NUCL597 Manufacturing and Materials for Modern Nuclear Reactors

1. **Credit Hours:** 3
   Meeting time: TBA

   Terms Offered: Spring 2022

2. **Instructors:** Xiaoyuan Lou, 765-496-2327, lou49@purdue.edu
3. **Office hours:** TBD
   Option 1: Wang Hall 4096
   Option 2: Zoom meeting
   https://purdue-edu.zoom.us/j/4911916187

4. **Textbook(s):**
   No required textbook

   References:
   - *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Mikell P. Groover*
   - *Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani*
   - *An Introduction to Nuclear Materials: Fundamentals and Applications, Murty & Charit*
   - *Fundamentals of Radiation Materials Science: Metals and Alloys, Gary Was*
   - *Physical Metallurgy Principles, Reza Abbaschian, Robert E. Reed-Hill*

5. **Course Description:**
   Advanced materials and manufacturing methods are the backbone of the existing light water reactors and the ongoing development of advanced nuclear reactors. This course is designed to provide a comprehensive discussion of the material systems that are relevant to modern nuclear reactors, and the manufacturing methods to enable the reactor designs. Different from other manufacturing related courses, this course will focus on the fundamentals of material and manufacturing science, and discuss how manufacturing methods can affect material properties that are critical to nuclear applications. We will establish the connections between basic material science (structure and properties) and manufacturing science (heat transfer, mass transfer, deformation). Since this is a rapidly evolving field, the course will deliver the "modern" information about the nuclear material and manufacturing technologies. Besides the "conventional" technologies, the current development of advanced manufacturing and materials technologies will be discussed, with the strong focus on additive manufacturing.

6. **Prerequisites:** N/A

7. **Learning Objectives:**
   - Overview of the engineering materials and components that are relevant to modern nuclear reactors

- Understand the basics of metallurgy and materials science and establish the relationship between structure/microstructure and mechanical/physical properties
- Discuss different types of nuclear materials and their required properties
    - Structural alloys
    - Weldments
    - Nuclear fuels
    - Advanced materials
- Learn the fundamental manufacturing science and related material properties of key manufacturing processes
- Hands-on experience to work with the industry and fabricate sub-sized components by additive manufacturing
- Invited presentations from internal and external subject experts

8. Assignments:

- Homework assignments
- Midterm and final examinations
- Report

9. Course Schedule*:

Weeks	Topics
1	• A review of reactor systems, focusing on engineering materials, requirement, and components
2 - 5	• Review the fundamental metallurgy and required material properties for structural integrity
6 - 7	• Discuss the key nuclear materials o Structural alloys (RPV steels, stainless steels, Ni based alloys) o Weldments o Nuclear fuels o Advanced materials (corrosion resistant alloys, ODS alloys, ATF, refractory alloys) • Invited talks
8 - 9	• Course project instruction on metal additive manufacturing practice
10 - 16	• Manufacturing science, microstructure, and nuclear related properties o Solidification process o Metal working o Heat treatment o Joining and cladding o Additive manufacturing (technologies, processing science, material aspects, qualification)

	○ Powder metallurgy ○ Cold spray ○ Friction stir welding ○ Substractive manufacturing • Inspection and qualification • Automation technologies for manufacturing • Integrated or convergent manufacturing

* Schedule and assignments subject to change. Any changes will be posted on Brightspace.

10. Grading:

Homework	30%
Midterm Exam	25%
Final Exam	30%
Report	10%
Attendance	5%

Scale: A >= 85%, A- >= 82%, B+ >= 78%, B >= 75%, B- >=72%, C+ >= 68%, C >= 65%, C- >=62%, D+ >= 58%, D >= 55%, D- >=50%, F < 50%

11. Attendance Policy:

Students are expected to attend all classes unless prior permission for absence from the Instructor.