MFG 58000 - Manufacturing Processes for Composite Materials

Objective

This course will cover manufacturing processes and modeling for fiber reinforced polymer matrix composite materials. In order to model and optimize material formation and avoid process induced defects, process engineers need a thorough understanding of the coupling between material transformations, thermo- mechanical response, heat transfer, and viscous fluid flow. Students will be given an overview of applications of composite materials, forming processes, and types of process induced defects which may occur. Constituent materials will be discussed (thermosets, thermoplastics, advanced fibers), along with thermo-mechanical characterization methods and material models. The equations of transport, constitutive laws, and dimensionless analysis will be reviewed and given context in process modeling of composite materials. Models for short fiber suspensions in injection molding, compression molding, and extrusion will be introduced. Process modeling for continuous fiber reinforcement will include Pultrusion, Sheet Forming, Autoclave processing, Out-of-Autoclave processing, Filament Winding, Automated Fiber Placement, and Liquid Composite Molding.

Teaching Staff

Instructor:

	Hatice S. Sas	
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Office hours	Wednesdays 9.40-10.30*	*also appointment via email

Course Schedule

- Tuesday at 1.40 pm – 2.30 pm in FENS L062
- Thursday at 2.40 pm – 4.30 pm in FENS L047

Textbook and Reference Materials

I will use my own lecture notes compiled from different resources. Related reference sources are listed as below:

- Advani, S.G. & Sozer, E.M. (2010). Process Modeling in Composites Manufacturing (2nd Ed). CRC Press
- Strobl, G. (2007). The physics of polymers. Springer, Berlin
- Osswald, T. & Rudolph, N. (2014). Polymer Rheology: Fundamentals and Applications. Carl Hanser Verlag GmbH & Co. KG, München

Exams

You will have one midterm exam. The instructions will be shared. You will be responsible to follow the instructions.

Assignments

- There will be 5 homework assignments.
- Assignments should be written clearly. Diagrams or graphs should be given when necessary. They should be clearly labeled and contain enough information so that they can stand-alone.

Grading

Following is the list of items that will contribute to your final grade. Percentages are up to change and will be finalized at the end of the semester.

- Midterm 1 25%
- Assignment 25%
- Project 1 25%
- Project 2 25%

Course Policies

- Class attendance (physically or online) is required for your own benefit. It is imperative that you review the coverage of previous weeks prior to coming to class to increase your understanding of the materials to be covered in the class.
- Latecomers are welcomed to join the class without disturbing us.
- Working with others to learn the material is strongly encouraged. However, it is strictly forbidden to copy answers from one another without putting your efforts to solve them. All graded materials (assignments and exams) are intended to be solved or prepared individually. Any instance of giving or receiving aid on these issues will be viewed as a serious offence, which may result in a failing grade for the course and/or referral to the University disciplinary system
- Plagiarism
    - Definition: the practice of taking someone else's work or ideas and passing them off as one's own.
    - Proper citing is suggested to avoid plagiarism

Tentative Outline

Week 1	▪ Course Introduction ▪ Applications of Composite Materials ▪ Constituent Materials (Resins, Fibers, Fabrics) ▪ Manufacturing Processes ▪ Introduction to Process Modeling	▪ HW-0 assignment ▪ Project 1 and 2 assignments
Week 2 – 3	▪ Characterization methods for polymers (Cure/Crystallization Kinetics and Rheology) ▪ Material Constitutive Models & Parameter Evaluation	▪ HW-1 assignment
Week 4 – 5	▪ Transport and constitutive laws (conservation of mass, momentum, energy, + porous media) ▪ Non-dimensionalization (assumptions and simplifications) ▪ Model formulation (IC's & BC's)	▪ HW-2 assignment
Week 6	▪ Flow in an extruder, and injection/compression molding ▪ Short fiber orientation	▪ HW-3 assignment
Week 7	▪ Liquid Composite Molding (LCM) ▪ Permeability Characterization	
Week 8	▪ Race-tracking ▪ Process modeling practices (LIMS software)	▪ HW-4 assignment
Week 9	▪ Autoclave processing ▪ Midterm Exam	
Week 10	▪ Out-of-Autoclave Processing (i.e. Vacuum-Bag-Only prepreg processing)	▪ HW-5 assignment
Week 11-12	▪ Pultrusion (thermal modeling) ▪ Sheet forming ▪ Filament Winding	
Week 13, 14	▪ Project 1 submission and presentation	
Final's week	▪ Project 2 submission and presentation	