

SDC

The university partnership
Denmark – China

Master's Programme in
**Chemical and
Biochemical
Engineering**



Academic Regulations

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Legal Frame

Students enrolled in this programme are admitted as full-time students at University of Chinese Academy of Sciences.

This curriculum applies to students enrolled in the programme from 2019.

This master's programme is established within the framework of the following:

- Partnership Agreement between Graduate University of Chinese Academy of Sciences and University of Copenhagen (KU), Aarhus University (AU), University of Southern Denmark (SDU), Aalborg University (AAU), Roskilde University (RUC), Technical University of Denmark (DTU), Copenhagen Business School (CBS), IT University of Copenhagen (ITU), on the establishment of the Sino-Danish Centre for Education and Research, Graduate University of Chinese Academy of Sciences, signed on 12 April 2010
- Agreement between Graduate University of Chinese Academy of Sciences (GUCAS) and University of Copenhagen (KU), Aarhus University (AU), University of Southern Denmark (SDU), Aalborg University (AAU), Roskilde University (RUC), Technical University of Denmark (DTU), Copenhagen Business School (CBS), IT University of Copenhagen (ITU) concerning Master's Programmes at Sino-Danish Centre for Education and Research, Graduate University of Chinese Academy of Sciences, signed on 29 August 2011
- Agreement between Graduate University of Chinese Academy of Sciences and Technical University Denmark concerning Provision of the Master's Programme in Chemical and Biochemical Engineering – BBE (Specialization in Biomass Based Energy) at Sino-Danish Centre for Education and Research (SDC), Graduate University of Chinese Academy of Sciences, signed on 29 August 2011.

Students must observe and act accordingly to the following rules issued by the SDC Directors:

- Courses and Exams
- Exam regulations
- Thesis regulations 10 steps
- Avoid cheating on exams
- Student complaints

Students must also observe and act accordingly to Rules and Regulations for UCAS International Students. SDC rules are published on Moodle.

Title and degree

The degree awarded by Technical University of Denmark is Master of Science in Chemical and Biochemical Engineering - Specialization in Biomass Based Energy. The degree awarded by University of Chinese Academy of Sciences is Biochemical Engineering/ Chemical Engineering.

Duration

The master's programme has a duration of two academic years equivalent to 120 ECTS points (European Credit Transfer System). 60 ECTS points correspond to one year of full-time studies.

When choosing thesis period *Danish/International students* must be aware of UCAS' 4 years limit for awarding diploma. UCAS' degree application procedure **STEP 10 CN** (see Thesis regulations 10 steps) has to be completed within four years from the enrolment. This period includes leave of absence.

Admission requirements

Admission to the Master's programme in Chemical and Biochemical Engineering (Specialization in Biomass Based Energy) is based on:

- a successfully completed bachelor 's degree (or equivalent) in chemical engineering, biochemical engineering, chemical technology, biotechnology or related fields.
- high-level English language proficiency.
- a strong, working knowledge of mathematics and natural sciences based on 1-1½ years formal courses (60-90 ECTS), distributed among different subject areas approximately thus:
 - Engineering Mathematics
 - Organic and inorganic chemistry
 - Thermodynamics and physical chemistry
 - Physics
- basics of chemical and biochemical engineering based on ½-1 year of formal courses (30-60 ECTS), distributed among different subject areas approximately thus:
 - Applied thermodynamics, mass and heat transfer, unit ops with laboratory
 - Mathematical modelling, advanced. engineering math., process control, dynamics
 - Chemical kinetics and reaction engineering
 - Basic life science, biochemistry, fermentation technology

General programme regulations

The language of instruction in the SDC master's programmes is English. Teaching, supervision and assessment will be carried out in English.

Students will be graded according to both the Chinese and the Danish grading scale. However, for the Master's Thesis, students will be graded according to the Chinese 4-point scale. See Thesis regulations 10 steps.

DK	12	10	7	4	02	00	-3
CN	100-95	94-90	89-76	75-61	60	59-40	39-0

Leave of absence can be granted to students on the grounds of becoming a parent, illness, military service or exceptional circumstances

Students who wish to complete degree programme elements at another university or institution of higher education in Denmark, China or abroad as part of their degree programme may apply the Teaching Committee for advance approval of transfer credit for planned subject elements.

