240NU212 - Non-Destructive Testing Methods

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2017
Degree: MASTER'S DEGREE IN NUCLEAR ENGINEERING (Syllabus 2012). (Teaching unit Optional)
ECTS credits: 4,5  Teaching languages: English

Teaching staff

Coordinator: ALFREDO DE BLAS DEL HOYO
Others: GUILLEM PERE CORTES ROSSELL
Koubychine Merkulov, Youri Alexandrovich

Degree competences to which the subject contributes

Specific:
1. Knowledge of the diagnostic techniques used in the inspection and life management of nuclear plant components.

General:
2. Ability to design, calculate and design processes, equipment, facilities and plants related to the procurement of nuclear energy and the use of ionizing radiation.
3. Have adequate knowledge of mathematical aspects, analytical, scientific, instrumental, technological and management.

Teaching methodology

Combination of experimental sessions and lectures to introduce the basic information.

1) Lectures
The professor introduces the basic information of the several sections.

2) Scheduled independent learning
Throughout the course, students must solve some selected exercises; search some topics on the specialized literature and perform some simulations of instrumentation and detectors to analyze the systems and its operations.

3) Cooperative Learning
Resolution on class of some complex exercises that requires the complete collaboration of all the members of the working group

4) Laboratory
During the course, four experimental practices will be done at the laboratory. Each practice has a pre-laboratory work and the redaction of a report with some post-laboratory and analysis tasks is mandatory.

Learning objectives of the subject

1. Enumerate the basic features of an eddy current testing
2. Describe the physic foundations of an eddy current testing
3. Determine the operation point on the normalized impedance plot and the variation
4. Interpret the variations of the operation point on the normalized impedance plot
5. Describe the main features of the X-ray Fluorescence Analysis
6. Describe the basic instrumentation for generation and measurement of X-rays
7. Capacitate the student to propose an experiment to identify the composition of a material by means of X-ray Fluorescence Analysis
8. Describe the basic principles of ultrasonic testing for flaw detection/evaluation
9. Familiarize the student with the equipment employed in ultrasonic testing

10. Enumerate the basic features of some of the other most used techniques on nuclear power plants (surface methods, liquid penetrant, magnetic particles, visual methods)
11. Describe the physic foundations of some of the other most used techniques on nuclear power plants (surface methods, liquid penetrant, magnetic particles, visual methods)
12. Describe the basic steps of the manufacturing process of a fuel assembly
13. Explain the operation behavior and fuel reliability and localize the basic aspects of fuel assemblies to control
14. Describe the inspection of fuel assemblies.
15. Measure the impedance of a coil to plot the operation points of several tubes
16. Measure the conductivity of some tubes and blocks with eddy currents equipment
17. Identify flaws in a sample by ultrasonic testing techniques
18. Identify the composition of materials by X-ray fluorescence.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours large group: 0h</th>
<th>0.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 40h 30m</td>
<td>36.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 72h</td>
<td>64.00%</td>
</tr>
</tbody>
</table>
## 1. Eddy Currents

**Learning time:** 14h  
- Theory classes: 4h  
- Practical classes: 2h  
- Self study: 8h

**Description:**  
Exposition on class by the teacher of the fundamentals of the eddy currents techniques. The student will learn the main features, the physical foundations, the variable analyzed and its interpretation.

**Contents:**  
1. Introduction  
2. Basic principles (I). AC circuits  
3. Basic principles (II). Electromagnetism for eddy currents test  
4. Impedance diagram  
5. Models for eddy current test

**Related activities:**  
- 4h Presentation (theory)  
- 2h Problems in classroom  
  - 1h Analysis of AC circuits. Real inductance  
  - 1h Förster diagram

## 2. X-Ray Flourescence analysis

**Learning time:** 10h  
- Theory classes: 2h  
- Practical classes: 2h  
- Self study: 6h

**Description:**  
General overview of X-ray fluorescence analysis techniques for material composition measurement. Also will be described the working principles of X-ray tubes and their main features.

**Related activities:**  
General overview of X-ray fluorescence analysis techniques for material composition measurement. Also will be described the working principles of X-ray tubes and their main features.
### 3 Ultrasound testing

**Learning time:** 5h  
Theory classes: 2h  
Self study: 3h  

**Description:**  
At the end of this topic, the student will be able to describe the physical principles for flaw detection by ultrasound testing. Also the student will employ a commercial kit for flaw detection by ultrasound testing.

