SARVAJANIK UNIVERSITY

Sarvajanik College of Engineering and Technology

Bachelor of Technology (B.Tech)

B. Tech. Semester VI

Subject Code: BTCH13602

Subject Name: Chemical Reaction Engineering-II

Type of course: Professional Core Course

Prerequisite: Chemical kinetics and reaction engineering-I

Rationale: This course deals with macro and micro level reaction kinetics with homogeneous and heterogeneous system. The first part of this subject deals with residence time distributions, and how they can be used to characterize and design non-ideal reactors. Kinetics and design of reactors for non-catalytic fluid-fluid and fluid-particle reactions follows. And the last part of the subject deals with catalysis and catalytic reaction kinetics.

Teaching and Examination Scheme:

TEACHING SCHEME				Theory Marks			Practical Marks		Total
L	T	P	C	TEE	CA1	CA2	TEP	CA3	150
3	0	2	4	60	15	25	30	20	

CA1: Continuous Assessment (assignments/projects/open book tests/closed book tests **CA2:** Sincerity in attending classes/class tests/ timely submissions of assignments/self-learning attitude/solving advanced problems **TEE:** Term End Examination **TEP:** Term End Practical Exam (Performance and viva on practical skills learned in course) **CA3:** Regular submission of Lab work/Quality of work submitted/Active participation in lab sessions/viva on practical skills learned in course

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1.	**Non-Ideal Flow:** Basics of non-ideal flow, Residence time distribution, stimulus response techniques, The E,F and C Curves, their interrelationship, conversion in non-ideal flow reactors, Dispersion model, Chemical Reaction and dispersion, Intensity of fluid mixing. Tanks in series model, Deviation from plug flow, Models for real stirred tanks.	10	22%
2.	**Heterogeneous Reactions: Introduction:** Rate steps involved in heterogeneous systems, Overall rate expression for linear and non linear processes, contacting patterns for two-phase systems and product distribution.	6	13%
3.	**Fluid-Fluid systems:** Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, film conversion parameter, fluid-fluid reactor design.	6	13%

4.	**Fluid-Particle systems:** Fluid partial reaction kinetics, selection of a model, Shrinking Core Model for unchanging and changing size spherical partials, Diffusion through gas film and through ash layer controlling, Chemical reaction controlling, Shrinking core model, its limitations, Determination of rate controlling step.	8	**18%**
5.	**Catalysis:** Catalysts, Physical properties of catalyst, surface area, void volume, solid density, pore volume distribution, Classification and preparation of catalyst, catalyst promoters. Catalyst inhibitors, Catalyst poisons, Nature and Mechanism of Catalytic reactions. **Zeolite catalysts -** Applications, rise of acidity, modifications, shape selectivity, Monolithic reactors, configurations, preparation, hydrodynamics and applications, accelerated deactivation of catalysts, Laboratory reactors, Oscillatory motion of reactants in catalyst pores, Micro reactors.	8	**18%**
6.	**Solid-Catalysed reactions: Kinetics:** Introduction to LHHW (Langmuir-Hinshelwood-Hougen-Watson) kinetic model. Adsorption isotherms and rates of adsorption and desorption. Kinetic regimes, rate equations for surface kinetics, Pore diffusion, determining rate controlling step, experimental methods for finding rates, product distribution in multiple reactions.	4	**9%**
7.	**Introduction to Catalytic Reactors:** Packed bed catalytic reactors, fluidized bed reactors, trickle beds, slurry reactors. Introduction to flow chemistry.	3	**7%**

Suggested Specification table with Marks (Theory/Practical):

% Distribution of Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	**25**	**25**	**15**	**05**	**–**

Legends: R: Remembrance, **U:** Understanding; **A:** Application, **N:** Analyze, **E:** Evaluate **C:** Create and above Levels **(Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Text Books:

Sr. No.	Title of book /article	Author(s)	Publisher and details like ISBN	Year of publication	Publication Edition
1	Chemical Reaction Engineering	Octave Levenspiel	John Wiley & Sons (Asia) pvt. Ltd.	1998	3rd Edition

2	Elements of Chemical Reaction Engineering	H. Scott Fogler	Prentice Hall of India Pvt Ltd	2014	3rd Edition November
3	Chemical Engineering Kinetics	J.M.Smith	McGraw-Hill	1981	2nd edition
4	The Engineering of Chemical Reactions	L. D. Schmidt	Oxford Press.	1998	1st edition
5	Chemical and Catalytic Reaction Engineering"	J. J. Carberry	McGraw Hill, New York	1976	2nd edition
6	Reaction kinetics for Chemical Engg.	S.M.Walas	McGraw Hill Co., New york	1959	2nd edition
7	Chemical Reactor Analysis and Design	Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde	Wiley ,ISBN: 978-0-470-56541-4	August 2010	3rd Edition

