Nuclear Fuel Performance

NE 533

Spring 2022

3 Credit Hours

Withers Hall 123b

Tues./Thurs. 3:00-4:30 pm

1. **Instructor**

Dr. Benjamin Beeler

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919-515-3737

Burlington 1110C

Office Hours: Wed. 10-11 am

1. **Course Description**

In this course we will study the basic role of fuel in reactor operation and understand how the fuel impacts heat generation and transport to the coolant. The course will begin with an overview of different fuels and the fabrication processes required to construct nuclear fuel. This will include various fuel types and geometries, with a focus on light water reactor fuel and cladding. Thermal transport, mechanics, and thermomechanics affecting fuel behavior will be introduced, and methods to solve the governing equations numerically and analytically will be developed. Subsequently, changes in the fuel and cladding material that degrade the performance of the fuel will be examined. Finally, the knowledge gained throughout the course will be utilized to conduct fuel performance simulations with MOOSE.

1. **Learning Outcomes**

By the end of this course, the student should be able to:

1. Summarize the basics of fuel fabrication
2. Evaluate traditional and alternative nuclear fuel types and their application
3. Determine the rate at which heat is transported to the coolant from the fuel
4. Determine the stress state within both the fuel and the cladding
5. Describe the most important microstructural changes that take place in the fuel and cladding and how they impact fuel performance
6. Use an existing fuel performance code
7. **Pre- or Co-Requisites**

NE 409 or equivalent

1. **Required Text(s)**

None.

Supplemental texts:

Light Water Reactor Materials, Vol. 1 Fundamentals, D. Olander and A. Motta

Nuclear Fuel Elements, B. Frost

Fundamentals of Radiation Materials Science, G. Was

1. **Course Requirements**

Examinations: Exam 1: 20 %; Exam 2: 20 %, Exam 3: 20 %

Projects: Presentation report 1: 15 %; Final Project: 25 %

1. **Topical Outline:**

Course schedule is subject to change with appropriate notification of students.

* 1. Introduction and Overview
  2. Fuel types, Heat generation, Reactor systems, Fuel fabrication, Heat transport – 4 weeks
  3. Mechanical behavior, Thermomechanics, Materials issues in the fuel – 4 weeks
  4. Materials issues in the clad, Advanced fuels materials issues – 4 weeks
  5. Overview and utilization of fuel performance codes – 2 weeks

1. **Grading**

Letter Grade Percent Grade

A+ 97-100; A 93-96; A- 90-92; B+ 87-89; B 83-86; B- 80-82; C+ 77-79; C 73-76; C- 70-72; D+ 67-69; D 63-66; D- 60-62; F Below 60

1. **Late Submission Policy**

All course work must be submitted no later than the due date unless prior arrangements are made with the professor and a new due date is established. If a student submits an assignment after the due date without having made arrangements with the professor, ten points will be deducted (based on a grading scale of 100) for each day that the assignment is late, with a maximum late turn-in of 5 days past due.

1. **Statement for students with disabilities:**

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State’s policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01).

1. **Academic Integrity**

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at <http://policies.ncsu.edu/policy/pol-11-35-01>. Violations of academic integrity will be handled in accordance with the Student Discipline Procedures (NCSU REG 11.35.02).

1. **N.C. State University Polices, Regulations, and Rules (PRR):**

Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include: http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity and Non-Discrimination Policy Statement), http://oied.ncsu.edu/oied/policies.php (Office for Institutional Equity and Diversity), http://policies.ncsu.edu/policy/pol-11- 35-01 (Code of Student Conduct), and http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average).

1. **Insurance of Course Continuity**

To ensure course continuity, changes made to the method of instructional delivery, course structure, course schedule, number of assignments, grading or other aspects of the course after the start of the term will be communicated to all students in written form (e.g., dated syllabus revision or syllabus addendum) when course changes are implemented

1. **Digital Course Content**

All lectures will be uploaded to the course Moodle page, which will be made available prior to the start of the semester. Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

1. **Attendance/Absentee Policy**

Student participation in class enhances the learning experience not only for the individual but for the class as a whole. As such, students are expected to regularly attend lectures. Please refer to NCSU Attendance regulation [Reg 02.20.03](https://policies.ncsu.edu/regulation/reg-02-20-03-attendance-regulations/) for university definition of excusable absences.