Course guide
220282 - 220282 - Heat Engines Technology

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 724 - MMT - Department of Heat Engines.

Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2013). (Optional subject).
Academic year: 2022  ECTS Credits: 7.5  Languages: Catalan

LECTURER
Coordinating lecturer: Yolanda Calventus Solé
Others: Àngel Comas Amengual, Carles Oliet Casasayas, Jesus Castro Gonzalez

PRIOR SKILLS
Thermodynamics

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge and ability to analyze the processes of heat transfer that allows the design and calculation of equipment and thermal applications.
2. Knowledge and capability to design and calculate equipment and refrigeration facilities (refrigeration and air conditioning).
3. Knowledge and ability to analyze, design, calculation and application of power cycles and alternative heat engines.

TEACHING METHODOLOGY

The subject is organized in:

1.- Classes in large groups: In these classes the theory classes, part of the problem classes and the evaluations corresponding to the 1st and 2nd Partial are developed. The expository model that the teacher deems most convenient will be used to achieve the objectives that have been set in the subject.

2.- Classes in small groups: In this activity the laboratory practices are developed and problems are solved.
LEARNING OBJECTIVES OF THE SUBJECT

Critically understand the defining processes of the design of alternative internal combustion engines.

Analyze, diagnose, and predict the behavior of elements, equipment, and systems characteristic of reciprocating internal combustion engines.

Choose them under different restrictions (economic and energy, mechanical, environmental)

Know, model and simulate the systems of renewal of the load, of regulation, of ignition, of expansion and of escape.

Proceed to the fluid dynamic design of the engine: Intake, load movement, fuel supply, combustion, exhaust.

Proceed to the mechanical design of the engine: Balanced, vibration, noise, regularity, mechanical losses, lubrication, tightness. Auxiliaries.

Proceed to the thermal design of the engine: Thermal losses. Refrigeration
Analyze heat exchangers as a basic component of thermal machines. Calculation and analysis.
Compressor analysis, design and characterization.
Study the thermodynamic cycle of absorption and adsorption cooling.
Analysis and calculation of refrigeration systems by steam compression
Know and be able to work with the Stirling engine as a direct and reverse thermal machine
Know the operation of an ejector and its applications in the field of refrigeration

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Hours large group</td>
<td>45,0</td>
<td>24.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>22,5</td>
<td>12.00</td>
</tr>
<tr>
<td>Self study</td>
<td>120,0</td>
<td>64.00</td>
</tr>
</tbody>
</table>

Total learning time: 187.5 h

CONTENTS

(ENG) Contingut 1: Tipus de motors i definició de paràmetres i variables de disseny i operació

Description:
1.1 An Introduction to the Combustion Engine: Types of Engines
1.2 Design and operation parameters

Specific objectives:
Introduce the different types of engines that are on the market, at the beginning of their operation. Introduce the design and operation parameters of the engines, the basic definitions and the relationships between them and at the same time take the opportunity to enter the values to be expected depending on the type of engine.

Related activities:
Theory classes and practice classes
The practice that will be carried out: "Dis / assembly of a two-stroke engine"
Midterm or Second exams as correspond

Full-or-part-time: 18h
Theory classes: 4h
Laboratory classes: 2h
Self study : 12h
**Contingut 2: Cinemàtica i dinàmica del motor**

**Description:**
2.1: Engine dynamics  
2.2: Balanced  
2.3: Torsional and flexural vibrations

**Specific objectives:**
To study the kinematics and dynamics of the connecting rod - crank mechanism of the centered and off-center motor of the reciprocating motor as well as of other mechanisms such as the Wankel motor.
Analyze the polycylindrical motor in line and in V and study the balanced one. Completing the module with the introduction of the study of the torsional and bending vibrations requested by the crankshaft and its sizing.

**Related activities:**
Theory classes  
Midterm or second exam as appropriate.

**Full-or-part-time:** 12h  
Theory classes: 4h  
Self study: 8h

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**Contingut 3: Arquitectura del motor**

**Description:**
3.1 Engine architecture  
3.2 Lubrication and cooling systems

**Specific objectives:**
Introducing the different engines and analyzing their behavior addresses the different configurations used, the metallurgical and mechanical characteristics of the elements that make up the engine. Address the different engine lubrication and cooling systems.