Students can maximum be granted 30 ECTS credit transfer.

Either the Teaching Committee or the SDC Directors may grant exemptions to this curriculum or other SDC rules. Applications for exemption are submitted to the SDC Secretariat.

Qualifications

Purpose

The programme focuses on theoretical, experimental and practical aspects of chemical and biochemical process engineering that are of relevance for the use of biomass and waste as feedstocks and energy sources, replacing fossil resources and fuels. Key elements are:

- Processes rooted in chemical or biochemical engineering, but applicable to the biomass and energy field.
- Cross-disciplinary and cross-cultural design and development.
- Sustainability of biomass based chemical production and fuel conversion.
- Knowledge about Chinese culture and business environment integrated in the programme

Qualification Profile

The programme has two central objectives:

- Academic cutting-edge qualifications
- Polytechnic holistic qualifications that, in addition to an identity-creating professionalism, also include being able to gain an overview of a complex technical problem and being able to think in technical terms in commercial and societal contexts

The graduate has the qualifications required to analyse, synthesise and evaluate theory and experiments relating to complex and complicated engineering systems, issues and solutions for the benefit of society.

Knowledge and understanding

The graduate:

- has a solid understanding of and a firm base of knowledge in natural sciences and technological principles, possesses comprehensive knowledge within a given subject area, and is familiar with the current development trends and opportunities within the academic area.
- can identify and reflect on technical scientific issues and understand the interaction between the various components of an issue.
- can, based on a clear academic profile, apply elements of current research at international level to develop ideas and solve problems.
- has insight into and understanding of the internal interaction between the various engineering domains and other competences in connection with solving specific engineering problems.
- possesses knowledge about sustainability, innovation and entrepreneurship.
- is familiar with the application of relevant natural sciences to process and product-oriented technical issues.
- possesses knowledge about mathematical and model-based description at scientific level of chemical and biochemical process equipment and the processes to be found in the same.
- can differentiate between stationary conditions for open systems and equilibrium.
- possesses knowledge about the use of numerical tools (programming in high-level language or professional simulation software) for analysing chemical and biochemical engineering problems and dimensioning equipment.
- is familiar with methods for addressing process and/or product-oriented open design issues.
- is familiar with chemical and biochemical process equipment and its application, including ongoing development and research results within one or more delimited areas.

Skills

The graduate:

- masters technical scientific methodologies, theories and tools, and has the capacity to take a holistic view of and delimit a complex, open issue, put it into a broader academic and societal perspective and, on this basis, propose a variety of possible actions.
- can, via analysis and modelling, develop relevant models, systems and processes for solving technological problems.
- can communicate and mediate research-based knowledge both orally and in writing.
- can discuss technological issues with various types of stakeholder.
- is familiar with and can seek out leading international research within his/her specialist area.
- is trained in the assessment of process and product engineering knowledge in relation to chemical and biochemical engineering problems in development and research.
- can understand and critically assess knowledge in the professional field—both internally and in partnership with external players.
- can apply advanced chemical, physical-chemical, biochemical and biological knowledge to process and/or product-oriented technical issues.
- can scale chemical and biochemical processes up from laboratory to industrial production.
- can dimension equipment for both rate-based and equilibrium-based processes.

Competences

The graduate:

- masters technical problem-solving at a high level through project work, and has the capacity to work with and manage all phases of a project – including preparation of timetables, design, solution and documentation.
- can work independently and reflect on his/her own learning, academic development and specialisation.
- can independently combine his/her technological knowledge with knowledge about business, management, organization and project work.
- can organize the operation and optimization of chemical and biochemical production, including reduction of energy consumption and environmental impact.
- can analyse, process and assess issues, both qualitatively and quantitatively, in operation, development and research within one or more specialist areas.
- can apply advanced chemical and biochemical engineering theory for the solution of research or development assignments.
- can present results of research and development work in writing and orally, and can mediate results to people with the same or a different professional background—both those with and without a scientific education.
- can plan, execute and manage experimental studies on any scale from laboratory to production facility, including handling large datasets.
- can launch and participate in development and research teams involving laboratory staff, technicians and other people who have completed professional and/or short-term courses of higher education.
- can synthesise commercially viable and societally acceptable proposals for operational improvements and process or product development in chemical and biochemical plants.
- can - on the basis of the programme - participate in the management of research teams.
- can account for objectives, challenges and methods included in interdisciplinary research, development and innovation groups.
- can assimilate new and relevant natural science knowledge, and develop this in a commercial chemical and biochemical engineering context.

