
Master [120] in Chemistry and Bioindustries	BIRC2M	5		🔍