**Related activities:**
Theory classes and practice classes  
The practices will be carried out: "From / assembly of a Wankel engine", "From / assembly of a four-stroke engine"  
Midterm or 2nd exam as appropriate.

**Full-or-part-time:** 19h  
Theory classes: 3h  
Laboratory classes: 4h  
Self study: 12h
### (ENG) Contingut 4: Determinació de magnituds indicades i efectives

**Description:**  
4.1 Engine cycles. Open loop fuel air cycle  
4.2 Obtaining indicated and effective quantities. Variable measurement systems  
4.3 Effective magnitudes  
4.4 Mechanical friction losses

**Specific objectives:**  
Introduce the constituent elements a chain of measurement of the potential work that can give the gases in the engine and the methodology used.  
Explain the test benches and their performance characteristics, the experimental determination of the effective magnitudes.  
Analyze the methods used to determine friction losses and their modeling.

**Related activities:**  
Theory classes and practice classes  
Midterm or 2nd exam as appropriate.

**Full-or-part-time:** 12h  
Theory classes: 4h  
Self study : 8h

### (ENG) Contingut 5: Model·lització de l’evolució seguida per el fluid motor

**Description:**  
5.1 Engine power: Carburetion and injection  
5.2 Heat transfer  
5.4 The distribution system and the load renewal process  
5.5 A heuristic model of progressive combustion and load renewal

**Specific objectives:**  
Introduce and analyze the performance characteristics of the necessary equipment depending on the type of engine, the most common distribution systems for the renewal of the load  
Introduce experimental and empirical ways to evaluate heat exchange.  
Explain as a colophon the heuristic model for the motor cycle that constitutes an embryonic model of the models commonly used by researchers in the area.

**Related activities:**  
Theory classes and practice classes  
The practices will be carried out: Carburetion and petrol injection", "The Ignition system", "Obtaining the injection characteristics of the Mono-Jetronic system"  
Midterm or 2nd exam as appropriate.

**Full-or-part-time:** 32h 45m  
Theory classes: 7h 30m  
Laboratory classes: 5h 15m  
Self study : 20h
(ENG) Contingut 6: Heat exchangers

Description:
6.1 Introduction. Definition, classification and typology. General aspects of design
6.2 Analytical methods of resolution without phase change. Application examples
6.3 Phase change resolution analytical methods. Condensers and evaporators
6.4 Heat pipes. Concept, phenomenology and applications

Specific objectives:
Analyze heat benders as an important component of thermal machines. Calculation and design.

Related activities:
Theory classes and problem classes
Midterm or 2nd exam as appropriate.

Full-or-part-time: 31h 15m
Theory classes: 6h
Laboratory classes: 5h 15m
Self study: 20h

(ENG) Contingut 7: Steam compression cooling systems

Description:
7.1 Compressors. Definition, classification and typology. General aspects of design
7.2 Calculation methods for compressor design
7.3 Elements of expansion. Definition, classification and typology. General aspects of design
7.4 Simple compression refrigeration systems and their variants
7.5 Multiple compression cooling systems (double stage, cascade)
7.6 Ejectors, concept, phenomenology and applications

Specific objectives:
Compressor analysis, characterization and design.
Analysis and design of steam compression refrigeration systems

Related activities:
Theory classes and problems
Internship classes. Practice: “Heat pump”
Informative-demonstrative session of simulations of refrigeration systems with Modèlica
Midterm or 2nd exam as appropriate.

Full-or-part-time: 22h 30m
Theory classes: 4h 30m
Laboratory classes: 3h
Self study: 15h
**Content 8: Absorption cooling systems**

**Description:**
8.1 Introduction: review of basic cycles and technological aspects  
8.2 Component-by-component analysis of the absorption circuit: absorbers, generators, condensers, evaporators, internal exchangers and auxiliary systems.  
8.3 Study of the transfer of heat and mass in the exchangers of absorption machines: review of the phenomenologies involved and of empiricisms of calculation.  
8.4 Zero-dimensional model of simultaneous heat transfer and mass calculation in absorbers and generators