Structure

The programme contains the following elements:

*SDC Research Immersion can only be taken by students who have had similar laboratory courses in unit operation in DTU during bachelor study.

Semester	Course / Programme element	Exam	Grading	Examiners	ECTS
1	Industrial Reaction Engineering	Assignments and oral	7/100 scale	External	7,5
	Transport Processes	Assignments and written	7/100 scale	External	10
	Industrial BioReaction Engineering	Assignments and written	7/100 scale	Internal	5
	Biorefinery	Assignments and written	7/100 scale	Internal	5
2	Green Chemical Engineering	Assignments	7/100 scale	Internal	5
	Process Design - Principle and Methods	Assignments and oral	7/100 scale	Internal	10
	Coatings Science and Technology	Written	7/100 scale	Internal	5
	SDC Green Challenge	Assignments and oral	Pass/Not-pass	Internal	5
	SDC Summer School in Unit Operation/SDC Research Immersion*	Assignments	7/100 scale	Internal	7,5
3	Laboratory Experiments	Assignments	7/100 scale	Internal	5
	Progress in Research	Assignments	Pass/Not-pass	Internal	5
	Technology, Economics, Management and Organization	Assignments and written	7/100 scale	External	10
	Combustion and High Temperature Processes	Assignments	7/100 scale	Internal	5
	Fluidization and Multiphase Flow	Assignments	7/100 scale	Internal	5
4	Thesis	Assignment and oral	7/4 scale	External	30

All programme elements are mandatory.

Course and exam descriptions

Industrial Reaction Engineering

7,5 ECTS

CONTENT

A major part of chemical reactions in production processes and in gas cleaning processes takes place in multi-phase reactors, e.g. production of pharmaceuticals, calcination of lime in the production of calcium hydroxide, production of cement, combustion of solid and liquid fuels in the production of power and heat, catalytic and non-catalytic cleaning of flue gas and catalytic production of important products in different reactors including two or more phases. The examples are homogeneous or heterogeneous catalysed, gassolid, gas-liquid, liquid-solid and gas-liquid-solid reactions that take place in a number of different reactor types (batch fixed bed, moving bed, spray absorbers, packed towers, membrane reactors, fluidized bed reactors, entrained flow reactors etc.). The theory covering the different types of reactions and a number of the reactors is expounded together with examples. During the semester, the students cooperate in teams solving practical oriented reactor design problems.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- characterise solid particulates with respect to size, size distribution, shape, porosity, texture.
- calculate effective diffusion coefficients in simple structures.
- establish and solve mathematical models for gas-solid reactions (transport phenomena coupled to chemical reactions).
- evaluate structure models for gas-solid reactions.
- establish and solve models for gas-liquid-solid reactions.
- explain the enhancement factor for gas-liquid reactions.
- analyse and simplify complicated reaction engineering problems in order to establish mathematical models for the main phenomena.
- evaluate calculations for reaction engineering problems in order to use the results for practical design.

EXAMINATION

The course is evaluated based on solutions of three home exercises, three course assignments and an individual oral exam of 10 minutes. In the oral exam, each student is examined based on questions related to one of the course assignments chosen randomly by the examiners. No aid is allowed in the oral exam. External examiner.

RE-EXAMINATION

The re-exam consists of re-submission of home exercises and course assignments specified by the teacher based on results of the ordinary exam, and an individual oral exam of 10 minutes following the same rules as the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Transport Processes

10 ECTS

CONTENT

Mechanisms for the transport of momentum (flow), energy and mass in chemical and biological systems. Introduction to computational fluid dynamics (CFD) as basis for analysis and simulation of transport processes. Applications in the design of equipment and analytical instrumentation in the chemical, biotechnological and pharmaceutical industry.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- describe the molecular processes behind viscosity, thermal conduction and diffusion.
- obtain analytical solutions for flow problems with simple boundary and initial data.
- formulate and analyse models for combined flow and heat transport.
- formulate and analyse models for combined flow and diffusion.
- formulate and analyse models for combined flow and chemical reaction.
- do order of magnitude estimates for key quantities such as fluxes, reaction rates and equilibration times.
- use CFD for the simulation of flow with combined heat and mass transport (COMSOL).
- evaluate the accuracy of approximations obtained by Computational Fluid Dynamics.
- formulate models for transport with a small or large parameter (boundary layers).

