Birla Institute of Technology & Science, Pilani
Hyderabad Campus

Second Semester 2022- 2023
Course Handout (Part-II) Date:28/12/2022

In addition to Part I (General Handout for all courses appended to the Time Table), this portion gives further specific details regarding the course.

Course No.	**:**	**CHE G641**
Course Title	**:**	**Reaction Engineering**
Instructors	**:**	**SRIKANTA DINDA (IC) & Iyman Abrar**

Scope & Objective:
This course includes basic and advanced topics in Chemical Reaction Engineering. The initial part of the course includes reaction mechanisms, basic reaction kinetics (like rate, concentration, conversion, and selectivity), and ideal reactor configurations. The design of catalytic and other multiphase reactors is elaborated. The characterization of non-ideal reactors and modeling of these, especially with reference to Residence Time Distribution (RTD Models) are dealt with. Thermal and Mass Transfer effects are also explained in multi-phase reactors. The main objective of this course is to give the student a better understanding of Chemical Reaction Engineering of Multi-Phase Non-ideal reactors encountered in Industry from the point of view of design and performance evaluation of such actual reactors. Short projects/assignments and industrial visits shall be planned to imbibe the concepts learned better.

Course Description:
Viscosity, thermal conductivity and diffusivity, Shell momentum and energy balance, equations of change for isothermal and non-isothermal systems, Concentration distribution in solids and laminar flows, momentum, thermal and concentration boundary layers near walls, origin of turbulence, length scales in turbulent flows, Reynolds (RANS) equations, estimates of Reynolds stress (k-epsilon and k-omega type models), turbulent shear flow near a wall, turbulent flow in pipes and channels, turbulent heat transfer, Introduction to large eddy simulations models, rheology and material functions, non-Newtonian viscosity and generalized Newtonian models, Linear and non-linear visco-elasticity, radiation heat transfer, multi-component systems, Coupled heat and mass transfer, evaporation, boiling and condensation, chemical reactions, Special topics: Flow through porous media, compressible flows, multiphase flow, Transport phenomena in biochemical systems.

Learning outcomes:

After studying this course, students will be able to

- Have the knowledge to what kind of reactor system is to be used for what situation.
- Student will be able to analyze the kinetic related data to find the size of the reactor for a specific reaction
- Lab exposer will help to know how to find the reaction kinetics of an unknown system

Text Books

T1 Levenspiel, Octave, *Chemical Reaction Engineering*, Wiley India Pvt. Ltd., New Delhi, 3rd Edition, 2000 (or higher edition if available!).

T2 Fogler, H. Scott, *Elements of Chemical Reaction Engineering*, Prentice-Hall of India Pvt. Ltd., New Delhi, 4th Ed., 2006 (or higher edition if available!).

Reference Books

R1 Salmi, Tapio O., Jyri-Pekka M., and Johan P, W., *Chemical Reaction Engineering and Reactor Technology*, CRC Press, Taylor &Francis, New York, 2011 (or higher edition if available!).

Course Plan

Lecture No.	Learning Objectives	Topics to be covered	Reference
1-6	Review of chemical kinetics and ideal reactor concepts and ideal reactor designs, conversion, and sizing of ideal reactors including multiple reactors in series or parallel	Review of kinetics and ideal reactors	Chap No. 1-8 of T1 Chap No. 1-3 of T2 Chap No. 1-3 of R1
7-10	Reaction mechanisms, elementary and non-elementary homogeneous reactions, order of reactions	Review of mechanism of reactions, order, and effect on reactor design	Chap No. 1 of T1 Chap No. 7 of T2
10-12	Laboratory reactors, collection, and analysis of rate data	Rate models and rate expressions, Laboratory data analysis and Interpretation	Chap No. 1 of T1 Chap No. 5 of T2
13-19	Multiple reactions – series-parallel and effect on ideal reactor design	Multiple reactions	Chap No. 7-8 of T1 Chap No. 6 of T2 Chap No. 4 of R1
20-21	Temperature and pressure effects on single and multiple reactions	Effects of temperature and pressure	Chap No. 9 of T1 Chap No. 5 of R1
22-24	Catalysis and Catalytic reactors, catalyst deactivation,	Heterogeneous catalysis introduction	Chap No. 17-19 of T1 Chap No. 10 of T2
25-29	Packed bed catalytic reactors and external and internal diffusion, basics of gas-liquid reactions.	Heterogeneous catalysis with mass transfer	Chap No. 19 of T1 Chap No. 10-11 of T2
30-32	Multiphase reactors including gas-solid and liquid slurry, bubble columns and fluid bed reactors, trickle bed reactors	Multiphase catalytic reactors	Chap No. 20-22 of T1 Chap No. 12 of T2
33-35	Non-Catalytic systems, fluid-fluid, fluid-particle kinetics and reactor design	Multi-phase non-catalytic reactors	Chap No. 23-26 of T1
36-41	Tracers, methods of obtaining Residence time Distribution (RTD), one-dimension models for flow patterns	Residence time Distribution (Macro mixing)	Chap No. 11-16 of T1 Chap No. 13-14 of T2 Chap No. 6 of R1

Lab experiments:

Lab Name	Experiment Name & Objective
CRE lab	Batch Reactor: To study the order and rate constant for the reaction between KOH and ethyl acetate in a batch reactor @30 °C.
CRE lab	Batch Reactor: To study the order and rate constant for the reaction between KOH and ethyl acetate in a batch reactor @40 °C.
CRE lab	Batch Reactor: To study the order and rate constant for the reaction between KOH and ethyl acetate in a batch reactor @50 °C.
CRE lab	Batch Reactor: To study the order and rate constant for the reaction between KOH and butyl acetate in a batch reactor @30 °C.
CRE lab	Continuous Stirred Tank Reactor: To study the order and rate constant for the reaction between KOH and ethyl acetate in a CSTR @ 30 °C.
CRE lab	Plug Flow Reactor: To study the order and rate constant for the reaction between KOH and ethyl acetate in a PFR @ 30 °C.
CRE lab	RTD study using CSTR
CRE lab	RTD study using PFR
CRE Lab	To find conversions using a single and a cascaded CSTR
CRE Lab	To find conversion of a reaction using GC analysis
Research lab	To find the adsorption capacity of an adsorbent for adsorption of a gas on solid adsorbent
Petroleum lab	Cracking of liquid fuel

Evaluation scheme

EC	Evaluation Component	Duration	Weightage, %	Date, Time	Remarks
1.	Mid sem	90 min	25	17/03 9.30 - 11.00AM	10% CB & 15%OB
2.	Comprehensive	180 min	35	17/05 FN	15% CB & 20% OB
3.	Assignment & / seminars	-	10	It will be announced in class	OB
4	Quizzes/ class test	-	10	It will be announced in class	OB
5	Lab experiments	-	20		OB

- **Chamber consultation hour** will be announced in the class.
- The **notices,** if any**,** concerning the course, will be displayed on CMS /Departmental notice board.
- **Make-up for mid & comprehensive** may be granted for **genuine cases with** prior permission of IC.
- **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge | CHE G641
Srikanta Dinda