Universitat de Lleida

DEGREE CURRICULUM

THERMAL AND HYDRAULIC MACHINES

Coordination: MONSERRAT VISCARRI, JOAQUIM

Academic year 2023-24

THERMAL AND HYDRAULIC MACHINES 2023-24

Subject's general information

Subject name	THERMAL AND HYDRAULIC MACHINES
Code	14524
Semester	1st Q(SEMESTER) CONTINUED EVALUATION
Typology	

Degree	Course	Character	Modality
Master's Degree in Industrial Engineering	2	COMPULSORY	Attendance-based

Course number of credits (ECTS)	6
Type of activity, credits, and groups	

Activity type	PRACAMP	PRALAB	PRAULA	TEORIA
Number of credits	0.2	0.2	2.6	3
Number of groups	1	1	1	1

Coordination	MONSERRAT VISCARRI, JOAQUIM
Department	AGRICULTURAL AND FOREST SCIENCES AND ENGINEERING
Teaching load distribution between lectures and independent student work	Lectures 40 % Student work 60 %
Important information on data processing	Consult this link for more information.
Language	Language Percentage Catalan 50.0 English 0.0 Spanish 50.0

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
CASTELL CASOL, ALBERT ORIOL	albert.castell@udl.cat	1,5	
MONSERRAT VISCARRI, JOAQUIM	joaquim.monserrat@udl.cat	3	
MONSERRAT VISCARRI, JOAQUIM	joaquim.monserrat@udl.cat	0	
ORTIZ PENA, CEDRIC		1,5	

Subject's extra information

The course has two distinct blocks, one around incompressible fluid machines (Hydraulic machines : Pumps and Turbines) and the other around compressible fluid machines (Thermal machines : internal combustion engines, Steam and Gas turbines) with three credits each.

To follow this subject properly some previous knowledge on Hydraulics and Thermodynamics are recommended.

All unauthorized recordings of class are prohibited.
Mobile phones, tablets and computers remain off in the classroom until they are required.

In the laboraty practices It is **COMPULSORY** that the students bring the following elements of individual protection (EPI) to the practices at the laboratory.

- Blue laboratory gown from UdL (unisex)
- Protection glasses
- Mechanical protection gloves

They can be purchased through the shop Údels of the UdL:

C/ Jaume II, 67 baixos
Centre the Cultures i Cooperació Transfronterera

http://www.publicacions.udl.cat/

The use of other elements of protection (for example caps, masks, gloves of chemical or electrical risk, etc.) will depend on the type of practice to be done. In that case, the teacher will inform of the necessity of specific EPI.

Not bringing the EPI's described or not fulfilling the norms of general security that are detailed below imply that the student can not access to the laboratories or have to go out of them. The no realisation of the practices for this

reason imply the **consequences in the evaluation** of the subject that are described in this course guide.

GENERAL NORMS OF SECURITY IN LABORATORY PRACTICES

- Keep the place of realisation of the practices clean and tidy. The table of work has to be free from backpacks, folders, coats...
- No short trousers or short skirts are allowed in the laboratory.
- Closed and covered footwear is compulsory in the laboratory.
- Long hair needs to be tied.
- Keep the laboratoy gown laced in order to be protected from spills of chemicals.
- Bangles, pendants or wide sleeves are not allowed as they can be trapped.
- Avoid the use of contact lenses, since the effect of the chemical products is much bigger if they enter between the contact lense and the cornea. Protection over-glasses can be purchased.
- No food or drink is allowed in the laboratory.
- It is forbidden to smoke in the laboratories.
- Wash your hands whenever you have contact with a chemical product and before going out of the laboratory.
- Follow the instructions of the teacher and of the laboratory technicians and ask for any doubt on security.

For further information, you can check the following document of the *Servei de Prevenció de Riscos Laborals de la UdL*: http://www.sprl.udl.cat/alumnes/index.html

Learning objectives

Will present the range of thermal and hydraulic machines that are available and the criteria for selecting the most appropriate for different situations. The specific objectives are:

Get the principle of operation of various types of thermal and hydraulic machines
Knowing how to select different heat engines and hydraulic applications
Learn regulate hydraulic and thermal machines when the load varies
Know how to protect against abnormal operation (cavitation, turbine run away and overpressures)

Competences

Basic Competencies:
• CB4. To be able to communicate conclusions –and knowledge and reasons that support them– to either specialized or not specialised publics in a clear way and without ambiguities.