EXAMINATION

The report on Project 1 contributes 20%, and the report on Project 2 contributes 20% of the final grade. Each project is estimated to amount to about 1 week's full time work. Project reports are limited to 10 pages each, not including a title page. Turn-in of reports resulting in a grade of at least 00/40 for each is a mandatory condition for participation in the written exam. The final 4-hour written exam (all aids except internet) contributes 60% of the final grade.

RE-EXAM

Grades for projects 1 and 2 carry over from the ordinary exam (weights 20% and 20%), and no new or substitute project reports can be submitted for the re-exam. The re-exam only covers the 4-hour written exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Industrial Bioreaction Engineering

5 ECTS

CONTENT

Role of fermentation in industrial manufacture of chemicals. Stoichiometry of cellular reactions, degree of reduction balances, yield coefficients and black box models. Mass balances evaluation of the feasibility of fermentation processes in an industrial context. Growth kinetics. Thermodynamics of bioreactions and heat balances. ATP balances and energetics. Scale-up and design of fermentation processes. Process evaluation project.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- describe the role of fermentation processes in the context of processes for production of industrial chemicals.
- calculate mass balances for fermentations including gas-liquid mass transfer.
- calculate carbon and degree of reduction balances for fermentation processes.
- evaluate the feasibility of fermentation processes in an industrial context.
- analyse the consistency of experimental data using simple models.
- describe different types of growth kinetic models.
- calculate the heat of production of fermentation processes.
- describe the principles for design and scale-up of a bioreactor.

EXAMINATION

- a process evaluation project (50%). The project will evaluate a given chemical made by fermentation on the basis of techno-economic performance and sustainability. The analysis will be used to identify a research and development plan. Projects are in groups of 2 and include a presentation and submission of a single written report of around 20 pages.
- A written exam (50%). The exam will be 4 hours, with aids, but without internet access.

RE-EXAM

The same as the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Biorefinery

5 ECTS

CONTENT

To provide the students with basic knowledge about the biorefinery concept and integrated processes that convert biomass into multiple products of bioenergy, biomaterials and biochemicals.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- Describe the physical and chemical structures of biomass and their potential use for production of bioenergy, biomaterials and biochemicals
- Identify and describe biomass resources (forest, agricultural, municipal and marine biomass), their occurrence and application in a biorefinery concept
- Identify and describe biomass constituents (starch, cellulose, hemicellulose, lignin, pectin, protein, lipids)
- Outline the principles of a biorefinery including chemical, biological and thermo-chemical conversion methods
- Outline and compare various methods of biomass processing for production of bioenergy products, biomaterials, chemicals and building blocks for chemical synthesis
- Design a theoretical and creative biorefinery based on scientific references

Content and perspective:

The course will give a broad perspective over the biorefinery concept by introducing the key integrated processes, such as biomass production, pretreatment, and chemical-, biological- and thermo-chemical- conversion. The lectures will focus on bioresources and single processing steps and will include industrial and scientific examples. In the case study the students will combine multiple processing steps into a novel biorefinery concept. There will be emphasis on sustainable systems throughout the course.

Module structure and teaching approach:

The course is divided into four main blocks:

- Chemical characterization of biomass and recovery of biochemicals of industrial interest. Calculations include mass balances and stoichiometry.
- Green processes/techniques used in biorefineries: Enzyme technology, Membrane technology, Clean solvents, Integration reaction-separation, Use of microwaves/ultrasound.
- Introduction to Energy from biomass: Physical, microbiological and thermodynamical processes. Gasification and pyrolysis. Biogas. (To be continued in course "Production of Biofuels")
- Other applications: Biomaterials.

