Course Package

Process Technology – Q3

Name module	Process Technology – Q3
Educational programme	MSc Chemical Engineering
Period	Third quartile of second semester – Q3
Study load	15 ECTS
Coordinator	C. C. Diepenmaat

Process Technology			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
		Turbulent Combustion 201700218 (5 EC)	
		Process Equipment Design 201300155 (5 EC)	
		Electives: choose 5 EC	
		Process Dynamics & Control - 201800324 (2,5 EC)	
		Chem. Process Analysis - 201800328 (2,5 EC)	
		Electrochemical Engineering - 201800326 (2,5 EC)	

Required preliminary knowledge: Thermodynamics; Fluid Dynamics; Heat and Mass Transfer; Reaction Engineering; Separations Technology; Mathematic (among others statistics for Chemical Process Analysis); Basic fluid flow theory; Transport Phenomena and Heat Transfer on bachelor level; Intro in Reaction Engineering; Intro Separation Technology; Basic (molecular) biology; Organic chemistry; Electrochemistry and/or Electrochemistry: Fundamentals & Techniques.

201700218 - Turbulent Combustion

The course targets the student to know about numerical modelling approaches of transport in turbulent flows, and how to use them in a commercially available CFD code. The student will know about, and how to analyse, turbulent flows with chemical reactions by means of models and numerical simulation. The student will be able to handle modeling off chemical reaction described by mechanisms with many elementary reactions. He will know how use and understand turbulent flow models in a RaNS and LES approach.. The student will learn how to characterize the regime of turbulent combustion on basis of dimensionless numbers such as Reynolds, Lewis, Prandtl, Schmidt and Karlovitz numbers.This knowledge will enable the student to solve numerically turbulent transport problems in for example the process industry or power generation industry.The course treats the transport in the turbulent flow of gaseous fluids composed of multiple species, by means of diffusion, convection or chemical reaction.

Turbulence has a large effect on both convective transport and chemical reaction. The course intends to give an overview of the major processes, and a description by means of transport equations is presented. Numerical tools (Computational Fluid Dynamics) are used for product optimization and analysis. In the course several assignments in the use of numerical models for chemical reaction, turbulent convection and mixing and combustion will be given. The course will be finalized by means of a computer assignment using a CFD package made available to the students for use on their lap top computer. A practical case with application on a combustion problem will be worked out. The marking will be done on basis of the assignment reports and an oral exam.

201300155 - Process Equipment Design

An industrial process consists mainly of a reactor, separation equipment (for instance distillation), heat exchangers and pumps/compressors. This course starts with lectures to discuss the design in general, and the design of various types of unit operation in detail. Also the mechanical aspects are discussed.

Topics of the different lectures:

- design methodology in general,
- equipment for momentum transport (pumps, fans, compressors),
- equipment for heat transfer, with and without phase transition,
- equipment for mass transfer: focus on distillation.
- mechanical design aspects of process equipment.

The course is finalized with a group design assignment of three types of unit operations for momentum, heat and mass transfer from an industrial scale process. Each team (in general of 3 to 4 students) delivers a report with the results of the design calculations. At the exam two teams will present their results. Before the exam the team reports are exchanged to give the team the opportunity to study the other design. The students are asked during the final exam to compare and discuss the two different designs and to come up with a final concept. Finally, the mark is based on the group effort: the report + presentation and an individual mark for the oral exam about the design and redesign of the used process equipment part.

Electives: choose 5 EC

201800324 - Process Dynamics and Control

Part	Subjects of lecture/tutorial	Book chapter	Contents
1. dynamic process modeling	1. introduction 2. modeling	1, 2 3, 4	- Context model design - basic control scheme design - behavioral model design
2. IO-model behavior	3. process in operating point 4. process behavior	7, 6 5.1-3 5.4 10	- linearization - laplace transform - input-output again - examples
3. Controlled process behavior	5. PID behavior 6. PID in frequency domain	32.1-2 32.5 9 32.3-5	- closed-loop behavior - PID-controller tuning - Bode-plot of transfer function - PID-controller tuning

201800328 - Chemical Process Analysis

This course aims to equip students with the knowledge and skills to design experiments for chemical processes that prioritize sustainability. Emphasizing efficient and effective data collection, the course will guide participants in developing methodologies to optimize parameters in chemical processes and products while minimizing environmental impact.

Students will explore analytical strategies for continuously monitoring chemical processes, products, and instruments, ensuring that sustainability metrics are integrated into performance evaluations. The course will cover chemometric data analysis concepts, including pattern recognition and multivariate analysis, within the context of characterizing chemical process performance and selecting, verifying, and validating chemical models.

Additionally, the principles of statistical process control will be discussed, highlighting their role in maintaining quality and efficiency in sustainable manufacturing practices. Students will be able to apply their acquired knowledge and skills to real-world industrial cases, focusing on innovative solutions that enhance sustainability in chemical engineering.

201800326 - **Electrochemical Engineering**

The course will comprise of lectures and tutorials on the following topics:

- Thermodynamics of electrochemical devices (Gibbs free energy, electrical work, Nernst equation)
- Definition of real cell potential (thermodynamics vs kinetics), losses in electrochemical devices
- Novel applications of electrochemistry to replace traditional chemical processes
- Industrial electrolysis – chlor-alkali and chlorate processes: energy and cost considerations, cell configurations, operating conditions
- Hydrogen fuel cells and water/steam electrolysers – working principles of Alkaline, PEM and solid oxide cells, advantages and disadvantages of each technology
- Model-guided design of electrochemical cells using PEM/solid oxide cells as an example – relevant reaction kinetic and transport phenomena and theories used to study them, performance metrics
- Low temperature electrochemical CO2 reduction to valuable chemicals – technological advances, pH effects, operating modes and conditions, deactivation and its mediation.