ESE-908 Nuclear Thermal Hydraulics

Course Objectives

1. The objective of "Nuclear Thermal Hydraulics" course is to acquire knowledge and highlight the heat transfer and fluid flow that take place in nuclear power plants. The objectives of this course are:

   a. To deliberate the Heat generation in Reactor
   b. To study the Thermal analysis of fuel element
   c. To describe the phenomenon heat transfer fluid flow
   d. To enlighten the advanced treatment phenomenon of heat transfer in phase change
   e. To provide knowledge of two phase flow and study its application in nuclear power plants
   f. To integrate the advance studies and research in experimentation and numerical methods

Course Contents

2. Contents with suggested contact hours

No.	Topics	Contact Hours
a.	**Thermal Design Principles** • Power Cycles • Primary Coolant Systems • Reactor Cores • Fuel Assemblies • Plant Characteristics by Thermal Hydraulics • Thermal Design Limits • Thermal Design Margin	3
b.	**Reactor Heat Generation** • Energy Release and Deposition • Heat Generation Parameters • Power Profiles in Reactor Core • Heat Generation Within Fuel	3
c.	**Thermal Analysis of Fuel Element**	6

	• Heat Conduction in Fuel Elements • Thermal Properties of UO2 • Temperature Distribution in Plate Fuel Elements • Temperature Distribution in Cylindrical Fuel Elements • Temperature Distribution in Restricted Fuel Elements • Thermal Resistance between Fuel and Coolant	
d.	**Heat Transfer Fluid Flow** • Heat Removal • Heat Transfer Coefficient • Effect of Prandtl Number on convective Heat Transfer • Convective Heat Transfer Coefficient • Effect of length and Shape of Coolant Channel	6
e.	**Heat Transfer with Change in Phase** • Process Phase Change • Bubble Formation, Growth and Detachment • Boiling Regimes • Boiling Crisis and Burnout • Critical Heat Flux Correlation for Water	6
f.	**Two Phase Flow** • Two phase flow • Quality and Void fraction in a Non-flow System • Flow System • Boiling and Non-boiling Heights • Friction Drop in Two Phase Channel • Acceleration Pressure Drop • Two Phase Pressure Drop at Restriction • Pressure Drop due to Sudden Expansion • Pressure Drop due to Sudden Contraction	8

	• Two Phase Flow in Orifices • Critical Flow • Single Phase Critical Flow • Two Phase Critical Flow	
g.	**Single Heated Channel: Steady State Analysis** • Formulation of 1-D Flow Equation • Steady State Single Phase Flow in Heated Channel • Steady State Two Phase Flow in Heated Channel • Pressure Drop	6
h.	**Advances in experiments and numerical methods** • Advances in experimental thermal-hydraulics • Advances in numerical thermal-hydraulics • Multi-scale thermal-hydraulics codes • Verification and validation of numerical codes • CFD Application to nuclear engineering	7
		45

3. **<u>Outcomes</u>**

a. The students will be familiarized with important parameters of thermal Hydraulics
b. The students have adequate knowledge about the heat transfer with phase change
c. The students will calculate pressure drop in single channel, sudden contraction, sudden expansion, and orifice
d. The students will analyze and solve problems in heat transfer in complex systems
e. The students will analyze and solve problems in single and two-phase flows of power plant
f. It benefits the students to have knowledge about advancement in experiments and numerical method which guide them in research phase.

4. Recommended Reading (including Textbooks and Reference books).

S. No.	Title	Author(s)	Remarks
a.	Nuclear System I: Thermal Hydraulic Fundamentals	N.E. Todreas, and M.S. Kazimi	Text Book
b.	Nuclear Heat Transport, International, 1981	M. M. El-Waqil	Text Book
c.	Nuclear System II: Elements of Thermal Hydraulic Design	N.E. Todreas, and M.S. Kazimi	Reference Book
d.	Boiling heat transfer and two-phase flow, 2nd Ed	L. S. Tong, and Y. S. Tong	Reference Book
e.	Heat Transfer: A Practical Approach	Yunus A. Cengel	Reference Book
f.	Steam Plant Operation, 9th Edition	E. B. Woodruff, H. B. Lammers, and T. F. Lammers	Reference Book