EXAMINATION

Attendance is mandatory

The course is evaluated based on: 1) a project report (max. 5 pages per student) that the students develop in groups of 4 people (50%). Each group shares the same raw material, but each of the students work on the production of an individual different product. Therefore, the assessment of the report is individual, and 2) a written exam (50%). The written exam is 2 hours and 25 minutes and consists of a theoretical quiz (25 minutes) and a calculations part (2 hours). No aids allowed only a simple calculator for the final written exam.

RE-EXAMINATION

The re-exam is evaluated based on: 1) an individual project report of max 5 pages (50%) and 2) a written exam (50%). The written exam is 2 hours and 25 minutes and consists of a theoretical quiz (25 minutes) and a calculations part (2 hours). No aids allowed only a simple calculator for the final written exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Green Chemical Engineering

5 ECTS

CONTENT

- Introduction to green chemical engineering
- History of green chemical engineering
- Catalysis in green chemical engineering
- Green chemical engineering in organic synthesis
- New green materials
- Green materials design

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- understand the basic concept of green chemical engineering and state of the art of research and application.
- carry out basic approaches of design catalysts for application to green chemical engineering.
- make the preliminary design of a green process.

EXAMINATION

2 course assignments of 4-6 pages each are to be solved individually. The final marks are given based on the marks of the course assignments (50 % each).

RE-EXAMINATION

The same as the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Process Design – Principles & Methods

10 ECTS

CONTENT

The course will be divided into two parts.

The first part will deal with introduction to process design principles, the stages of the process design life cycle and the preliminary design steps (flow sheet synthesis, equipment sizing/costing, economic evaluation, scheduling of batch operations, distillation sequences, and pinch analysis).

The second part will deal with conceptual design (advanced process synthesis (such as heat integration, heat exchanger networks, reactor networks, reaction-separation sequences, and solvent selection), equipment selection, and flow sheet optimisation).

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- make design related decisions.
- use knowledge to solve practical engineering problems.
- collect and assess missing data and information from the open scientific literature.
- work in groups.
- use computer aided tools.
- generate and screen alternatives.
- verify and analyse simulation results.
- formulate process design problems and to develop systematic solution strategies.
- apply chemical engineering principles learned from other courses.
- apply "green" or environmental issues in process design.

EXAMINATION

Evaluation of exercises/design project report plus oral presentation of design project and minor take-home exam problems.

RE-EXAMINATION

The same as the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Coatings Science and Technology

5 ECTS

CONTENT AND PERSPECTIVE

The course will give a broad perspective on polymers and coatings. Course contents are: basics of polymers, molecular weight, mixtures and blends, crosslinking chemistry (acrylics, polyurethanes, epoxy and alkyds), mechanical and thermal properties of polymers, corrosion, electrochemistry, anticorrosive coatings, basics of coatings, crosslinking in coatings, solvents, latex, rheology, pigments, pigment dispersion, exterior durability, intumescent coatings, insulation coatings, blade coatings, coating failures and degradation, coatings specification, testing, and inspection.

LEARNING OBJECTIVES

To provide the students with a basic knowledge on coatings and polymers used in coatings. The course focus is on understanding and principles (as opposed to systematically going through specific coating ingredients).

A student who has met the objectives of the course will be able to:

- Determine polymer molecular weight distributions from average molecular weights
- Draw phase diagrams for polymer melts/mixtures and determine miscibility of systems
- Estimate suitable solvents for different polymers
- Explain crosslinking mechanisms
- Determine the effect of various parameters on the mechanical and thermal properties
- Estimate solvent properties and analyze rheological phenomena in coatings
- Characterize pigments and pigment dispersion
- Set up simple rate models for coatings behaviour
- Identify types of corrosion/corrosion mechanisms
- Understand the fundamentals of electrochemistry
- Classify methods used for corrosion prevention
- Select the coatings for protection against corrosion and deterioration of industrial structures
- Understand common coating degradation mechanisms
- Explain and identify common coating failures
- Select relevant coatings standards and test protocols
- Do basic coating system specifications for the heavy industry
- Identify common surface preparation and application techniques

EXAMINATION

4-Hour written exam. All aid, without internet.

RE-EXAMINATION

Oral exam. The student(s) who attend(s) the re-exam will draw one question from a pool of ten questions. Questions related will be asked. The students do not know the questions beforehand and the questions will be based on the topics taught in the course. The total evaluation is 15 minutes.