Course Outcome:

Sr. No.	CO Statement After learning this subject, students will be able to	Marks % weightage
CO-1	Explain the behaviour of flow in chemical reactors.	15
CO-2	Model various types of RTD curves with changes in reactor size, shape and fluid mixing intensity.	25
CO-3	Interpret reaction mechanism for kinetic behaviour of chemicals for fluid-fluid and fluid-solid.	25
CO-4	Design the slurry reactor, fixed bed reactor, trickle bed reactor, fluidised bed reactor, laminar flow reactor and other multiphase reactors.	15
CO-5	Demonstrate the catalytic reaction with Intermediate steps.	20

Mapping with POs:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	P O 11	PO1 2	PSO 1	PSO 2	PSO 3
CO-1	2	2	2	1	1	2	3	3	3	2	2	3	1	2	3
CO-2	2	2	2	3	2	2	3	3	3	2	3	3	2	3	2
CO-3	3	3	2	2	3	2	3	3	3	3	2	3	2	2	2

CO-4	3	3	3	1	2	3	3	3	3	2	3	3	2	3	2
CO-5	2	3	2	2	2	3	3	3	3	2	2	3	3	2	2
Rationale*	**12**	**13**	**11**	**9**	**10**	**12**	**15**	**15**	**15**	**11**	**12**	**15**	**10**	**12**	**11**

Rationale*: This course deals with macro and micro level reaction kinetics with homogeneous and heterogeneous system. The first part of this subject deals with residence time distributions, and how they can be used to characterize and design non-ideal reactors. Kinetics and design of reactors for non-catalytic fluid-fluid and fluid-particle reactions follows. And the last part of the subject deals with catalysis and catalytic reaction kinetics.

<u>LIST OF PRACTICALS</u>: (Minimum 6-8 performed.)

Experiments need to be performed during the semester.

1. To construct various curves for RTD studies by E, E□, F, F□, I, I□ for the case of coil tube reactor
2. To obtain the response of a Cascade of stirred vessels for a step change
3. To calculate the mass transfer effect, relative to the intrinsic kinetics for ethyl-acetate sodium hydroxide system conducted in heterogeneous manner
4. To compare the experimental and theoretical F□ curve and also to generate the F□ curve for given single stirred tank.
5. To construct various curves such as E, E□, F, F□, I, I□ for the case of annular flow of water and predict the conversion for a first order irreversible reaction of known rate.
6. To construct various curves such as E, E□, F, F□, I, I□ for the case of Sine tubular flow of water and predict conversion for Ist order irreversible reaction.
7. To obtain various F□ curves from the experimental E□ curve and compare with theoretical F□ - curve for given laminar flow system.
8. To apply tanks in series model to annulus flow of water.
9. To obtain the dispersion no. in the case of relatively low flow rate of water through a packed bed using the dispersion model and subsequently the dispersion coefficient.
10. To obtain the dispersion no. in the case of relatively high flowrate of water through a packed bed using the dispersion model and subsequently the dispersion coefficient.
11. Simulation of the unit operation using process simulator should be included to study the behaviour of mass transfer operation in each experiment

Major Equipment: NIL

List of Open Source/learning website:

- https://ocw.mit.edu/courses/chemical-engineering/
    - Chapter-1,2,3 & 4
- https://www.digimat.in/nptel/courses/video/103106117/L01.html
    - Chapter-1,2,3, 4,5,6 & 7
- https://www.digimat.in/nptel/courses/video/103101008/L01.html
    - Chapter-1,2,3, 4,5,6 & 7
- https://nptel.ac.in/courses/103/101/103101141/
    - Chapter-1,2,3, 4,5,6 & 7

List of Open Source Software:

- https://www.mogroup.com/portfolio/hsc-chemistry/?gclid=CjwKCAjwieuGBhAsEiwA1Ly_nUbLvs_dP4IfrVhBtdovTbWEmSdxn7cn8pUwAwaX1lUisxoOgQvHzxoCw1sQAvD_BwE
- https://www.smartdraw.com/process-flow-diagram/process-flow-diagram-software.htm
- https://dwsim.inforside.com.br/new/
- https://www.cocosimulator.org/index_download.html
- https://sourceforge.net/directory/os:windows/?q=chemical+reaction+software
- https://www.sciencebysimulation.com/chemreax/Faq.aspx
- https://libguides.mines.edu/oer/simulationslabs
- https://www.simulations-plus.com/software/medchem-designer