KMUTNB
Thai – German Graduate School

Microreactor Engineering

Instructor: Dr. Goran N. Jovanovic
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Co-Instructor

Lectures **TBD (Monday 12-1 pm and Thursday 10 am-12 noon)**

Office Hours: Monday 1-2 pm; Thursday 12-1pm and BY APPOINTMENT

Suggested Texts:
(a) W. Ehrfeld, V. Hessel and H. Lowe, *"Microreactors"*, Wiley -VCH 2000
(b) V. Hessel, S. Hardt, H. Lowe, *"Chemical Micro Process Engineering"* Wiley -VCH 2004
(c) O. Levenspiel, "*The Chemical Reaction Omnibook*", OSU Book Stores Inc. (1997)

Course Goals:

This course provides an introduction to necessary fundamentals and tools for the design and application of chemical microreactors. The course is planned and proposed to graduate students in all engineering disciplines that substantially contribute to the development of microscale materials and devices.

A short review of chemical reaction kinetics and models for fluid flow through reactor vessels is presented at the beginning of the course to facilitate an easy and unconstrained participation of all course participants.

A review of the 'state of the art' microreaction technology, and modern fabrication techniques for microreactors, are also presented to emphasize contributions of different science and engineering disciplines in the design, manufacturing, and integration of microreactors in microtechnology systems.

Mathematical modeling is adopted as an engineering approach in the development and analysis of chemical microreactor systems. Consequently, it is expected that course participants are familiar with at least one numerical software package that can solve mathematical models typically represented by a set of partial differential equations. No preference will be given to any of the available software packages (Matlab, Mathematica, COMSOL, any CFD software that can handle chemical reactions, and/or programming using Fortran or C++).

The first goal of this course is to introduce students to novel and practical application of microreactor systems. Emphases will be given to applications that include heterogeneous catalytic reactions, homogenous gas/liquid phase reactions, and multiphase reaction processes.

The second goal is to introduce necessary tools for the engineering analysis of microreactor design: Age-Distribution Functions, Characteristic Reaction Process Times, Earliness of Mixing, and Fluid Segregation (macro vs. micro types of fluids).

The third goal of this course is to demonstrate the applicability of different microreactor systems in solving chemical reaction problems in chemical, biochemical, biomedical, and environmental processes. Students, working in small groups, will be encouraged to formulate and design an innovative microtechnology based process in the area of their professional interest.

Majority of lectures will be available in electronic form (voice over power-point slides)

Topics

Topic	Hours Assigned	Source File	Electronic
Course Syllabus: Expectations; Goals & Objectives; Learning Objectives; Project; Communication methods	1 hour		**Yes**
Advantages of Microtechnology Fundamental advantages Advantages emerging from Parallel Architecture Advantages emerging from Distributed implementation Safety and Security advantages	4 hours	**Lecture A**	**Yes**
Principles of Mathematical Modeling Modeling of momentum, and mass	1 hour	**Lecture B**	**Yes**
Introduction to Chemical Kinetics First order kinetics Second order kinetics Surface catalytic reaction kinetics Catalyst deactivation kinetics	2 hours	(Text c)	**NO**
Time Scale Analysis for Catalytic Chemical Reaction Process Characteristic times for diffusion, reaction, and residence times Engineering Catalyst deposition	2 hour	**Lecture C**	**Yes**
Project 1 Presentation of Projects and Assignment of Projects:	1 hour	handouts	**NO**
Project 2 Discussion of Project Design Elements	1 hour	handouts	**NO**
Homogenous Chemical Reaction Processes in Microreactors	2 hours	**Lecture D**	**Yes**
Homogenous Chemical Reaction Processes in Microreactors Alternative boundary conditions and Origin of Time Scales	2 hours	**Lecture E**	**Yes**
Solid Catalyzed Chemical Reaction Processes in Microreactors	2 hours	**Lecture F**	**Yes**
Solid Catalyzed Chemical Reaction Processes in Microreactors Alternative boundary conditions and Origin of Time Scales	2 hours	**Lecture G**	**Yes**
Class Example – Dechlorination Chemical Reaction Process	2 hours	**Lecture H**	**Yes**