No aids are allowed.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

SDC Green Challenge

5 ECTS

CONTENT

This course will provide the students with an opportunity to use their knowledge obtained from the SDC MSc Program in Chemical and Biochemical Engineering to identify an energy or environment related challenge in China or Denmark, to develop a concept addressing the challenge, and to evaluate the feasibility of the concept with respect to technology, economy and sustainability.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- identify and analyse an energy or environment related challenge in China or Denmark.
- conceive chemical and biochemical engineering solutions.
- develop a solution concept to the point where the feasibility of the concept can be decided.
- evaluate the technical, economic and sustainable aspects of the solutions.
- present the results to non-specialists and participate in scientific/non-scientific discussions.

EXAMINATION

The students will work in teams of four students. Each team must:

- 1) participate in the GRØN DYST at DTU, including submitting of abstract and presentation to the conference.
- 2) complete a report for the developed project for GRØN DYST. The report is expected to be 10-30 pages and be submitted at the end of the course.

The course is evaluated based on the report (50%) and an individual presentation of the GrønDyst project at the oral exam (50%). The duration of the presentation is 2 minutes (same as the final presentation of GrønDyst), followed up by a discussion/question session of 5 minutes.

Evaluation: pass/not pass, internal examiner.

RE-EXAMINATION

The re-exam consists of re-submission of the report and an individual oral exam following the same rule as the ordinary exam.

GRADING

The course is evaluated according to pass/non-pass.

Summer School in Unit Operations

7,5 ECTS

CONTENT

1-week theoretical study, 3-week experiments and half-week visits to companies and chemical plants.

In the 1-week theoretical study, the students will be introduced to core theory in Unit Operations, such as liquid and gas flow, absorption and distillation columns, drying, extraction, pumps, filtration, mixing, and heat transfer. The students will carry out five individual theory exercises.

In the 3-week experiments, in groups of two, the students perform and report on four exercises within the following areas: flow in pumps, pipes and fittings, flow through particle beds, heat transmission, distillation, absorption, extraction, filtration, membrane filtration, centrifugation, drying, evaporation/crystallization, agitation.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- understand the core theory in unit operations.
- apply theory to practical experimental problems.
- analyse results and formulate conclusions concerning the quality and applicability of the results and to draw consequences for the process operation, plant design and functionality of the components.
- operate process units incl. data acquisition systems and measuring equipment in pilot scale size.
- explain the design of processes.
- recognise technical components on real life plants.
- identify and explain practical tasks concerning sampling and measuring techniques.
- make a report on an experimental job in an organised way, which makes it easy to read and understand calculations on conclusions.

EXAMINATION

The course is evaluated based on the five individual theory exercises (25%) and the four reports (in a group of two students) on experiments (75%). The reports must be done according to a report writing guide provided by the teacher.

RE-EXAMINATION

The re-exam consists of re-submission of theory exercises and/or reports specified by the teacher based on the results of the ordinary exam,

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

SDC Research Immersion

7.5 ETCS

CONTENT

Through participation in a research project in a shorter period of time, the student will try to answer a question or solve a problem, which is connected to the work of the supervisors. The student will gain knowledge within a topic related to the research area of the Department of Chemical & Biochemical Engineering, while gaining insight into how the scientific method is put into practice to solve a given problem. The student will also gain general competences, e.g. the ability to participate in constructive mentor-mentee relationships and the ability to communicate science – in writing as well as orally.

Participation in a research project in collaboration with supervisors. The supervisors can be professors, researchers, postdocs or PhD students at DTU Chemical Engineering. The exact content of the project will be further agreed upon with the supervisors. The project must be communicated in a final, written report.

LEARNING OBJECTIVES

A student who has met the objectives of the course will be able to:

- work in a focused and strategic manner to retrieve scientific literature.
- extract information from scientific articles of relevance to a scientific project.
- critically evaluate his/her own and others experimental designs.
- plan, carry out and finalise a project under tight time constraints.
- communicate the results of a scientific project in a report that could be shaped like a scientific article.
- constructively participate in a student-supervisor relationship.
- explore and analyse relevant technologies for solving the given problem.

EXAMINATION

The course is evaluated based on a final, written report by individual student.

