GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (05)

PROCESS HEAT TRANSFER

SUBJECT CODE: 2140503

B.E. 4th SEMESTER

Type of course: Chemical Engineering.

Prerequisite: none.

Rationale: The main objective of this subject is to study the basics of heat transfer takes place during the process in industry. This subject provides knowledge regarding to the basic modes and aspects of heat transfer process as well as it also provides an idea about various equipment used for heat transfer

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	3	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Introduction to three modes of heat transfer:** Conduction convection & radiation. General laws of heat transfer.	**03**	**5**
2	**Conduction:** Fourier's law, Thermal Conductivity – its variation with temperature & Pressure and its relationship with electrical conductivity. Heat transfer through composite walls and cylinders. Unsteady state heat transfer through some important shapes. Different types of insulating materials, general properties & application of insulators.	**09**	**16**
3	**Natural convection:** Natural convection from vertical plates & horizontal cylinders. **Forced convection:** In laminar flow - Heat transfer in plate & tubes. In turbulent flow - Empirical equations for individual coefficients: inside tubes, outside tubes, outside bundle of tubes, flow past spheres. Significance of Prandtl No., Nusselt No., Grashof No., Graetz No. & Peclet No. Correction for tube length. Corrections for heating and cooling the fluid. Various analogies between heat & momentum transfer.	**10**	**19**
4	**Radiation:** Radiation laws like Stefan Boltzmann's law, Kirchhoff's law, Wien's law, Plank's law etc. Black body, Grey body. Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces. Radiation through semi transparent materials.	**08**	**15**
5	**Heat transfer with phase change:** Boiling of liquids, Pool boiling curve, different types of pool boiling, condensation of vapor, film wise & drop wise condensation, weighted LMTD & Overall Heat transfer Coefficient for desuperheating & sub cooling.	**08**	**15**
6	**Evaporation:** Performance of tubular evaporator. Individual & overall Coefficients, Capacity & economy of evaporators. Boiling point elevation, Durhing's rule, Effect of liquid head & friction on pressure	**08**	**15**

	drop, Types of evaporators, Multiple effect evaporators. Vapor recompression, Thermal recompression & mechanical recompression.		
7	**Heat Exchange equipments:** Double pipe heat exchangers. Individual and overall heat transfer coefficient, LMTD, Variable overall Heat transfer coefficient, fouling factors, Shell & tube heat exchangers, LMTD correction factors, Extended surface heat exchangers, Fin efficiency and fin effectiveness	**08**	**15**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
20	15	20	15	0

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. "Heat Transmission", W. H. McAdams, McGraw Hill, 3rd Edition.
2. "Process Heat Transfer", D. Q. Kern, McGraw Hill.
3. "Unit Operations of Chemical Engineering", McCabe W L, Smith J C, Harriott P, 7th Ed. McGraw Hill, 2005.
4. "Heat Transfer", J. P. Holman, McGraw Hill, Tenth Edition

Course Outcome: After learning the course the students should be able:

1. To build basic knowledge of the heat transfer.
2. To review the practical importance and relevance of energy transfer and its conservation in chemical industry.
3. To utilize the technological methods related to heat transfer in process plant.
4. To study a detailed overview of heat transfer equipment and problems associated at preliminary stage of design.
5. To build a bridge between theoretical and practical concept used in industry.

List of Experiments and Open Ended Projects:

Minimum **5** practicals to be performed and remaining time should be allotted to open-ended projects / study reports / latest outcomes in technology study:-

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Project / Study Report / Latest outcome in technology.
2. Literature survey including patents and research papers of fundamental process

- Design based small project **or**
- Study report based on latest scientific development **or**
- Technology study report/ modeling/ simulation/collection report **or**
- Computer based simulation/ web based application/ analysis presentations of basic concept field which may help them in chemical engineering.

3. These can be done in a group containing maximum **three** students in each.
4. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.

5. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to study the design module of given task.
6. In the semester student should perform **minimum** 5 set of experiments and complete **one small open ended dedicated project** based on engineering applications. This project along with any performed experiment should be **EVALUATED BY EXTERNAL EXAMINER.**

PRACTICALS (ANY FIVE):

Sr. No.	List of experiments
1.	To determine the thermal conductivity of given metal rod.
2.	To determine the thermal conductivity of the given composite walls.
3	To determine the thermal conductivity of lagging material, by heater input to be heat flow rate through the pipe
4.	To determine heat transfer co-efficient by forced convection.
5.	To determine the emissivity of gray body.
6.	To determine Stephan Boltzmann constant experimentally.
7.	To determine the overall heat transfer co-efficient of shell and tube type heat exchangers.
8.	To determine overall heat transfer co-efficient for finned tube type heat exchangers.
9.	To determine outside and inside heat transfer for parallel plate type heat exchanger.
10.	To study drop & film wise condensation & determine the film co-efficient
11.	To determine the heat flow rate through the lagged pipe and compare it with the heater input for known value of thermal conductivity of lagging material
12.	To study the boiling of liquid by submerged heated surface & determine critical heat flux.

Major Equipments:
Emissivity apparatus, Metal rod apparatus, composite wall apparatus, lagged pipe apparatus, various heat exchange equipments like shell and tube heat exchanger, plate type heat exchanger etc...

Open Ended Project fields:-
Students are free to select any area of science and technology based on chemical engineering applications to define Projects.

Some suggested projects are listed below:

- Preparation of non working models of various heat exchange equipments and its importance.
- Practical importance of different modes of heat transfer and various analogies associated with it.

List of Open Source Software/learning website:
1) Literature available in any laboratory manual of Process heat transfer.
2) NPTEL
4) MIT Open course lecture available on Internet etc…

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.