Course guide
240EI022 - 240EI022 - Hydraulic Machines

Last modified: 15/06/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics.

Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Presas Batlló, Alexandre

Others: Escaler Puigoriol, Francesc Xavier
Jou Santacreu, Esteban
Presas Batlló, Alexandre
Ramos Martin, David
Sitges De La Sotilla, Oscar
Valentin Ruiz, David
Egusquiza Montagut, