GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2018-2019

Polymer Processing (E064960)

Course size (nominal values; actual values may depend on programme)

Credits 6.0 Study time 180 h Contact hrs 60.0 h

Course offerings and teaching methods in academic year 2018-2019

A (semester 2)	Dutch	practicum	15.0 h
		guided self-study	30.0 h
		seminar: coached exercises	15.0 h
B (semester 2)	English	seminar: coached exercises	15.0 h
		lecture	30.0 h
		practicum	15.0 h

Lecturers in academic year 2018-2019

D'hooge, Dagmar	TW11	lecturer-in-charge
Cardon, Ludwig	TW11	co-lecturer

Offered in the following programmes in 2018-2019	crdts	offering
Bridging Programme Master of Science in Sustainable Materials Engineering	6	B
Bridging Programme Master of Science in Materials Engineering	6	A
Master of Science in Electromechanical Engineering (main subject Control Engineering and Automation)	6	B
Master of Science in Electromechanical Engineering (main subject Electrical Power Engineering)	6	B
Master of Science in Electromechanical Engineering (main subject Maritime Engineering)	6	B
Master of Science in Electromechanical Engineering (main subject Mechanical Construction)	6	B
Master of Science in Electromechanical Engineering (main subject Mechanical Energy Engineering)	6	B
Master of Science in Chemical Engineering	6	B
Master of Science in Sustainable Materials Engineering	6	B
Master of Science in Materials Engineering	6	A
Master of Science in Chemical Engineering	6	B

Teaching languages

Dutch, English

Keywords

polymer flow, extrusion, polymer degradation, film blowing, spinning, thermoforming, injection moulding, additive manufacturing, chemical and mechanical recycling, polymer tribology and permeability

Position of the course

The combined application of the basic concepts of polymer physics, polymer chemistry, material science, mechanical engineering, structure and dynamics of polymers, and transport phenomena with as aim the fundamental understanding, design, and optimization of the major industrial polymer processing techniques. Attention is focused on both operational and simulation characteristics on the one hand and sustainability and recycling on the other hand. Case studies are included per polymer processing technique considered.

Contents

- Chapter 1: Introduction
  - Principle of main polymer processing techniques, *i.e.* extrusion, thermoforming, injection moulding, additive manufacturing, and polymer recycling
  - Importance of polymer synthesis prior to polymer processing
  - Importance of polymer degradation during polymer processing
    - experimental characterization, including rheological measurements
    - simulation techniques, including method of moments
- Chapter 2: Extrusion
  - Operational characteristics
    - screw pump principle for single screw extrusion, energy comsumption, and overall energy balance
    - added value components
  - Simulation techniques
    - hopper section
      - pressure distribution
      - flow instabilities
      - case study
    - melting section
      - basic 1D model: melt removal by drag
      - extended 2D model: convection and temperature dependent shear
      - case study: determination of optimal height for fast melting
    - pressurization section
      - basic 1D model: combined drag and pressure flow
      - extended 2D model: Newtonian extrusion theory
      - relation with die
      - case study: calculation of complete pressure and temperature profile of non-Newtonian polymer melt
    - reactive extrusion
      - basic model
      - case study
  - Special applications
    - twin screw extrusion
    - wire/tube/foil/profile extrusion
    - extrusion & stretch blow moulding
    - co-extrusion
    - drawing setup for fibre/filament or tape/yarn extrusion
    - basic models
- Chapter 3: Thermoforming
  - Operational characteristics
    - thermoforming and heating methods
    - mould setup
    - deformation range
    - shrinkage after thermoforming
  - Simulation techniques: basic models
- Chapter 4: Injection moulding
  - Operational characteristics
    - injection process
    - parameters affecting rheological and morphological structures
  - Simulation techniques
    - basic 1D-model: conduction with stepwise temperature change, including extension to finite dimensions and contribution of convection
    - extended Leveque model: calculation of cooling efficiency
    - case study: design of preforming injection moulding step for production of polyethylene terephthalate (PET) bottles
    - reactive injection moulding:
      - basic model
      - case study: highly filled copolymer of ethylene and vinyl acetate
- Chapter 5: Additive manufacturing
  - Processing methods
  - Parameters affecting the processability and material perfomance: mechanical, physical-chemical and morphological
  - Case studies: (i) laser sintering; (ii) extrusion-based additive manufacturing
- Chapter 6: Polymer recycling
  - Chemical or feedstock recycling
    - main characteristics and methods (*e.g.* thermal and catalytic cracking)
    - case studies: chemical recycling of (i) poly(methyl methacrylate); (ii) polyethylene; (iii) polypropylene (PP); (iv) PET and poly (vinyl chloride), including feasibility of direct repolymerization and recycling for steelmaking
  - Mechanical recycling
    - main characteristics and methods: collection, washing, sorting, and recompounding

