



Universitat de Lleida

DEGREE CURRICULUM
**THERMAL AND HYDRAULIC
MACHINES**

Coordination: MONSERRAT VISCARRI, JOAQUIM

Academic year 2017-18

Subject's general information

Subject name	THERMAL AND HYDRAULIC MACHINES			
Code	14524			
Semester	1st Q(SEMESTER) CONTINUED EVALUATION			
Typology	Degree	Course	Typology	Modality
	Master's Degree in Industrial Engineering	2	COMPULSORY	Attendance-based
ECTS credits	6			
Groups	1GG			
Theoretical credits	2			
Practical credits	4			
Coordination	MONSERRAT VISCARRI, JOAQUIM			
Department	ENGINYERIA AGROFORESTAL			
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			
Office and hour of attention	Prof. J. Monserrat Tuesday de 16 a 18 h, ETSEA, E4.2.01 Friday de 10 a 12 h			

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
BARRAGAN FERNANDEZ, JAVIER D.	barragan@eagrof.udl.cat	1	To arrange with professor
GRACIA PEREZ, ENRIQUE	egracia@eagrof.udl.cat	3	To arrange with professor
MONSERRAT VISCARRI, JOAQUIM	monserrat@eagrof.udl.cat	2	Room 4.2.01 ETSEA Tuesday and Thursday, 16 to 18 p.m.

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.

In the laboratory 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 laboratory 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 Rotodynamic Machines or turbomachinery.

1.3 Classification of turbomachinery according compressibility fluid.

1.4 hydraulic and thermal turbomachinery.

Chapter 2. Energy exchange between the rotor 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 Tip 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 Principles of operation.
- 1.2. Characteristic parameters.
- 1.3 cycles ideals cycles indicated.
- 1.4 Powers and yields.
- 1.5 ignition, combustion and fuels for Otto and Diesel engines.
- 1.6 Renewal of the load and overfeeding.
- 1.7 Benefits and curves.
- 1.8 emissions.

Chapter 2. Steam Turbine .

- 2.1 Classification of critical steam turbines.
- 2.2 Degree of reaction.
- 2.3 Performance.
- 2.4 Particular Euler equation .
 - speeds Triangle
 - 1st form of the equation of Euler's .
 - 2nd form of the equation of Euler's.
 - Performance procedure.
- 2.5 Turbines action.
 - Triangles theoretical speeds.
 - Performance conditions and internal theoretical design.
 - Triangles actual speeds.
 - Performance internal design and actual conditions.
 - Escalonaments speed turbines action.
 - Escalonaments pressure turbines in action.
- 2.6 turbines reaction.
 - Triangles theoretical speeds.
 - Performance conditions and internal theoretical design.

- Performance internal real.

2.7 Comparison between turbines action and reaction turbines.

- Number of escalonaments.
- Type of loss.
- Push axial.

2.8 Limitation of power steam turbines.

2.9 Current Trends.

Chapter 3. Gas turbines (TG).

3.1 Constructive elements of TG`s.

3.2 Types of TG's. Classification.

Compressor 3.3. Type.

3.4 Combustion chamber

- Types of combustion chambers.
- Stability of the flame.
- Contribution of fuel.
- Systems of ignition.
- Start the TG.

3.5 TG's radial flow and axial flow.

TG's 3.6 p / aircraft propulsion.

- Turbojet.
- Turbofan.
- Turboprop and turboshaft.
- Influence of the speed of the aircraft.
- Investors thrust.
- Noise pollution.

3.7 Regulation of power.

Chapter 4. A practical application: Cogeneration.

4.1 Types.

4.2 Evaluation technical and economic characteristics of these facilities.

Technical visits

Throughout the course, try a visit to a cogeneration plant and another gas turbine.

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.

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.

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. Barragan
8 - 11	Master class Problem resolution	Internal combustion engines	14	21	E. Gracia
12- 15	Master class Problem resolution	Steam turbines	12	18	E. Gracia

Evaluation

Contents	Avaluation	Criteria	%	Dates	O/V (1)	I/G (2)	Observations
Pumps	Written Exam Exercises Practice		18 2 10	week 6	O	I	
Turbines	Written Exam Exercises		20 5	week 9	O	I	
Thermal Machines	Written Exam		50	week 15	O	I	

A minimum punctuation of 3.5 is needed in each part to make average

Bibliography

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