Universidad Zaragoza

Academic Year/course: 2021/22

29913 - Technical Thermodynamics and Fundamentals of Heat Transfer

Syllabus Information

Academic Year: 2021/22
Subject: 29913 - Technical Thermodynamics and Fundamentals of Heat Transfer
Faculty / School: 110 - Escuela de Ingeniería y Arquitectura
Degree: 435 - Bachelor's Degree in Chemical Engineering
ECTS: 6.0
Year: 2
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

The subject has been proposed so that the student will be able to:

- Calculate the thermophysical properties of a system using simple models or tables.
- Determine the mass-energy interactions of a system during a given process, by means of process equations and balance equations.
- Know and apply the laws of thermodynamics to the energy analysis of basic equipment and processes in chemical engineering.
- Analyze the performance of energy installations based on thermodynamic cycles: power and cooling cycles, steam compression and gas turbine.
- Know the basic criteria for the main performance and performance improvements of the thermodynamic cycles.
- Apply the basic laws that govern the three mechanisms of heat transfer in simple situations.
- Learn to use a computer tool for the simulation of thermal systems and for the graphic representation of the processes that take place.

1.2. Context and importance of this course in the degree

The subject provides the basic principles to understand the energy transformations and allows to analyze and design thermal installations for the generation, transfer and use of energy.

It serves as an introduction for students to learn the language and basic concepts to understand any specialized text or manuals of the most common equipment in energy facilities, such as compressors, turbines, pumps, heat exchangers, etc.

With this subject, the student becomes familiar with the thermodynamic methodology to address, simplify, model and simulate important energy facilities: thermal power plants, gas turbines, refrigeration and air conditioning systems, etc. He/she also learns the basics of the three mechanisms of heat transfer, conduction, convection and radiation, and learns to solve stationary problems in simple geometries.

The subject is essential to take the subsequent subjects of Thermo-technology (compulsory), and Fluid dynamics (compulsory).

1.3. Recommendations to take this course

It is recommended that the student has studied the part corresponding to Thermodynamics in the subjects of Physics I, Chemistry and Chemistry II.

The knowledge of mathematical concepts, such as derivatives and basic integrals, logarithmic and exponential functions, graphic representations, etc., will be essential. Also the resolution of simple differential equations will have some importance for the Heat Transfer part. All this is learned in the Mathematics subjects corresponding to Basic Training.

It should be remembered that the habit of reading will facilitate the understanding of the recommended texts and, therefore, will promote the learning of the subject and improve the academic performance.

The student is recommended to actively attend classes on theory and problems, as well as a continuous study of the subject, the preparation of practical problems that can be solved in subsequent sessions, the study of scripts and the preparation of the results of the practices.

The constant work is fundamental to overcome with the maximum use this subject, since in each part a coherent analysis procedure is gradually studied. Therefore, when doubts arise, it is important to resolve them as soon as possible to guarantee the correct progress in this matter.

The student can consult the teacher to solve any doubts, both during the classes and in the tutoring hours for that purpose.

2. Learning goals

2.1. Competences

Generic competences

C04 - Ability to solve problems and make decisions with initiative, creativity and critical reasoning.

C07 - Ability to use the techniques, skills and tools of Industrial Engineering necessary to practice it.

C11 - Ability to learn on a continuous basis and develop autonomous learning strategies.

Specific competences

C18 - Knowledge of applied thermodynamics and heat transfer. Basic principles and their application to solving Engineering prc

2.2. Learning goals

The student, to pass this subject, must demonstrate the following results:

- He/She knows the thermophysical properties of industrial interest and has the capacity to use and select suitable procedures and tools for its calculation.
- He/She knows and applies the laws of thermodynamics to the energy analysis of basic equipment and processes in engineering.
- He/She knows the basic criteria for the analysis of thermodynamic cycles.
- He/She knows and applies the basic mechanisms of heat transfer to the analysis of thermal equipment.
- He/She reasonably solves basic problems of technical thermodynamics and heat transfer applied to engineering.

2.3. Importance of learning goals

The analysis and optimization of energy facilities is of vital importance for the Graduate in Chemical Engineering, since these are essential technologies for the current social, technological and economic development.

According to the professional competences of this degree, the future graduate must address projects to improve the performance of a given installation, obtain the same result through different systems or equipments, use a particular phenomenon for a specific purpose or develop new applications for it.

The subject of Technical Thermodynamics and Fundamentals of Heat transfer provides the student with the basic tools to successfully tackle these tasks, together with later subjects that go deeper into certain aspects and present more advanced techniques and methods of analysis.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The student must demonstrate that he/she has achieved the expected learning outcomes through the following assessment activities:

- Laboratory practices. Character: on campus. Duration per practice: 3 h. The student becomes familiar with thermal systems and with the collection and analysis of experimental data. He/she applies the procedures of the subject and delivers a report of results.
- Practices with computer tools. Character: on campus. Duration per practice: 3 h. The student learns to solve problems of Thermal Engineering using computer tools. He/she solves problems and issues and delivers a results report.
- Tutored works. Character: mixed, on and off campus. Estimated total duration: 6 h. The student with the help of the teacher solves problems of certain complexity and delivers a report of results.
- Written exam. Duration: 3 h. It will consist of three different parts: a theoretical part in the form of T / F type questions and short theoretical-practical questions; a second part, purely practical, consisting of several problems

similar to those solved in class; a third part that will consist in the resolution of one of the problems raised in the practical activities (those students who have passed this practical part during the teaching period will be exempt from this third part, keeping the grade obtained).