        - Effects on polymer structure and properties
        - origin, properties and (dis)advantages of recycled polymer blends
        - case studies: (i) mechanical recycling of mixed polyolefins; (ii) mechanical recycling of PET-PP blends; (iii) resource efficiency of recycled polymers
    - Life cycle analysis:
    - Integration of recycling methods
    - Multi-objection optimization: global warmth potential and net present value
- Chapter 7: Application properties
    - Main properties
        - importance of polymer synthesis and processing parameters
        - mechanical properties (*e.g.* elasticity modulus and thougness)
        - recovery: fibers
        - permeability: packaging
        - tribology: thermoplasts, elastomers and composites (optimal composition)
    - Case studies: (i) resilience for artificial turf; (ii) barrier properties via polymer/clay nanocomposites: model description; (iii) controlled friction for rubber tires: weather conditions; (iv) sustainability solar cells

Initial competences

This course builds on basic knowledge on material science, organic chemistry, polymer chemistry and physics, and transport phenomena.

Final competences

1 Knowledge: describing and defining the following concepts: polymer degradation, extrudor sections, (non-)Newtonian extrusion theory, thermoforming, injection moulding, additive manufacturing, chemical/mechanical recycling, pyrolysis, catalytic cracking, permeability, recovery, tribology, flow stability, pressurization, melting efficiency, reactive extrusion, reactive injection moulding, multi-objective optimization, life cycle analysis, polymer modification during polymer processing.
2 Knowledge: discussing the relation between process parameters and industrial performance of polymer processing units, the importance of the polymer microstructure during polymer processing, the major production processes for polymer applications and the integration of polymer recycling techniques.
3 Skills: distinguishing and identifying polymer processing techniques for a given final application, applying conservation laws for mass, momentum and energy for industrial polymer processing, evaluating the importance of the polymer microstucture and transport phenomena on various length and time scales, assessing typical order of magnitudes related to the design of polymer processing units, and understanding the relevance and interconnection of mechanical engineering, material science and polymer chemistry for the fundamental understanding and optimization of polymer processing units.
4 Attitude: being able to solve a design problem in het field of polymer processing independently and in group.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Guided self-study, lecture, practicum, seminar: coached exercises

Extra information on the teaching methods

The lectures are used to teach the theoretical background complemented with some practical examples/case studies. During the seminars (about 3), further practical examples are provided and the solution is reached in essence during the seminars themself. During the practical sessions (about 3) attention is focused on the operational characteristics and the importance of an appropriate design is further highlighted.

Learning materials and price

Syllabus (handouts); electronically available via Minerva (https://minerva.ugent.be)

References

1. Introduction to polymers, R.J. Young, P.A. Lovell, 2011, ISBN 978-0-8493-3929-5
2. Handbook of Polymer Reaction Engineering (volume 1 and 2), T. Meyer and J. Keurentjes, Wiley- VCH, 2005 ISBN 3-527-31014-2
3. Modeling and Simulation in Polymers, P.D. Gujrati and A. I. Leonov, Wiley-VCH, ISBN: 978-3-527-32415-6
4. Degradable Polymers, Recycling, and Plastics Waste Management . A.C. Albertsson, S.J. Huang, CRC Press, ISBN: 0-8247-9668-3

Course content-related study coaching

Lecturer and assistant are available after appointment for extra explanation about the course and for feedback on the evaluations.

Evaluation methods

end-of-term evaluation

Examination methods in case of periodic evaluation during the first examination period

Oral examination

Examination methods in case of periodic evaluation during the second examination period

Oral examination

Examination methods in case of permanent evaluation

Possibilities of retake in case of permanent evaluation

not applicable

Extra information on the examination methods

Periodic evaluation: oral exam (closed-book), written preparation

Calculation of the examination mark

Periodic evaluation: theory (14/20) and exercises (6/20)