Two Phase Chemical Reaction Processes in Microreactors	2 hours	**Lecture I**	**Yes**
Two Phase Chemical Reaction Processes in Microreactors	2 hours	**Lecture J**	**Yes**
Class Example – Biodiesel Chemical Reaction Process	2 hours	**Lecture K**	**Yes**
Class Example – Desulphurization Chemical Reaction Process Photochemical Reaction process	2 hours	**Lecture L**	**Yes**
Photo Chemical Reaction Processes in Microreactors	2 hours	**Lecture O**	**Yes**
Electro Chemical Reaction Processes in Microreactors	2 hours	**Lecture P**	**Yes**
Project 2 Project Analysis Report Prepared by students	2 hours		**No**
Project 3 Project Discussion – Critique of Projects Prepared by instructor	2 hours		**NO**
Bio-Microreactors – Microreactors with Immobilized Enzymes Guest Lecturer	2 hours	**Lecture M**	**Yes**
From Idea to Realization – Enabling Microtechnologies Encapsulation of chromatophores and Bio-Boolean-Board micro sensor for human pathogens	2 hour	**Lecture N**	**Yes**
Project 4 Project Analysis Report Prepared by students	*4 hour*		**Yes**
Project 5 Project Discussion Prepared by instructor	*2 hour*		**Yes**
Project 6 Project Defense Prepared by students	*2 hour*		**Yes**

COURSE LEARNING OBJECTIVES

By the end of the course, you will be able:

1. To assess conditions (reactor geometry, diffusion, convection, chemical kinetics) under which a given microreactor is more efficient/productive than classical macro-reactor.

2. To develop a mathematical/numerical model and evaluate the performance of microreactors.

3. To develop the functional design of a novel microreactor system, which is essentially ready for microfabrication design phase.

GRADING

Item: % Grade

Homework Sets: **20 %**

There will be three homework sets assigned in this course.

Project: **60 %**

Students (in groups of three) are encouraged to formulate and solve one problem related to their specific area of interest. Start thinking about your project as soon as possible. If you are not able to formulate a project from your own research expertise, your instructor will help you define a suitable challenge. Let me know by the end of the first week of classes what content of the project you are considering. The problem description and solution should be well documented in the form of a technical report. Specific details of the report format will be given separately.

(instead of) **Final Exam** **20%**

The final exam will be a public presentation of your project. Presentation material, and presentation delivery will be graded.

Students with Disabilities

Students with documented disabilities who may need accommodations, who have any emergency medical information the instructor should know of, or who need special arrangements in the event of evacuation, should make an appointment with the instructor as early as possible, no later than the first week of the term. Students with disabilities are encouraged to contact the Services for Students with Disabilities Department (SSD) and obtain professional opinion and recommendation. SSD website: http://ssd.oregonstate.edu/. These documents are needed for specific accommodation and should be presented to the instructor as early as possible.

Disruptive Behavior

While the University is a place where the free exchange of ideas and concepts allows for debate and disagreement, all classroom behavior and discourse should reflect the values of respect and civility. Disruptive behavior is defined as behavior that “interferes with university or university-sponsored activities, including but not limited to classroom related activities, study, teach, research, intellectual or creative endeavors, administration, service or the provision of communication, computing or emergency services.” The following disruptive behavior is often noticed and it is not allowed: i) Cell phones or pagers in class; ii) Use of Laptops or other electronic devices for activity outside of its use in this class (i.e, surf the web email pictures); iii) Eating during class.

Discrimination

As your instructors, we are dedicated to establishing a learning environment that promotes diversity of race, culture, gender, sexual orientation, and physical disability. Anyone noticing discriminatory behavior in this class or elsewhere on campus, or feeling discriminated against should bring it to the attention of the instructors or other University personnel as appropriate.