**Specific objectives:**
Study the exchangers of absorption cooling systems and their calculation

**Related activities:**
Theory classes and problem classes  
Midterm or 2nd exam as appropriate

**Full-or-part-time:** 9h  
Theory classes: 4h  
Self study: 5h

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**Content 9: Adsorption cooling systems**

**Description:**
9.1 Introduction: basics  
9.2 Technological aspects  
9.3 Cycle design  
9.4 Component design

**Specific objectives:**
To study the thermodynamic cycle of adsorption refrigeration as an alternative system to compression refrigeration and as an application to trigeneration

**Related activities:**
Theory and practice classes  
Second exam

**Full-or-part-time:** 9h  
Theory classes: 4h  
Self study: 5h

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**Content 10: Stirling heat engine**

**Description:**
10.1 Introduction. Definition, classification and typology. General aspects of design  
10.2 Thermodynamic analysis of the ideal cycle vs. real cycle: models, yields

**Specific objectives:**
Study the Stirling engine as an industrial direct or reverse thermal machine

**Related activities:**
Theory classes and problems  
Internship classes. Practice: “Stirling Motor”

**Full-or-part-time:** 22h  
Theory classes: 4h  
Laboratory classes: 3h  
Self study: 15h
ACTIVITIES

(ENG) ACTIVITY 1: THEORY CLASSES

Description:
Large group methodology
Presentation of the contents of the subject following a model of expository and participatory class
The subject matter has been organized into 8 thematic areas
Problems will be solved with the whole group.

Specific objectives:
At the end of this activity students must be able to master the knowledge worked on, consolidate it and apply it correctly to problems that involve real situations.

Material:
Basic bibliography
Notes and list of problems done by the teacher, if he/she considers appropriate
Description of the expected delivery and links to the evaluation.

Delivery:
This activity will be evaluated in both, midterm and second exam

Full-or-part-time: 136h
Theory classes: 41h
Self study: 95h

(ENG) ACTIVITY 2: LABORATORY SESSIONS

Description:
Small group methodology
From the different contents, laboratory sessions will be carried out.
For contents 6, 7, 8 small problems with computer support will also be solved in small groups.

Specific objectives:
At the end of this activity students must be able to:
- Know how to describe the tasks performed
- Process the experimental data obtained and draw conclusions
- Prepare a report of the work done
- Perform simple thermal exercises through programming, which incorporate variable physical properties

Material:
Basic bibliography
Statements of activities.

Delivery:
A report of this activity will be deliver and it will be evaluable.
The qualification of the laboratory sessions (NL) will be a 30% of the final grade of the subject

Full-or-part-time: 47h 30m
Laboratory classes: 22h 30m
Self study: 25h
**ENG ACTIVITY 3: MIDTERM EXAM**

Description:
Carrying out the midterm exam

Specific objectives:
Show the level of knowledge achieved in the corresponding contents.

Material:
No support

Delivery:
The exam is solved on the sheets delivered at the beginning of the test
The grade for this N1P activity is worth 35% of the final grade of the subject.

Full-or-part-time: 2h
Theory classes: 2h

**ENG ACTIVITY 4: 2ND EXAM**

Description:
Do the second exam of the subject

Specific objectives:
Show the level of knowledge achieved in the corresponding contents.

Material:
No support

Delivery:
The exam is solved on the sheets delivered at the beginning of the test
The grade for this N2P activity is worth 35% of the final grade of the subject.

Full-or-part-time: 2h
Theory classes: 2h

**GRADING SYSTEM**

- Midterm exam N1P weight: 35%
- Second exam N2P weight: 35%
- Practices: NL weight: 30%

Students who failed the N1P will have the option of recovering it on the day of the final exam marked on the official calendar. The recovery test will consist of solving some exercises in writing, only those students who have failed the N1P will be able to do them and the maximum mark of the recovery will be 5.0. The recovery grade will only replace the N1P grade if it is higher than the grade initially obtained.

**EXAMINATION RULES.**

1.- The exams corresponding to midterm and the second exam will be done without using books, notes or other teaching material, except, in the case of a book of Tables and Graphs or a form if the teacher deems it appropriate.
2.- Regarding the practices will have to deliver a report that opportunely communicate the professor.
BIBLIOGRAPHY

Basic: