GUJARAT TECHNOLOGICAL UNIVERSITY

METALLURGY ENGINEERING (21)

HEAT AND MASS TRANSFER IN METALLURGY

SUBJECT CODE: 2142105

B.E. 4th SEMESTER

Type of course: Engineering

Prerequisite: N.A.

Rationale: The course of Heat and Mass Transfer in Metallurgy deals with various principles of fluid their flow and heat and mass transfer. As any metallurgical process involves fluids, heat and mass transfer this course aims to develop a basic understanding about the properties of fluids. Heat transfer is involved in metallurgical engineering processes like casting, welding, metal extraction by pyrometallurgy or heat treatment of materials. The heat transfer modes namely conduction, convection and radiation are based on fundamental laws and its knowledge enhances the understanding of energy transfer in metallurgical processes. This will enable the students to apply basic principles of fluid mechanics and heat transfer to understand its role and to analyze and solve problems.

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)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Fluid Behaviour Definition and classification of fluids. Viscosity, Newtonian and non-Newtonian fluids. Viscous and non-viscous fluids. General features of fluid flow. Laminar and turbulent flow	06	10
2	Mass and Momentum Balance Differential mass balance (continuity equation). Differential momentum balance (equation of motion). Navier Stokes Equation. Application of Differential Balance Equation. Overall mass balance and momentum balance. Euler's equation and its integration to obtain Bernoulli's equation. Flow through fluidised beds. Flow rate measuring equipments.	14	24
3	Conductive Heat Transfer Modes of heat transfer. Conduction of heat through solid. Steady and unsteady state. Fourier law of heat conduction. General equation of heat conduction in cartesian co-ordinate, spherical and cylindrical systems.	10	16
4	Convective Heat Transfer Convective heat transfer. Free and forced convection. Application dimensional analysis of effective boundary layer.	08	12
5	Radiative Heat Transfer Aspects of Radiative Heat Transfer. Reflection, absorption and transmission of radiation. Black body radiation. Planck's Law. Wein's distribution Law. Heat transfer between two bodies by radiation.	10	18

	Lambert's Law.		
6	Mass Transfer Fluid flow and its relevance to mass transfer. General mass transport equation. Modes of mass transfer. Film and boundary layer theories. Diffusion-diffusion convection. Generalised diffusion equation. Diffusivity in gases, liquids and solids. Steady diffusion. Pseudo-steady diffusion. Diffusion through porous solids. Convective mass transfer-Mass transfer in fluid at solid-fluid interface. Mass transfer between two fluids. Mass transfer v/s chemical control, enhancement of process rates. Application to metallurgical system.	12	20

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
10%	30%	30%	20%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate 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 Books:

1. Rate Processes in Metallurgy, A. K. Mohanty
2. Principles of Extractive Metallurgy, A. Ghosh and H. S. Ray
3. Elements of Heat and Mass Transfer, Prof. R. C. Patel
4. Fundamentals of Heat and Mass Transfer, Inpropera and Dewitt
5. Rate Phenomena in Process Metallurgy, J. H. Szekely and N. J. Themelis
6. Fundamentals of Momentum, Heat and Mass Transfer, J. R. Welty, C. E. Wicks (Pub.-Wilson Wiley)
7. Chemical Engineering, J. M. Coulson and J. F. Richardson (Pub.- Mc. Hill ELBS)
8. Engineering in Process Metallurgy, RLL Guthrie (Pub.- Oxford).
9. Heat Transfer, Yunus Cenge

Course Outcomes:
After successful completion of the course students should be able to:

1) Explain Newton's law of viscosity and classify fluid and fluid flow.
2) Derive mass and momentum balance equations and use it for applications of flow measurement.
3) Derive equation of heat conduction, convection and radiation for various conditions and solve problems.
4) Explain different mass transfer modes and derive their equations.

List of Experiments:

1. To study fluid and Fluid Properties
2. To study Pressure, measuring equipments, Pascal's Law and Bernoulli's Equation
3. To measure Thermal Conductivity of Insulating Powder
4. To determine Heat Transfer Coefficient For Given Composite Wall
5. To determine Heat Transfer Coefficient By Natural Convection
6. To determine Heat Transfer Coefficient In Force Convection

7. To determine Stefan Boltzmann Constant
8. To determine Emissivity Measurement

Design based Problems (DP)/Open Ended Problem:

Apart from above experiments a group of students has to undertake one open ended problem/design problem. Few examples of the same are given below.

1. Measurement of viscosity of different fluids
2. Develop venturimeter/orifice meter.
3. Measurement of pressure and discharge in pipe flow
4. Problems based on Fluid Properties
5. Problem based on Application of Differential Balance Equation
6. Problems based on Heat Conduction
7. Problems based on Heat Convection
8. Problems based on Heat Radiation
9. Problems based on Mass Transfer

Major Equipment:

Set up for determination of following:

1. Thermal Conductivity of Insulating Powder
2. Heat Transfer Coefficient For Given Composite Wall
3. Heat Transfer Coefficient By Natural Convection
4. Heat Transfer Coefficient In Force Convection
5. Stefan Boltzmann Constant
6. Emissivity Measurement

List of Open Source Software/learning website:

I. http://nptel.iitm.ac.in/
II. http://ocw.mit.edu/
III. http://wikipedia.com/

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.