COURSE OUTLINE

Department & Faculty: Department of Energy Engineering **School of Chemical and Energy Engineering**	**Semester: 1** **Academic Session: 2018-2019**
Course & Code: Nuclear Reactor Materials – SKPN 4123 **Contact Hours: 42 hours**	

Lecturer	:	**Mr. Mohsin Mohd Sies**
Room No.	:	N01-324 , School of Chemical and Energy Engineering
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Section	:	2018/2019 - I
Lecture Time	:	
Tutorial Time		
Venue	:	
Assistant	:	
Prerequisite	:	None
Synopsis	:	This course will provide a valuable insight on some of the key issues facing the nuclear power generation industry. Many of these are related to the materials involved, their response to, and their reliability under extreme conditions. The effects of radiation on various properties of materials in nuclear applications will be dealt with to get an appreciation of the materials' limitations on the operation of reactors. Students will first be introduced to the basic concepts of materials science. The basic aspects of the nuclear fuel cycle, current and future nuclear reactor designs, and the materials problems associated with nuclear energy production will be discussed. The key issues in materials failures and the requirements for efficient and safe operation of current reactor designs as well as design of novel materials for future reactors will be discussed. A few applications of radiation effects will then be treated with this newfound framework, including the change of material properties under irradiation, void swelling, embrittlement and loss of ductility. At the end of this course, students will be familiar with the basic issues concerning the selection of materials for various components in nuclear reactors.
Learning Outcomes	:	By the end of the course, students should be able to i) Evaluate the effect of radiation on the microscopic and macroscopic properties of the materials ii) Describe and compare the properties various structural materials in nuclear reactors iii) Analyze materials-related issues and problems encountered in nuclear reactor structures and the remedial approaches iv) Evaluate the fuel properties and testing for nuclear reactor v) Describe procedures for detecting the problems and suggest plausible remedial solutions
Generic Skills Addressed	:	Function effectively as an individual, and as a member or leader in diverse teams or multi-disciplinary settings (PO5)

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Course Mapping on Bloom Taxonomy and Key Performance Index (KPI) of Course Outcome

CO	Course Outcome	Program learning outcomes	Weightage	Assessment	KPI
CO1	Evaluate the effect of radiation on the microscopic and macroscopic properties of the materials	PO1 (C3) PO2 (C3)	10% 10%	Assignment Quiz Test Final Exam	
CO2	Describe and compare the properties of various structural materials in nuclear reactors	PO1 (C2)) PO2 (C2)	12.5% 12.5%	Assignment Quiz Test Final Exam	
CO3	Analyze materials-related issues and problems encountered in nuclear reactor structures and the remedial approaches	PO1 (C4) PO2 (C4)	10% 10%	Assignment Quiz Test Final Exam	
CO4	Evaluate the fuel properties and testing for nuclear reactor	PO1 (C4) PO9 (C4)	17.5% 7.5%	Assignment Quiz Test Final Exam	
CO5	Describe procedures for detecting the problems and suggest plausible remedial solutions	PO1 (C2) PO2 (C2)	5% 5%	Assignment Quiz Test Final Exam	

Program Outcomes (PO) related to the course:

PO1 Apply knowledge of mathematics, science, engineering fundamentals, chemical and gas engineering principles to the solution of complex engineering problems.

PO2 Identify, research relevant literature, formulate and solve complex engineering problems using first principles of mathematics and engineering sciences.

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STUDENT LEARNING TIME (SLT)

Teaching and Learning Activities	**Student Learning Time (hours)**
1. Face-to-Face Learning	
a. Lecturer-Centered Learning i. Lecture	45
b. Student-Centered Learning (SCL) i. Laboratory/Tutorial ii. Student-centered learning activities – Active Learning, Project Based Learning	14
2. Self-Directed Learning	
a. Non-face-to-face learning or student-centered learning (SCL) such as manual, assignment, module, e-Learning, etc.	20
b. Revision	30
c. Assessment Preparations	6
3. Formal Assessment	
a. Continuous Assessment	5
b. Final Exam	3
Total (SLT)	120

Teaching Methodology : This course will utilize cooperative learning technique. At the beginning of the semester, the students will be divided into group of four and are assigned to sit together in their respective group. The group team members will help each other during the problems solving session in class.

For soft skill the students will be assessed on the communication skills as well as the effectiveness of the students as individual and group member Students are given problem and they will be required to solve it in class following the 10 steps of problem solving given in class. The skills are also reflected by quizzes, assignments, test and overall performance of his/her in the class.

