UNENE Graduate Course Reactor Thermal-Hydraulics Design and Analysis

McMaster University
Whitby
March 11-12, March 25-26,
April 8-9, April 22-23, 2006

Dr. Nik Popov

Course Schedule (March 11)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
March 11 UOIT - Whitby	1. Course introduction: • Scope and schedule • Course requirements, assignments, tests	Nik Popov	9:00 – 10:30
March 11 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	Nik Popov	10:30 – 12:30
March 11 UOIT - Whitby	3. Power reactor types and designs • CANDU • CANDU 6 • ACR-700 and ACR-1000 • LWRs	Nik Popov	13:30 – 15:30
March 11 UOIT - Whitby	4. Process Design Evolution • Reactor HTS • Steam Generator • Reactor Core • Radiation Exposure • Recent design changes • History of CANDU Design	Nik Popov	15:30 – 17:00
March 11 UOIT - Whitby	5. Assignments given to students	Nik Popov	17:00 – 18:00

Course Schedule (March 12)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
March 12 UOIT - Whitby	6. 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)	Nik Popov	9:00 – 12:00
March 12 UOIT - Whitby	7. Flow instabilities	Nik Popov	13:00 – 14:00
March 12 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	Nik Popov	14:00 – 17:00

Course Schedule (March 25)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
March 25 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	Nik Popov	9:00 – 11:00
March 25 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	Amad Abdul-Razzak	11:00 – 13:00
March 25 UOIT - Whitby	11. Critical Heat Flux • CHF terminologies • CHF mechanisms • Experimental techniques • Prediction methods • Applications for design and safety analyses	Amad Abdul-Razzak	14:00 – 15:30
March 25 UOIT - Whitby	12. Post dryout heat transfer • Introduction • Transition boiling • Film boiling • Drypatch spreading	Amad Abdul-Razzak	15:30 – 17:00

Course Schedule (March 26)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
March 26 UOIT - Whitby	13. Pressure drop • Background • Conservation equations • Single-phase pressure gradient • Onset of significant void • Two-phase pressure gradient	Amad Abdul-Razzak	9:00 – 10:00
March 26 UOIT - Whitby	14. Basic equations for t-h analysis	Nik Popov	10:00 – 12:00
March 26 UOIT - Whitby	15. Equation of state	Nik Popov	13:00 – 15:00
March 26 UOIT - Whitby	16. Nodalization	Nik Popov	15:00 – 17:00

Course Schedule (April 8)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
April 8 UOIT - Whitby	17. The rate form of equation of state	Nik Popov	9:00 – 11:00
April 8 UOIT - Whitby	18. Student discussions - preparations	Students	11:00 – 12:00
April 8 UOIT - Whitby	19. Assignments - student presentations	Students	13:00 – 17:00

Course Schedule (April 9)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
April 9 UOIT - Whitby	20. Thermal-hydraulic network calculations	Nik Popov	9:00 – 10:30
April 9 UOIT - Whitby	21. Review of computer programs (CATHENA)	Nik Popov	10:30 – 12:00
April 9 UOIT - Whitby	22. Review of computer programs (CATHENA)	Nik Popov	13:00 – 16:00
April 9 UOIT - Whitby	23. Preparation for the test	Nik Popov	16:00 – 17:00

Course Schedule (April 22-23)

Class Date/ Location	Class Topic	Lecturer Name	Lecture Time
April 22 UOIT - Whitby	24. Final test 25. Submission of assignment papers	Students	9:00 – 12:00 13:00 – 17:00
April 23 UOIT - Whitby	26. Final test (alternate) 27. Submission of assignment papers (alternate)	Students	9:00 – 12:00 13:00 – 17:00

Course Preliminaries

- UNENE TH Course is based on course given in the past years
  - UNENE Course in March-April 2004
  - 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, and from this semester will be taken into consideration for preparing the course for next years
- 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.

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 2nd session (second weekend)

Assignments

- Main assignment
  - Comparison of reactor types CANDU 6, ACR, Advanced PWR
  - 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 that will be completed either in class or at home

Test

- Open-book test scheduled for April 22 or April 23, 2006
  - Students will be allowed to prepare up to 10 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 30%
    - Presentation 15%
    - Paper 15%
  - Small assignments 30%
  - Class participation 10%
  - Test 30%
- Marks will be given to McMaster one week after the Test (by first week of May 2006).

Graduate Marks

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

Questions?