Evaluation procedures:

1st Call: The proposed procedure consists of a set of tests on the subject. Some of them, practical ones, could have been done during the teaching period, while the written exam will be done during the exam period. The final grade will be calculated by weighting the notes of each of the parties, according to the following weights:

- 70% written exam (Theory and Problems, minimum of 4 points in each part)
- 15% tutored works (mandatory)
- 15% practices (mandatory)

In the event that the student has not passed the practical activities and tutored works during the teaching period, or want to raise the grade obtained in that part, he/she has the option to do a test of practices and tutored works, which may be done with the written exam, during the period of exams or in separate hours and that will have a weight in the final grade of 30%.

Class attendance will be assessed with up to 1 point, to add to the final grade of the course. In any case, if in the written exam the minimum threshold is not reached in any of the parts, the subject is not passed and the student must repeat the exam in the next call with both parts. Class attendance will be saved for the next call.

2nd Call: Identical to the first call.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process has been proposed to encourage continued student work and participation and focuses on the theoretical and practical aspects to understand, analyze and apply knowledge to solve real problems. In the lectures the theoretical bases that form the subject will be developed, solving some basic problems. The practical lectures complement the lectures, helping the student to acquire a more applied point of view through the solving of more complex problems with the help of appropriate resources. Finally, tutored work will complement the above.

4.2. Learning tasks

The learning process is based on the following:

1.- Lectures to the entire group, in which the teacher will explain the basic principles of the subject and resolve some representative problems of implementing the content to real cases. The participation of students in this activity will be sought. In parallel, the student must perform homework for a better comprehension of the contents explained during the course.

2.- Computer simulation and laboratory practices are distributed throughout the semester and their assessment will form part of the final grade for the course. Practices will be solved by groups of two or three students, thereby fostering teamwork.

3.- Tutored work in small groups (ideal couples): students analyze and solve a problem of the subject. Independent learning and teamwork is enhanced.

4.- Exercise approach, issues and additional problems solved in class: This self-learning process is encouraged to study the matter and applying it to the resolution of the exercises. This directed, but autonomous execution activity is essential in the process of student learning and overcoming evaluation activities.

5.- Academic tutoring: The teacher will provide the student with certain procedures to solve doubts. The use of these tutorials is recommended to ensure adequate progress in learning.

4.3. Syllabus

The course will address the following topics:

Topic 1: Basic concepts and definitions in thermodynamics. Definition and classification of systems, states, processes and properties. Property measuring instruments. Change of units.

Topic 2: Properties of a pure, simple and compressible substance. Isobaric heating of a liquid. Phase change. Diagrams T-v, P-v, P-T. Biphasic mixtures. Subcooled liquid. Incompressible substance. Real gases. Calculation of thermophysical properties.

Topic 3: Energy and the first law of thermodynamics. Mathematical formulations The Joule experiment. Balance for closed systems. Modes of energy transfer. Expansion and compression work. Polytropic processes.

Topic 4: Basics of heat transfer. Introduction to conduction, convection and radiation. Fundamental equations and their application to simple systems.

Topic 5: Energy analysis in a control volume. Develop the principles of mass and energy conservation with control volumes. Stationary state (mainly). Transitional state. Study different practical examples of control volumes: turbines, pumps, compressors, nozzles, exchangers, valves.

Topic 6: The second law of thermodynamics. Understand the concept of irreversibility. Analyze different formulations of the second principle of thermodynamics. Application of the second law to thermodynamic cycles: Carnot cycle and Kelvin temperature scale.

Topic 7: Entropy and its use. Introduce the concept of entropy and its use for thermodynamic analysis. Inequality of

Clausius. Entropy balances for closed systems and control volumes. Isentropic performance of equipment. TdS equations.

Topic 8: Thermodynamic cycles. Calculation of energy and exergy efficiencies of Ideal and real simple Rankine cycle and with overheating, reheating and regeneration. Ideal and real gas power cycles, simple and regenerative Brayton cycle with intermediate cooling and reheating. Carnot refrigeration cycles, ideal and real. Carnot and real heat pump cycles.

Practices may cover any of the following contents:

- Calculating properties of substances
- Modeling power cycle steam turbine
- Modeling power cycle gas turbine
- Modeling refrigeration cycles
- Modeling cycles
- Energy balance in an electromagnetic brake
- Experimental characterization of operation of a refrigeration cycle
- Experimental characterization of operating an evaporative cooler
- Modeling heat exchangers
- Dimensioning optimal insulation
- Experimental characterization of heat transfer in a tube bank

4.4. Course planning and calendar

Lectures and solving problem classes are held according to the schedule established by the EINA. The practical sessions in the laboratory are given in the schedule and the groups are set depending on the number of students and will be announced in time. The tutored projects are proposed along the course and in parallel to the topics explained in class.

4.5. Bibliography and recommended resources

http://biblos.unizar.es/br/br_citas.php?codigo=29913&year=2019