Course-Plan

School : ENGINEERING
Department : Mechanical Engineering
Course Code : ME 550
Course Name : Heat Transfer Equipment Thermal Design

Instructor: Dr. Monoj Bardalai

1. Abstract:

ME 550 is an elective course offered for the M. Tech. Programme in Mechanical Engineering (Specialization: Thermal and Fluids Engineering) under the Department of Mechanical Engineering. The course covers classification of heat transfer equipment, basic consideration and thermal design of double pipe heat exchanger, shell and tube heat exchanger, finned surface heat exchanger, plate and spiral plate heat exchanger, heat exchanger for dairy industry, air preheaters, economizer, compact heat exchanger and cooling towers. The course also includes the economic consideration and optimization of thermal design.

2. Objectives:

The course shall be taught with the following objectives:

i. To provide a quick review on different types of heat exchangers and their heat transfer analysis
ii. To offer basic design methodology of heat exchangers.
iii. To impart the knowledge of pressure drop and fouling in heat exchanger design.
iv. To provide the design procedures of different types of heat exchangers such as shell and tube, compact heat exchangers, condensers and evaporators etc.
v. To impart the knowledge of selecting heat exchangers and their components.
vi. To offer the knowledge of thermodynamic modeling and analysis of heat exchanger.

3. Prerequisites of the course:

Elementary knowledge of heat exchangers and heat transfer phenomena in heat exchangers.

4. Course outline: Classification of heat exchanger design; Basic heat exchanger design methodology, basic heat exchanger design procedure, convection heat transfer relations, pressure drop and pumping power in heat exchanger, heat exchanger design subject to fouling, heat exchanger design: double pipe heat exchanger, shell and tube heat exchanger, compact heat exchanger, design of condenser and evaporator, polymer heat exchanger, selection of heat exchanger, Thermodynamic modeling of heat exchanger.

4. (a) Time-Plan

Topic	Content	Contact Hours
Overview of heat exchanger design methodology	Classification of heat exchangers, Process and Design Specifications, Thermal and Hydraulic Design, Mechanical Design, Manufacturing Considerations and Cost Estimates	2

	Arrangement of Flow Paths in Heat Exchangers, Basic Equations in Design, LMTD and effective-NTU Method for Heat Exchanger Analysis, at Exchanger Design Calculation, Variable Overall Heat Transfer Coefficient, Heat Exchanger Design Methodology	2
Forced Convection Correlations for the Single-Phase Side of Heat Exchangers	Turbulent Forced Convection- Turbulent Flow in Smooth Straight Noncircular Ducts, Effect of Variable Physical Properties in Turbulent Forced Convection	1
	Forced convection in straight ducts, heat transfer in tube bundles, helical coils and spirals, in bends.	1
	Pressure Drop for Abrupt Contraction, Expansion, and Momentum Change, Heat Transfer and Pumping Power Relationship	1
Heat Exchanger Pressure Drop and Pumping Power	Tube-Side Pressure Drop	1
	Pressure Drop in Tube Bundles in Crossflow	1
	Pressure Drop in Helical and Spiral Coils	1
	Pressure Drop in Bends and Fittings	1
Design of Heat Exchangers Subject to Fouling	Fouling Resistance, Percent over Surface, Cleanliness Factor	2
Heat Exchanger Design Procedures	Fluid Mean Temperatures- Heat Exchangers with C* ~0, Counterflow, Crossflow and multipass Heat Exchangers	1
	Shell-and-Tube Heat Exchangers: Heat Transfer and Pressure Drop Calculations, Rating Procedure, Approximate Design Method, More Rigorous Thermal Design Method	3
	Compact heat exchangers: Plate-Fin Heat Exchangers-rating and sizing problem, Tube-Fin Heat Exchangers- Surface Geometries, Heat Transfer Calculations, Pressure Drop Calculations, Plate Heat Exchangers- Limiting Cases for the Design, Limiting Cases for the Design, Rating and sizing a PHE	4
	*Thermal Design Theory for Regenerators***:** Air preheaters and economiser	2
	*Polymer Heat Exchangers***:** Thermal Design of Polymer Heat Exchangers	1
	Condensers and evaporators: Film Condensation on a Single Horizontal Tube, Film Condensation in Tube Bundles, Condensation inside Tubes, Flow Boiling	3
Selection of Heat Exchangers and Their Components	*Selection Criteria Based on Operating Parameters*-operating pressure and temperature, cost, fouling and cleanability, fluid leakage, fluid type, fluids and material compatibility	2
	General Selection Guidelines for Major Exchanger Types	1
	Quantitative consideration- screening methods, performance evaluation criteria	1

Thermodynamic Modeling and Analysis of heat exchanger	Modeling a Heat Exchanger Based on the First Law of Thermodynamics-temperature distribution in counter flow, parallel flow and cross flow heat exchangers	2
	Irreversibilities in Heat Exchangers-entropy generation due to finite temperature difference, fluid mixing and fluid friction.	2
	A Heuristic Approach to an Assessment of Heat Exchanger Effectiveness	1
	Energy, Exergy, and Cost Balances in the Analysis and Optimization of Heat Exchangers: Temperature–Enthalpy Rate Change Diagram, Analysis Based on an Energy Rate Balance, Analysis Based on Energy/Enthalpy and Cost Rate Balancing, Analysis Based on an Exergy Rate Balance, Accounting for the Costs of Exergy Losses in a Heat Exchanger	4
	Performance Evaluation Criteria Based on the Second Law of Thermodynamics.	2
Total contact hours		**42**

Textbooks

1. Kakac, S., Liu, H., Pramuanjaroenkij, A. Heat Exchangers, Selection Rating and Thermal Design. CRC Press, 3rd Edition, 2012.
2. Shah R.K., Sekulic, D.P. Fundamentals of Heat Exchanger Design. Jhon Wiley & Sons, Inc, Hoboken, New Jersey, 2003

References

1. Jaluria, Y. Design and Optimization of Thermal Systems. CRC Press, 2nd Edition, 2008.
2. Sears, F.W. and Salinger, G.L. *Thermodynamics, Kinetic Theory and Statistical Thermodynamics* (Narosa Publishing House, New Delhi, 3/e, (1995)
3. Wylen and Sontag, *Fundamentals of Classical Thermodynamics* (Wiley Eastern Limited, New Delhi, 1985)
4. Moran, M.J. and Shapiro, H.N.. *Fundamentals Of Engineering Thermodynamics* (John Wiley and Sons, 6/e, 2008)
5. Zemansky, *Engineering Thermodynamics* (Mc Graw Hill, 2/e)
6. Bejan, *Advanced Engineering Thermodynamics* (John Wiley and sons, 2006)

5. Evaluation Plan:

Test No.	Marks	Duration (minutes)
Test I (Objective type)	25	30
Test II (Mid-semester)	40	2 h
Test III (Assignment type)	25	-
End Term	60	3 h
Total Marks	150	

All the tests will be held as per the schedule notified by the Controller of Examinations, Tezpur University

6. Pedagogy:

Teaching-learning methods to be used:
Lecture and Discussion
Presentations
Assignments
Class Tests/Quiz

7. Expected outcome: Towards the end of the course the student would be able to

i. Analyze the heat exchangers used in different purposes.
ii. Design heat exchangers such as shell and tube, compact heat exchangers, condensers, evaporators considering the pressure drop, fouling etc.
iii. Select the heat exchangers and their components based on operating parameters and quantity.
iv. Perform the thermodynamic modeling of heat exchangers based on energy, exergy and cost analysis.