UNENE Graduate Course Reactor Thermal-Hydraulics Design

McMaster University
Whitby
March 1-2, March 15-16,
April 5-6, April 19, 2008

Dr. Nik Popov

Course Schedule (March 1)

Class Date/ Location	Class Topic	Lecture Time
March 1 UOIT - Whitby	1. Course introduction: • Student introduction • Scope and schedule • Course requirements, assignments, tests	9:00 – 10:30
March 1 UOIT - Whitby	2. Design Requirements • Heat transfer considerations • Uranium fuel forms • Fuel sheath (cladding) materials • Reactor coolants • Neutron moderators • Moderator arrangements and HTS engineering considerations	10:30 – 13:00
March 1 UOIT - Whitby	3. Power reactor types and designs • CANDU • CANDU 6 • ACR-700 and ACR-1000 • LWRs	14:00 – 17:00

Course Schedule (March 2)

Class Date/ Location	Class Topic	Lecture Time
March 2 UOIT - Whitby	**4. Process Design Evolution** • Reactor HTS • Steam Generator • Reactor Core • Radiation Exposure • Recent design changes • History of CANDU Design	9:00 – 10:30
March 2 UOIT - Whitby	**5. Heat Transport System Thermal-Hydraulics** • Reactor Heat Balance • Steam Generator • Primary Side Flow • Secondary Side Flow • Approximate solution • Heat balance for CANDU 6 • Steam generator with preheater (analytical solution) • Steam generator with preheater (numerical solution)	10:30 – 13:00
March 2 UOIT - Whitby	**6. Flow instabilities**	14:00 – 16:00
March 2 UOIT - Whitby	**7. Assignments**	16:00 – 17:00

Course Schedule (March 15)

Class Date/ Location	Class Topic	Lecture Time
March 15 UOIT - Whitby	**8. Fuel-coolant heat transfer** • General heat conduction equation • Heat transfer in radial direction • General thermal energy equation • Heat transfer in axial direction • Axial quality distribution	9:00 – 12:00
March 15 UOIT - Whitby	**9. Reactor Thermodynamics** • 1st and 2nd Laws • Work, Enthalpy, Energy Equation, Carnot Cycle, Entropy • Reactor power cycle • Efficiency Improvements • Complex Rankine cycle for CANDU	13:00 – 15:00
March 15 UOIT - Whitby	**10. Two-Phase Flow Fundamentals and impact on the design process** • Two-phase flow terminologies • Model assumptions • Flow patterns and transition • Boiling flow • Void fraction	15:00 – 17:00

Course Schedule (March 16)

Class Date/ Location	Class Topic	Lecture Time
March 15 UOIT - Whitby	11. Critical Heat Flux • CHF terminologies • CHF mechanisms • Experimental techniques • Prediction methods • Applications for design and safety analyses	9:00 – 12:00
March 16 UOIT - Whitby	12. Post dryout heat transfer • Introduction • Transition boiling • Film boiling • Drypatch spreading	13:00 – 16:00

Course Schedule (April 5)

Class Date/ Location	Class Topic	Lecture Time
April 5 UOIT - Whitby	13. Pressure drop • Background • Conservation equations • Single-phase pressure gradient • Onset of significant void • Two-phase pressure gradient	9:00 – 10:30
April 5 UOIT - Whitby	14. Overview of computer programs used in thermal-hydraulics analysis	10:30 – 13:00
April 5 UOIT - Whitby	15. Assignments - student presentations	14:00 – 17:00

Course Schedule (April 6)

Class Date/ Location	Class Topic	Lecture Time
April 6 UOIT - Whitby	15. Assignments - student presentations	9:00 – 13:00
April 6 UOIT - Whitby	16. Preparation for the test	14:00 – 16:00

Course Schedule (April 19)

Class Date/ Location	Class Topic	Lecture Time
April 19 UOIT - Whitby	17. Final test 18. Submission of assignment papers	9:00 – 12:00 13:00 – 17:00
April 21 AECL – SP4	19. Final test (alternate) 20. Submission of assignment papers (alternate)	9:00 – 12:00

Course Preliminaries

- UNENE TH Course is based on course given in past years
  - UNENE Course in March-April 2004
  - UNENE Course in March-April 2006
  - Composed from material used in the past – McMaster Nuclear Technology Graduate Diploma Program
    - EP716 – Reactor TH Design
    - EP718 – Reactor TH Analysis
  - Experience from past semesters is taken into account in this semester
- Course material contains more information that can be covered in 6 x 8 hours over three weekends
- Course material available on the web site
  - http://nuceng.mcmaster.ca/ep704th/ep704index.htm.
  - www.unene.ca/un804-2006/index.htm

Course Preliminaries (cont'd)

- Course format
  - Lectures, assignments, test at the end
  - Student participation in discussions encouraged and important
  - Material on the web site will not be covered in class on page-by-page and line-by-line basis, instead informal discussions will be encouraged
  - Student suggestions and preferences will be taken into account as much as possible and feasible
  - Student presentations on specific topics will be considered in the 3rd session (third weekend)

Assignments

- Main assignment
  - Comparison of reactor types CANDU 6, ACR, Advanced PWRs
  - Details will be explained at the end of the 1st session
  - Assignment to be ready at the first class of 3rd session
  - Students will be organized in groups
  - Student presentation for each group are scheduled at the beginning of 3rd session
- Several minor assignments will also be given

Test

- Closed-book test scheduled for April 19 or April 21, 2008
  - Students will be allowed to prepare up to 4 pages hand-written material (each student to have his own; no copies allowed) to use for the test (other textbooks or material will not be allowed)
- Test will include questions that cover most important parts of the course
- Calculations will not be included, but explaining calculation methodology may be
- Formula derivation will be avoided

Marks

- Mark composed of:
  - Main assignment 40%
    - Presentation 20%
    - Paper 20%
  - Small assignments 20%
  - Test 40%
- Marks will be given to McMaster one week after the Test (by first week of May 2008).

Graduate Marks

- McMaster University Marks
  - A+ 90 – 100%
  - A 85 – 89%
  - A- 80 – 84%
  - B+ 77 – 79%
  - B 73 – 76%
  - B- 70 – 72%

Questions?