RE-EXAMINATION

The same as the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Note: This course is only offered to SDC students who have taken a laboratory course in unit operations at DTU Chemical Engineering during bachelor study.

Laboratory Experiments

5 ECTS

CONTENT

The course contains six experiments in laboratories at Institute of Process Engineering (IPE)

- CaCo₂ decomposition in TGA
- Enzyme immobilisation in membranes
- Membrane separation
- Gas adsorption
- Dissolution of cellulose by ionic liquid
- Catalysts synthesis and evaluation

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- collaborate in team work during experiments.
- understand the appropriate approaches and the fundamentals of process engineering by carrying out the experiments.
- treat experimental data in a scientific way.

EXAMINATION

Perform six laboratory experiments in groups of 2-3 students in rotation. Each group will submit a report in a standard template for each experiment. The final marks are given based on the marks for the six reports (16.6 % each).

RE-EXAMINATION

The form of re-exam will be the same as the ordinary exam, but will only cover the experiments that fail in the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Progress in Research

5 ECTS

CONTENT

This course will provide the student with information on both academic research from Denmark and China and industrial research and development from companies with activities in both Denmark and China.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- describe examples of industrial research and development.
- describe examples of front line academic research.
- understand the difference between academic and industrial research.
- read and understand scientific literature.
- participate in research based discussions.

EXAMINATION

Each student has to complete at least 10 reports about the individual research presentations. Each report is three pages, including an introduction to the research organization, a summary of a research paper related to the presentation, and a description of the student's opinions about the research challenges and potential research ideas. Evaluation pass/non-pass based on the reports.

RE-EXAMINATION

The re-exam consists of re-submission of reports that are failed in the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Technology Economics Management and Organization

10 ECTS

CONTENT

The student is introduced to theories and models of business design, management and organization and to specific issues such as planning, organizing, leading, controlling, strategy, innovation, and business models.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- identify and summarise key theories and models from the curriculum.
- explain and describe business models, organisational design and management activities in a specific case.
- apply theories and models from the curriculum in a solution proposal for a specific problem and explain the relevance of the chosen theories and models.
- analyse a specific case from a strategic, tactical and operational perspective.
- formulate a synthesis including managerial, organisational and business perspectives in relation to a specific problem.
- select organisational interventions and management activities from the curriculum to support the implementation of a strategy in a company and make an argumentation for the selection.
- outline the assumptions and preconditions of a specific problem and give an account of the consequences on the possible solution if these assumptions and preconditions are changed.

EXAMINATION

The course is evaluated based on an individual 45 minutes multiple choice exam on the entire syllabus (30%) and a written group report on a business challenge from a company (70%).

RE-EXAMINATION

The same as the ordinary. The written report can be written individually or in groups of up to 3 students provided that other students are taking the re-exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Combustion and High Temperature Processes

5 ECTS

CONTENT

Topics covered in the course include combustion of gaseous, liquid and solid fuels in different combustion systems such as gas turbines, motors, pulverised fuel combustors, fixed bed and fluid bed, as well as related industrial high temperature processes. The different systems are treated theoretically and the students solve larger, practically oriented problems during the course.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- set up mass and energy balances for combustion systems.
- estimate flue gas amount and composition from stoichiometric calculations.
- use simplified and detailed chemical models to estimate combustion rate and formation of pollutant species.
- couple chemical and thermal analyses of reacting systems.
- set up simplified conservation equations for reacting flows.
- explain conceptual and practical differences between premixed and diffusion flames.
- assess the impact of turbulence on combustion rates.
- set up and use simplified models for droplet evaporation and combustion.
- set up and use simplified models for particle heating and pyrolysis.
- set up and use simplified models for char oxidation.
- use the above tools together with numerical solvers to evaluate and optimise industrial high temperature processes.

EXAMINATION

Evaluation of exercises/reports. The grade is determined from an overall evaluation of two course exercises (90%) and five problem sets (10%).

RE-EXAMINATION

The same as the ordinary exam

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Fluidization and Multiphase Flow

5 ECTS

CONTENT

- Fluidization phenomena
- Flow regime
- bubbling and circulating fluidized bed
- Multi-phase flow dynamics
- Models for the two-phase flow
- Application of fluidized bed

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- understand the flow regime of gas-solid flow and state of the art of research and application.
- manage basic calculations and solve practical problems related to fluidization.
- overview the modelling approached.
- design a fluidized bed reactor with preliminary requirement.

