GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)

FLUIDIZATION ENGINEERING

SUBJECT CODE: 2723015

SEMESTER: II

Type of course: Chemical Engineering (Major Elective-III)

Prerequisite: Basics of Fluid Mechanics, Heat Transfer, Mass Transfer and Reaction Engineering

Rationale:

Fluidization finds extensive application today in Process Industry and also in combustion. Objective of this course is to make the student aware of fundamentals of Fluidization and understand the design aspects of fluidized bed systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2#	0	4	70	30	30	0	10	10	150

Content:

Sr. No.	Content	Hrs	% Weightage
1	**Introduction** Different types of fluidized beds, advantages and disadvantages of fluidized beds, applications of fluidization technique in process industries, Comparison with other contacting methods, Physical operations and reactions.	3	5
2	**Fluidization and Mapping of Regimes** Characterization of Fixed Beds of Particles, Fluidization without Carryover of Particles: Minimum Fluidizing Velocity, Pressure Drop-verses-Velocity Diagram, Effect of Pressure and Temp. on Fluidized Behavior,Sintering and Agglomeration of Particles at High Temperature. Type of Gas Fluidization with and without Carryover, Turbulent and Churning Fluidization, Pneumatic Transport of Solids, Fast Fluidization, Voidage Diagrams for all Solid Carryover, Regimes, The Mapping of Fluidization Regimes	8	15
3	**Bubbles in Dense Beds** Single Rising Bubbles: Rise Rate of Bubbles, Evaluation of Models for Gas Flow at Bubbles, The Wake Region and the Movement of Solids at Bubbles, Solids within Bubbles. Coalescence and Splitting Bubbles: Interaction of Two Adjacent Bubbles, Coalescence, Bubble Size and Bubble Frequency, Splitting of Bubbles and Maximum Bubble Size, Bubble Formation above a Distributor, Slug Flow	8	15
4	**Bubbling Fluidized Beds** Emulsion Movement for small and Fine Particles, Emulsion Movement for Large Particles, Emulsion gas Flow and Voidage. Effect of Pressure on Bed Properties. Estimation of Bed Properties: Gas Flow in the Emulsion Phase, Bubble Gas Flow, Bubble Size and Bubble growth, Bubble Rise Velocity, Beds with Internals, Physical Models : Scale up and scale down	8	15

5	**Flow Models for Bubbling Beds** General Interrelationship among Bed Properties, Simple Two-phase Model, K-L Model with its Davidson Bubbles and Wakes	4	7
6	**High Velocity Fluidization** Turbulent Fluidized Beds, Experimental Findings, Fast Fluidization, The Freeboard Entrainment Model Applied to Fast Fluidization, Design Considerations, Pressure Drop in Turbulent and Fast Fluidization	4	7
7	**Circulation Systems** Circuits for the Circulation of Solids, Finding Required Circulation Rates, Flow of Gas-Solid Mixtures in Downcomers: Downward discharge from a Vertical Pipe, Moving Bed Downflow, Fluidized Downflow, Fluidized Downflow in Tall Downcomers. Flow in Pneumatic Transport Lines: Vertical Upflow of Solids, Horizontal Flow, Safe Gas Velocity for Pneumatic Transport, Pressure Drop in Pneumatic Transport, Pressure drop in Bends, Practical Consideration	5	9
8	**Transport Effects in Fluidized Systems** Heat and Mass transfer in fluidized bed systems: Mass and heat transfer between fluid and solid. Gas conversion in bubbling beds. Heat transfer between fluidized bed and surfaces	3	6
9	**Design of fluidized bed systems** Design of fluidization columns for physical operations, catalytic and non-catalytic reactions, three phase fluidization.	6	11
10	**Modern Techniques of Analysis** Modern experimental techniques – flow visualization and quantitative measurements, Modern simulation techniques - CFD models	3	6
11	**Three Phase Fluidization**	2	4

Reference Books:

1. Fluidization Engineering, D. Kunii and O. Lavenspiel 2nd Edition, , Butterworth- Hienemann, Elsevier.
2. Fluidization by Max Leva
3. Introduction to Particle Technology by Rhodes. M., 2nd Ed., Wiley (2008).
4. Fluidization – Dynamics, Gibilaro, L. G., Butterworth – Heinemann (2001).
5. Fluidization, Davidson, J. F., R. Clift and D. Harrison, 2nd Ed., Academic Press (1985).
6. J. F. Davidson and Harrison, "Fluidization", 10th Ed, Academic Press, London, 1994.
7. Jackson, R., "The Dynamics of Fluidized Particles," Cambridge University Press, New York (2000).
8. Fan, L.-S. and C. Zhu, Principles of Gas-Solid Flows, Cambridge University Press, New York (1998).

Course Outcome:

After learning the course the students will be able to:

1. Understand applications of fluidized bed systems
2. Determine the optimum operating conditions for fluidized bed reactors
3. Understand Transport Effects in Fluidized Systems
4. Be familiar with the flow models for Bubbling Beds
5. Design a fluidized bed system for specific application.

List of Open Source Software/learning website:

- Softwares: Computational Fluid Dynamics (CFD), Computational Practice Fluid Dynamics (CPFD)
- Students can refer to video lectures available on the websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website