General competences:
• CG1. Capacity of planning and organizing the personal work.
• CG3. Capacity to convey information, ideas, problems and solutions both to a specialised and no specialised public.

• CG4. Capacity to conceive, design and implement projects and/or provide new solutions, using the tools that the engineering offers.

Specific Skills according Order CIN / 311/2009 of 9 February:
• CE5. Knowledge and capacity for the design and analysis of heat engines, hydraulic machines and installations of heat and industrial refrigeration.

Transversal skills UDL:
• CT1. Appropriate skills in oral and written language.

CT2 Command of a foreign language.

Subject contents

Section I: Hydraulic machines (HM)

Program Theory

Chapter 1. Introduction to turbomachinery.

1.1 Machines fluids. Classification.

1.2 Rrotodynamic Machines or turbomachinery.

1.3 Classification of turbomachinery according compresibilitat fluid.

1.4 hydraulic and thermal turbomachinery.

Chapter 2. Energy exchange between the roller and fluid.

2.1 First Euler equation theorem of kinetic moment.

2.2. Euler equation for pumps, fans and turbochargers.

2.3 Euler equation for hydraulic turbines, steam turbines and gas turbines.

2.4 Triangles speeds. Second form of the Euler equation.

2.5 Degree of reaction.

Chapter 3. Losses jumps, energy, power and performance in hydraulic turbomachinery

3.1 Limits and out of the hydraulic turbomachinery.

3.2 Energy jump between the machine or height limits.

3.3 Height clean turbines and pumps manometric height.

3.4 Classification and study of losses (hydraulic, mechanical and volumetric).

3.5 Income. Powers.

Chapter 4. pumps and behavior

4.1 Classification of pumps.

4.2 constituent parts pumps.

4.3 Behavior theoretical pump.

4.4 Real characteristics Curves of a centrifugal pump.

4.5 priming pumps installed in aspiration.

4.6 Booting pumps

4.7 The regulation of the flow.

4.8 cavitation in pumps. Water hammer.

Chapter 5. Special hydraulic turbines.

5.1 Turbine Action and reaction characteristic elements.

5.2 Pelton turbines.

5.3 Francis and Kaplan turbines.

5.4 Equation of suction tube.

5.5 Regulation of turbines.

5.6 synchronous speeds and embalament.

5.7 cavitation in turbines. Water hammer.

Chapter 6. Similarity in hydraulic turbomachinery

6.1 Phenomena similar models and theory. Dimensionless groups.

6.2 Laws of similarity of the pumps.

6.3 Similarity Laws of hydraulic turbines.

6.4 Classification of Turbomachines the specific speed number .

Chapter 7. Variation speed pumps. Cut roller.

7.1 Full Test pump: Curves features.

7.2 Practical use of the laws of similarity.

7.3 Variation of the rotational speed.

7.4 Cut the roller.

7.5 coupling pumps

7.6 Selection of pump or pumping system more suitable

Chapter 8. Testing laboratory turbines.

8.1 Characteristic curves of hydraulic turbines

8.2 Curves universal variables reduced.

8.3 isoperformance curves

8.4 Formulas processing performance

8.5 Curves operating turbines

Chapter 9. Regulation of pumps and pumping stations

9.1 Introduction. pressurized tanks.

9.2 Adjustment valve in series and in parallel

9.3 Direct injection network with fixed speed pumps.

9.4 Features flat and vertical.

9.5 Pumping stations equipped with variable speed pumps VSP

9.6 Methods of regulation with VSP

9.7 Comparison of different types of energy cost of pumping regulation.

Chapter 10. Study of hydraulic transients

10.1 Introduction hammer in pumps and turbines

10.2 Analysis of transients. Equations. Rigid model and elastic model

10.3 Control Devices transients: Vessels.

Laboratory Practices (A performed in the laboratory of Hydraulic Engineering) They will be made on actual pumping station. Existing device will be characterized first and then students for a given demand will have to operate the station to obtain maximum performance.