EXAMINATION

Evaluation of exercises/assignments. The grade is determined on the basis of an overall evaluation of two course exercises (70%) and two assignments with presentation (30%). The exercises take the form of basic calculations and solving practical problems of design and scale-up of fluidized bed reactors. The assignments take the form of overview of literature on selected topics and oral presentations.

RE-EXAMINATION

The re-exam is based on resubmitted exercises/assignments and an oral exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales.

Thesis

30 ECTS

The MSc thesis in the CBE programme must abide by the 'SDC Thesis Regulations, 10 steps'. The following special CBE rules describe CBE specific interpretations, limitations, and approved extensions.

The MSc thesis in the CBE programme is a 30 ECTS thesis. The MSc thesis is the final assignment of the programme. The objective of the MSc thesis is to give students the opportunity to apply the knowledge they have acquired in an independent way on a larger project that concludes with a written report. The thesis must document skills in applying scientific theories and methodologies to a clearly defined academic topic. The Heads of the Educational Programme (HEPs) must approve that the MSc thesis falls within the technical and scientific field of the programme.

The MSc thesis must be written in English and it must include an abstract.

The MSc thesis may be undertaken in collaboration with a company.

Each of the student must have a Chinese supervisor and a Danish supervisor. For assignment of supervisors, 'SDC Thesis Regulations, 10 steps' must be followed. Both supervisors must regularly follow the progress of the thesis.

CONTENT AND LEARNING OBJECTIVES

The content of the thesis must be settled according to the procedure in 'SDC Thesis Regulations, 10 steps', steps 3 and 5. The thesis content is part of the SDC thesis contract. The thesis may contain a combination of experimental work, fieldwork, theoretical studies, synthesis, modelling and analysis. All thesis must include elements of literature studies and criticism. In addition, the thesis contains the following overarching learning objectives:

A graduate of the MSc programme in Chemical and Biochemical from SDC:

- can identify and reflect on technical scientific issues and understand the interaction between the various components that make up an issue.
- can, on the basis of a clear academic profile, apply elements of current research at international level to develop ideas and solve problems.
- masters technical scientific methodologies, theories and tools, and has the capacity to take a holistic view of and delimit a complex, open issue, see it in a broader academic and societal perspective and, on this basis, propose a variety of possible actions.
- can, via analysis and modelling, develop relevant models, systems and processes for solving technological problems.
- can communicate and mediate research-based knowledge both orally and in writing.
- is familiar with and can seek out leading international research within his/her specialist area.
- can work independently and reflect on his/her own learning, academic development and specialisation.
- masters technical problem-solving at a high level through project work, and has the capacity to work with and manage all phases of a project – including preparation of timetables, design, solution and documentation.

Submission of project plan must follow the procedure in 'SDC Thesis Regulations, 10 steps'. However, Step 5 must be completed no later than 1 month after the beginning date, and the thesis contract must include a project plan. In the project plan, the student is also to take into account the overarching learning objectives listed above. When submitting the thesis, the student is to enclose a separate document presenting the original project plan and a revision of the same, where appropriate. In addition, the document is to include a brief auto-evaluation of the project process.

Project deadline.

The project deadlines are given in 'SDC Thesis Regulations, 10 steps'.

Assessment

In assessment of a MSc thesis, the quality of the academic contents will carry the most weight. The students writing abilities will also count, though this will be weighted slightly less, while spelling will carry little weight.

The MSc thesis is evaluated based on a report and an oral defence. The report and the oral defence will be evaluated as a whole. The oral defence of the MSc thesis must follow the procedure in 'SDC Thesis Regulations, 10 steps'.

RE-EXAMINATION

The re-exam must follow the procedure in 'SDC Thesis Regulations, 10 steps'.

GRADING

For the Danish/international students, grades are given according to the Danish 7 step and the Chinese 4 step thesis grading scales.

For the Chinese students, grades are given according to the Danish 7 step grading scale only.

The details of the thesis procedure are described in SDC Thesis Regulations 10 Steps.

Commencement

Effective as of 01.09.2019

Changes to Curriculum

No changes yet.