**Related activities:**  
- 1.5 h Oral exposition by teacher (theory)  
- 0.5 h Experimental demonstration of the ultrasound testing kit operation

### 4. Ionizing radiation

**Learning time:** 7h  
Theory classes: 2h  
Practical classes: 2h  
Self study: 3h  

**Description:**  
General overview of non-destructive tests based on the interaction of ionizing radiation (alpha particles, electrons, X-rays, gamma and neutrons) with matter.

**Related activities:**  
- 2 h Oral exposition by professor (theory)  
- 2 h Exercises about radioactive gauges

### 5. Other NDT techniques

**Learning time:** 9h  
Theory classes: 3h  
Self study: 6h  

**Description:**  
Exposition on class by the teacher, of other Non-Destructive Techniques, not previously presented, but interesting of its application in the inspection of elements of Nuclear Power Plants.

The techniques here presented are Industrial Radiography, Surface Methods, Liquid Penetrant, Magnetic Particles and Visual Methods

**Related activities:**  
- 3 h of presentation (theory)
6. Application on nuclear power plants

**Description:**
The teacher exposes the main elements on a power plant requiring a regular inspection and monitorization. Then, the main techniques are presented.

**Related activities:**
- Presentation: 3h (Theory)

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7. Inspection of fuel assemblies

**Description:**
The teacher exposes the objectives and techniques of the inspection of fuel assemblies. The manufacturing of the fuel is presented, paying particular attention to inspection stages, with its equipment and procedures. The fuel performance on the reactor and its reliability are analyzed too, aspects like the surveillance and failure detection (and its characterization) are presented.

**Related activities:**
- 6h of presentation

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- Laboratory sessions

**Description:**
In groups of maximum 3 persons, the students will perform 4 laboratory sessions of 2h each one. Each session is focused mainly on two non-destructive techniques: Eddy currents and X-Ray fluorescence.

Each session has some post-laboratory work. The working group must deliver a report of each laboratory session, with the analysis of results, incidences and answers to some questions.

**Related activities:**
The laboratory sessions are:
1. Experimental determination of the Förster diagram
2. Determination of conductivity
3. Material identification by X-rays fluorescence
4. Salt concentration gauges
5. Transmission gauges
## Evaluation activities

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>2h</th>
<th>Other activities: 2h</th>
</tr>
</thead>
</table>

### Description:
- Evaluation activities:
  1. Section 1 to 4 of the Course description. Exam of theory and exercises
  2. Section 5 to 7 of the Course description. Test
# Planning of activities

## THEORY

<table>
<thead>
<tr>
<th>Description</th>
<th>Support materials</th>
<th>Descriptions of the assignments due and their relation to the assessment</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>At class, the teacher introduces the concepts in order to give to the students the capacity to develop the objectives of the subject</td>
<td>Oral presentations with the support of projectors. The presentation will be previously submitted to the students using the virtual campus.</td>
<td>Oral presentations with the aid of projectors and other media. The presentations will be previously submitted to the students using the virtual campus</td>
<td>1-14</td>
</tr>
</tbody>
</table>

## RESOLUTION OF PROBLEMS

<table>
<thead>
<tr>
<th>Description</th>
<th>Descriptions of the assignments due and their relation to the assessment</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems presented and discussed at class</td>
<td>Extra time to work at home and finish the problem.</td>
<td>3 and 7</td>
</tr>
</tbody>
</table>

## PRACTICAL SESSIONS

<table>
<thead>
<tr>
<th>Description</th>
<th>Support materials</th>
<th>Descriptions of the assignments due and their relation to the assessment</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four experimental practices on the Detection and Nuclear Instrumentation Laboratory of the Nuclear Engineering Section</td>
<td>The equipment of the Detection and Nuclear Instrumentation Laboratory. A guide for each session will be previously submitted to the students using the virtual campus.</td>
<td>A report for each experimental practice is delivered</td>
<td>15-18</td>
</tr>
</tbody>
</table>

## EVALUATION ACTIVITIES

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>The evaluation activities which will be carried out:</td>
<td>1. Section 1 to 3 of the Course description. Exam of theory and exercises 2. Section 4 of the Course description. Test 3. Section 5 of the Course description. Test</td>
</tr>
</tbody>
</table>
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**Descriptions of the assignments due and their relation to the assessment:**
Marks of the exam

**Specific objectives:**
1-18

**Qualification system**

FINAL MARK: \( FM = 0.4 \times EM + 0.2 \times PM + 0.4 \times LM \)

EM: Mean of the exam marks (evaluation activities)
PM: Problem resolution marks
LM: Laboratory marks and detector simulation mark

**Regulations for carrying out activities**

Laboratory sessions are mandatory

**Bibliography**