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820734 - EQT - Thermal Equipment

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines
Academic year: 2019
Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Compulsory)
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Compulsory)
ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Perez Segarra, Carlos David

Others: Carles Oliet Casasayas

Opening hours

Timetable: The specific timetable is agreed on with the student personally according to his/her availability (before setting up the meeting date, please send your time availability to segarra@cttc.upc.edu).

Prior skills

- Fundamentals of Thermodynamics, Fluid Mechanics, and Heat Transfer.
- It is not compulsory but advisable to have some basic knowledge of computer language (e.g. C++, C, Fortran, etc.)

Requirements

Minimum of 10 ECTS completed in Thermal Engineering, including:
- Fundamentals of thermodynamics.
- Fundamentals of fluid mechanics.
- Fundamentals of heat transfer.

Degree competences to which the subject contributes

Specific:

CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.

CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

Transversal:

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Teaching methodology

The course teaching methodologies are as follow:
- Lectures and conferences by guest speakers.
- Participatory sessions: collective resolution of exercises, debates and group dynamics with the lecturer and other students in the lecture room; presentation of an activity individually or in small groups.
- Supervised theoretical/practical work: activities carried out individually or in small groups, under the supervision of the professor/lecturers.
- Homework assignment: design, planning and implementation of a project or homework assignment, to be carried out individually or by a group of students, and writing a report that should include the approach, results and conclusions.

The course face-to-face training activities are as follow:
- Lectures and conferences: learning based on understanding and synthesizing the know-how presented by the lecturers or by invited speakers.
- Participatory sessions: learning based on participating in the collective resolution of exercises, as well as in discussions and group dynamics, with the lecturer and other students in the lecture room.
- Presentations: learning based on presenting in the lecture room an activity individually or in small groups.
- Theoretical/practical supervised work: learning based on performing an activity in the lecture room, or a theoretical or practical exercises, individually or in small groups, with the support form the lecturers.

Study activities
- Homework assignments: learning based on applying and developing know-how.
- Self-study: learning based on studying or developing the contents of the learning material, individually or in groups, understanding, assimilating, analysing and synthesizing know-how.

Learning objectives of the subject

Basic objectives of the course:
- description of selected thermal equipment: heat exchangers, heating, refrigeration and air conditioning systems, fired heaters
- introduction to basic simulation methodologies (analytical and computational tools, energy efficiency, optimization issues)
- consolidate and enhance the student's basic knowledge on thermodynamics, fluid mechanics and heat and mass transfer (thermal engineering fundamental issues)

Keywords: thermal systems and equipment, energy efficiency, ambient impact, design methods, optimization, heat exchangers, HVAC&R, natural fluids, sensitivity studies, thermodynamics, fluid dynamics, heat and mass transfer, combustion, furnaces, boilers.

At the end of the course the student:
- Is capable of describing the role of basic thermal equipment in the production and service sectors, as well as their importance in the energy chain: processing, transport, distribution and efficient use of energy.
- Is capable of selecting the most suitable thermal equipment from the energy point of view for each application (industry or services), and to analyze the performance of existing equipment.
- Is capable of proposing a project, at basic engineering scale or at functional scale, related to the design, sizing and/or the use of thermal equipment in various industrial and services sectors.
- Is capable of proposing improvements for thermal systems by developing new ideas.

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Study load

Total learning time: 125h	Hours large group:	30h	24.00%
	Guided activities:	15h	12.00%
	Self study:	80h	64.00%

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Content

1-Introduction	Learning time: 18h Theory classes: 6h Guided activities: 0h Self study : 12h

Description:

Presentation of the course structure. Brief introduction to basic thermal equipment and its applications in thermal systems: heat exchangers, heating, refrigeration and air conditioning, heat generation by combustion, power plants, etc. Energy efficiency issues. A brief review of fundamental concepts of thermodynamics, fluid mechanics and heat and mass transfer will also be carried out.

Related activities:

- Proposal of different exercises to be carried out.

Specific objectives:

- Review of different thermal equipment: description, technical issues, applications in different thermal systems
- Review of basic concepts of thermodynamics, fluid mechanics and heat and mass transfer (conduction, convection and radiation). Humid air. Exercises of application.

2. Heat Exchangers	Learning time: 36h 30m Theory classes: 11h Guided activities: 1h 30m Self study : 24h

Description:

Introduction to heat exchangers. Detailed description and classification. Basic methodology of analysis considering prediction and design cases: F-factor, phi-NTU2 and e-NTU methods. Examples of application.

The student should acquire the knowledge and skills necessary for the description, selection and dimensioning of heat exchangers, as well as for the calculation of the performance of existing equipment and facilities.

Related activities:

- Specific homework concerning the application of heat exchanger design methodologies.