Characterization of centrifugal pumps:

- Find the characteristic curves (Head, Power, performance, and NPSH) of a pump.

- Find the characteristic curves of the pumps in series and in parallel associated.

- To analyze the regulation of pumps with variable frequency.

Technical visits

During the course will take a visit to pumping stations and turbines.

Part II: Thermal machines (TM)

Program Theory.

Chapter 0. Heat Engines: An Overview.

Chapter 1. Alternative Internal Combustion Engine.

1.1 Otto cycle

1.2 Diesel cycle

1.3 Real cycle

Capítol 2. Gas and Steam Turbines .

2.1 Brayton cycle

2.2 Rankine cycle

Chapter 3. Turbines.

3.1 Fundamental concepts

3.2 Euler equation

3.3 Axial turbines

Technical visits

Throughout the course, a visit to a cogeneration plant and a gas turbine are planned. This sessions is conditioned to the possibility of visiting the different sites and installations.

Methodology

The methodological axes of the course will be divided into:

Master class:

In master classes the contents are presented orally by the lecturer with no active participation of the students. This sessions will be done virtually.

Problems resolution:

In this activity, the lecturer presents a complex question that the students must solve, either individually or in group.

Team work:

Learning activity that must be developed in collaboration with the other members of a team.

Laboratory:

It allows to apply and configure, at a practical level, the theoretical knowledge of a specific area in a defined context.

Technical visits :

Group activity led by teachers consistent to visit a facility to get direct information to improve the process of learning. This sessions is conditioned to the possibility of visiting the different sites and installations.

Development plan

Week	Metodology	Content	Attendance hours	Individual work hours	Professor
1 - 4	Master class Problem resolution Practices	Pumps	14	21	J. Monserrat
5 - 7	Master class Problem resolution	Turbines and Water hammer	10	15	J. Monserrat
8	Master class Problem resolution	Heat Engines: An Overview	4	6	A. Castell
9 - 11	Master class Problem resolution	Internal combustion engines	14	21	A. Castell
12- 14	Master class Problem resolution	Gas and Steam turbines	12	18	A. Castell
15	Master class Problem resolution	Turbines	4	6	A. Castell

Evaluation

Contents	Evaluation Blocks	Criteria	%	Dates	C/V (1)	I/G (2)	Observations
Hydraulic machines	Written Exam Exercises Practice		40 5 5	Week 6 and 9	C	I	
Thermal Machines	Written Exam Exercises/Activities		40 10	Week 16 Continuous	C	I	

(1) Compulsory/Voluntary

(2) Individual / Group.

Minimum punctuation of 4 is needed in each exam to make the average.

Alternative evaluation: Exam of all the contents of the course.

Bibliography

Basic References, HM

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- **Cabrera, E.; Espert, V.; García Serra, J.; Martinez, F.; Andrés, M.; García, M**. (1996). Ingeniería Hidráulica. (Aplicada a los sistemas de distribución de agua).Volumenes I y II, Universidad Politécnica de Valencia.

Complementary references, HM

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- **Mataix, Claudio**.(2000). Turbomáquinas Térmicas. (Turbinas de vapor, Turbinas de gas y Turbocompresores). Universidad de Comillas. ICAI. Madrid.
- **Alvarez, Jesús Aandrés**; **Callejón, Ismael** (2002). Máquinas térmicas motoras,(I y II). Edicions UPC.

- **Heywood, John B**. (1988). Internal combustion engine fundamentals. Ed. McGraw Hill.
- **Giacosa, Dante** (2000). Motores endotérmicos. Ed. Omega/14ª edición.
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- **Payri, Francisco; Desantes, Jose María.** Motores de combustión interna alternativos. Ed. Reverté.
- **Taylor, Charles F.** The internal combustion engine in theory and practice. Ed. The MIT Press.
- **Garcia, Santiago; Fraile, Diego.** Cogeneración. Ed. Diaz de Santos.