KTH Fiber- och polymerteknologi

Polymer Engineering & Processing – 2023 (7.5 hp)

KF2505

Overview:

The course provides an overview of the processing routes for thermoplastics, thermosets, and rubbers and describes how these can convert polymers into products with consideration to the macromolecular structures of the polymers. The polymer categories are described to extents that are representing their processing abundance in society.

Melt processing of thermoplastics is described in terms of the mechanical and physical behaviors related to processing parameters, including; melting, rheology and viscosity, molecular orientation, crystal formation/growth, and crystallization relevance. The industrial techniques extrusion, injection molding, hot forming, film blowing, and calendaring are discussed in detail. The mechanical properties of the formed materials are reviewed in terms of viscoelasticity, plasticity, deformation rates, and effects of temperatures (as a consequence of processing parameters).

The techniques are exemplified by laboratory exercises, including extrusion and injection molding of some of the most common thermoplastics.

Thermosetting polymers are introduced as a polymer category with cross-linked polymer chains and described as a matrix material for fiber-reinforced polymer structures. Laminates and different impregnation techniques with thermosetting polymers (epoxies, polyesters, and vinyl esters) are reviewed, as well as high and low-temperature curing. An introduction to the most common industrial methods to improve composite fiber/filler interfaces is given, e.g., for improved mechanical properties.

Cross-linked elastomers (rubbers) are presented, and the main types are discussed in detail, followed by a laboratory exercise introducing the students to natural rubber vulcanization.

A part of the course consists of projects. It concerns the selection of polymer materials in a product where the students analyze its constituent materials as related to its applied processing environment. The aim is to investigate the processing of the materials as related to material specific demands (and production costs), and to discuss possible improvements or drawbacks.

The overall learning goal with the course is that the students have acquired a general knowledge of the utilization of engineering thermoplastics, thermosets and rubber-like materials used in the diverse polymer processing industry.

Learning goals:

After completed course the student shall be able to:

- Describe the differences in processing strategies of different polymers as related their possibility to carry out continuous or intermittent polymer processing.

- Carry out the basics in processing of thermosets, thermoplastics and elastomeric materials in a processing laboratory.

- Relate the processing conditions to specific processing equipment, taking into account the rheological flow behavior of the polymers in injection molders, extruders (with film blowing systems), calendaring equipment, hot molding vacuum forming, rotational molding, etc. as well as vacuum bagging techniques for fiber laminate preparation.

- Describe the relevance of crystals and to which extent crystallization and post processing actions can be used to improve the performance of the polymer products.

- Be able to describe the internal components functions and relevance in the most common polymer processing machinery used in the polymer processing industry.

- Describe how fiber laminates, sewage pipes, vinyl floors, fiber reinforced inflatable boats, plastic bags, PET bottles, car tires, and the most frequently encountered large-scale produced polymer products are made in the industry.

More specific leaning goals are handed out at the start of each lecture. Each lecture is accompanied with 8-12 learning goals to facilitate studying and repetition of the lecture content.

Course literature

1. Handouts and lecture notes.

2. D. H. Morton – Jones: Polymer Processing; Chapman and Hall, 1989: ISBN: 0 412 26 690/700 is available in the Kårbokhandel or Amazon.com

Reading instructions (D. H. Morton)

A concise guide to the most important sections to study in the course literature is handed out after each lecture. Learning goals with each lecture is presented at the start of each lecture session. The students are encouraged to complement all learning goals on their own by additional reading in Morton et al. or equivalent literature.

Project

The final version of the student project report should be uploaded and emailed to course responsible before the course-ending seminar, or handed in directly to the course responsible.

Examination

The course is divided in 3 sections that are examined separately.

The 12 lectures are examined in a written exam that is graded from A to F where E is the minimum requirement for passing the exam. 10 questions are given as 100 points, where 50 points are equivalent to passing and the mark E. In rare cases, the grade Fx is given which mean that the student can ask for an assignment to reach the grade E. This section of the course is equivalent to 4.5 hp.

The material selection projects are examined by P or F (pass or fail) and will be based on the students' ability to review the use and material choices in a selected product, as well as the ability to provide constructional criticism to colleague students' reports. This section of the course is **compulsory** and equivalent to 1.5 hp.

Laboratory exercises are compulsory and will be examined by P or F. This section of the course is **compulsory** and equivalent to 1.5 hp.

The final grade will be reported when all the sections have been completed as the grade obtained on the written exam.

Course Responsible: Antonio Capezza (AC) / Richard Olsson (RO),

Examiner: Richard Olsson (RO), Fiber and Polymer technology, Teknikringen 56, phone 073-2701868, email: rols@kth.se

If you have questions, please contact the Course Responsible or Examiner

Welcome to the course!

SCHEDULE – Polymer Engineering, KF2505, 7.5 hp

Lecture	Date	Time	Place	Content
INFO	Wed 30/8	13-15	TRE	Introduction and organization of the course + Quizz (AC) +
F1	Fri 1/9	10-12	TRE	Background to the use of polymers in industry + Material selection methods and product to the market (RO)
F2	Mon 4/9	08-10	B22	Polymer material categories, relation between structure and properties and conditions for processing (RO)
F3	Tue 5/9	08-10	TRE	Extrusion to product (RO)
F4	Wed 6/9	13-15	TRE	Rheology of polymer melts with related parameters and viscoelastic models for describing materials behaviors' (MH)
F5	Fri 8/9	10-12	TRE	Film blowing, calendaring and hot forming (RO)
F6	Mon 11/9	08-10	TRE	Injection molding to product (RO)
F7	Tue 12/9	08-10	TRE	Functional plastic additives and their impact on polymer processing (MH)
F8	Wed 13/9	13-15	TRE	Thermosets and fiber composites (RO)
F9	Fri 15/9	10-12	TRE	Biopolymers + Sustainable production (AC)
F10	Mon 18/9	08-10	TRE	Natural and synthetic elastomers (RO)
F11	Wed 20/9	13-15	TRE	Foam materials (AC)

F12	Fri 22/9	10-12	TRE	Laboratory exercise intro (RO)
F13	Mon 25/9	-	-	EXTRA TIME
LAB	Tue 26/9	08-13	PRO	EX, IM, RP – Gr 1 (RO, BB, XF, TP)
LAB	Wed 27/9	13-18	PRO	EX, IM, RP – Gr 2 (RO, BB, XF, TP)
LAB	Fri 29/9	08-13	PRO	EX, IM, RP – Gr 3 (RO, BB, XF, TP)
LAB	Mon 2/10	13-18	PRO	EX, IM, RP – Gr 1 (RO, BB, XF, TP)
LAB	Tue 3/10	08-13	PRO	EX, IM, RP – Gr 2 (RO, BB, XF, TP)
LAB	Wed 4/10	13-18	PRO	EX, IM, RP – Gr 3 (RO, BB, XF, TP)
LAB	Thu 5/10	08-13	PRO	EX, IM, RP – Gr 1 (RO, BB, XF, TP)
LAB	Thu 5/10	13-18	PRO	EX, IM, RP – Gr 2 (RO, BB, XF, TP)
LAB	Fri 6/10	08-13	PRO	EX, IM, RP – Gr 3 (RO, BB, XF, TP)
SEM	Fri 6/10	13-18	TRE	Presentation of projects **compulsory presence.** (XF/RO)
Exam	Thu 26/10	08-13	E3	Final examination

Marked areas are to be determined at course start.

Teachers and teacher assistants:

RO = Richard Olsson (rols@kth.se)
MH = Mikeal Hedenqvist (mikaelhe@kth.se)
AC = Antonio Capezza (ajcv@kth.se)
TP = Torbjörn Pettersson (torbj@kth.se)
XF = Xinfeng Wei (xinfengw@kth.se)
BB = Björn Birdsong (teacher assistant, PhD student)