Short class assignments and discussions will be carried to assess the achievement of the students on the topic outcomes, whereas the tests are to evaluate their attainment of the intended course outcome in term of the technical skill.

Nuclear Reactor Materials - Course Schedule

Week	Topic	Topic Outcomes
Week 1	**1. Introduction to Nuclear Reactor and Materials** **1.1** Nuclear reactions as sources of energetic particles, Nuclear fusion and fission 1.2 Material properties 1.3 Atomic structures and bondings	*It is expected that students will be able to:* • understand the nuclear reaction and the effects of radiations on the materials • Understand the general properties of materials and their classification • describe different types
Week 2	**2. Material Nature** 2.2 Crystal Structure 2.3 Imperfections 2.3 Diffusion in Solids 2.4 Dislocation theory 2.5 Cascade collision	*It is expected that students will be able to:* • explain different material natures and their impacts on the integrity of the materials
Week 3	**3. Overview of nuclear reactor and Materials** 3.1. Various types [LWR, PHWR, GCR, FBR, Fusion] 3.2. Materials of nuclear reactor 3.3. Existing material selection	*It is expected that students will be able to:* • describe the properties of different materials for nuclear reactors
Week 4	**4. Nuclear Reactor design and its materials** 4.1 Brief outline of reactor types design and technology, and their particular demands for high-performance materials. 4.2 Introduction to material issues associated with nuclear power generation	*It is expected that students will be able to:* • describe different types of reactor and their designs • relate the types of reactors with their materials issues •
Week 5	**5. Mechanical Properties of Materials** 5.1. Strength of materials 5.2. Requirements of nuclear reactor materials	*It is expected that students will be able to:* • evaluate the criteria of nuclear reactor materials • describe the mechanical properties of different materials for nuclear reactor
Week 6	**6. Effect and Damage of Radiation on Materials** 6.1. Microstructural Changes 6.2. Friction and Source Hardening 6.3. Fracture and DBTT 6.4. Embrittlement and Fracture	*It is expected that students will be able to:* • evaluate the effects and damages of radiation on nuclear reactor materials
Week 7	**7. Welding** 7.1. Types and purposes of welding 7.2. Post welding heat treatment	*It is expected that students will be able to:* • Describe the different characteristics and applications of welding for nuclear reactor
Week 9	**8. Issues Related to LWR Materials** 8.1. Water chemistry 8.2. Stress corrosion cracking 8.3. Irradiation effects on LWR materials	*It is expected that students will be able to:* • understand the water chemistry of LWR • explain the formation of stress corrosion cracking • evaluate the general materials issues in LWR
Week 10	**9. Materials in PWR** 9.1. Materials and parts in PWR 9.2. Scientific issues related to PWR 9.3. Material selection for PWR	*It is expected that students will be able to:* • understand the water chemistry of PWR • explain the formation of stress corrosion cracking in PWR • evaluate the specific materials issues in PWR

Week 11	**10. Materials in BWR** 10.1.Materials and parts in BWR 10.2.Scientific issues related to PWR 10.3.Material selection for PWR	*It is expected that students will be able to:* • understand the water chemistry of PWR • explain the formation of stress corrosion cracking in PWR • evaluate the specific materials issues in PWR
Week 12	**11. LWR Fuel** 11.1.Fuel behavior 11.2.Pellet-cladding mechanical interactions (PCMI) 11.3.Scientific issues related to fuel engineering 11.4.Instrumentation and Testing-hot cell laboratory, post irradiation examinations	*It is expected that students will be able to:* • understand the fuel behavior • describe the occurrence of PCMI •
Week 13	**12. Material Degradation Detection and Instrumentation** 12.1.Approaches for degradation detection 12.2.Instrumentation	*It is expected that students will be able to:* • describe the approaches for material degradation detection • apply different instrumentations for material studies
Week 14	**Case Study and Presentation**	*It is expected that students will be able to:* • perform a group presentation that relate to nuclear reactor materials • relate the knowledge of nuclear reactor materials to real life application

References :

1. K. Linga Murty, Indrajit Charit, An Introduction to Nuclear Materials: Fundamentals and Applications, John Wiley & Sons, 2013
2. Todd R. Allen, Roger E. Stoller, Shinsuke Yamanaka, Comprehensive Nuclear Materials, Elsevier, 2012

Assessment :

Evaluation	Percent (%)
Continuous assessment (Assignments, quizzes)	30%
Test	20%
Final Examination	50%
TOTAL	100%

Academic Integrity:

The University has a strict policy on academic integrity. Any form of plagiarism or academic dishonesty will NOT be tolerated. If you have any questions, please consult the lecturer.