Specific objectives:

- Classification of heat exchangers according to the type of fluids, interaction between currents, flow arrangements, and technological applications. Detailed description and mode of operation. Working parameters.
- General issues related to heat exchanger design: hermo-hydraulic and mechanical requirements, production process considerations, maintenance and cost reduction.
- Thermal and hydraulic analysis. Mathematical formulation considering single-phase flows. Methodology for design and prediction cases based on F-factor, phi-NTU2 and e-NTU methods. Extended surfaces (fins).
- Examples of application.

3. Heating, refrigeration and air conditioning	Learning time: 40h Theory classes: 11h Guided activities: 5h Self study : 24h

Description:
Introduction to the field of heating, refrigeration and air conditioning. Identification of the main thermal equipment and operating conditions. Design/selection of system components of vapour-compression refrigeration systems. Analysis of design and prediction of the whole cycle. Examples of application.

The student should acquire the knowledge and skills necessary for the description, selection and dimensioning of heating, refrigeration and air conditioning systems, as well as for the calculation of the performance of existing equipment and facilities.

Related activities:
- Proposal of exercises and evaporator
- Guided activity in the lab concerning transcritical CO2 vapour-compression refrigerating cycles.

Specific objectives:
- Description of vapour-compression refrigeration systems, for cooling or heating, and their components (evaporator, compressor, condenser, expansion device, intercoolers, etc.).
- Thermodynamic analysis of different refrigeration systems (single-stage and two-stage refrigeration systems, ejector refrigeration, systems with intermediate heat exchanger, flooded evaporator, etc.). Diagrams p-h and T-s. Examples of application.
- Condensers and evaporators. Classification, description and operating conditions. Extension of the methodology of design of heat exchangers to two-phase flows. Examples of applications.
- Compressors. Classification, description and operating conditions. Detailed analysis of reciprocating compressors. Calculation methodology. Examples of applications.
- Expansion devices. Classification, description and operating conditions. Detailed analysis of capillary tubes and thermostatic valves. Examples of applications.
- Prediction analysis of the whole refrigeration system and components.

4. Fundamentals of combustion. Application to furnaces and boilers.	Learning time: 30h 30m Theory classes: 9h Guided activities: 1h 30m Self study : 20h

Description:

Introduction to boilers and furnaces: description and operating conditions. Combustion fundamentals and thermodynamic analysis. Heat transfer in a well-stirred furnace.

The student should acquire the knowledge and skills necessary for the description, selection and a preliminar dimensioning of fired heaters, as well as for the calculation of the performance of existing equipment and facilities.

Related activities:

- Exercises of application.

Specific objectives:

- Introduction to boilers and furnaces: description and operating conditions.
- Combustion fundamentals. Chemical reactions and combustion. Mixture of perfect gases. Fuels. Complete, stoichiometric, lean and rich combustion. Elementary vs. overall reactions. Formation enthalpy. Heat of combustion, HHV and LHV. Temperature of the combustion products. Exercises of application.
- Zero-dimensional modelling of well-stirred furnaces. Overall energy balance and heat transfer to the load. Heat losses through the refractory walls. Temperature of the combustion gases. Exercises of application.

Planning of activities

1. Lectures of theory	Hours: 24h Theory classes: 24h

Description:
Lectures of theory. Introduction (4 h); Heat exchangers (7 h); Heating, refrigeration and air conditioning (7 h); Combustion and fired heaters (6 h)

1. Lectures of theory

Description:
Lectures of theory. Introduction (4 h); Heat exchangers (7 h); Heating, refrigeration and air conditioning (7 h); Combustion and fired heaters (6 h)

2. Lectures of applied exercises and problems	Hours: 13h Theory classes: 13h

Description:
Lecture of applied exercises and problems: Introduction (2 h); Heat exchangers (4 h); Heating, refrigeration and air conditioning (4 h); Combustion and fired heaters (3 h).

3. Guided activities	Hours: 8h Guided activities: 8h

Description:
Guided activities: Heat exchangers (1.5 h); Heating, refrigeration and air conditioning (5 h); Combustion and fired heaters (1.5 h). Some of these activities involve guided work in the lab.

4. Self study	Hours: 80h Self study: 80h

Description:
Self study: Introduction (12 h); Heat exchangers (24 h); Heating, refrigeration and air conditioning (24 h); Combustion and fired heaters (20 h)

Qualification system

The evaluation is based on two exams (midterm and final exam), together with the development of homework and a guided work in the lab. Midterm and final exams account for a 35% and 40% of the final mark respectively. There will be a re-take exam to improve the marks obtained in the midterm and/or final exam.
Homework and guided work in the lab account for a 25% of the final mark.

Regulations for carrying out activities

The specific rules concerning individual and/or group work will be published in the teaching intranet (Atenea).

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Bibliography

Basic:

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R. Viskanta. Radiative transfer of combustion systems : fundamentals and applications. U.S.: Begell House Publichers Inc., 2005. ISBN 1567002110.

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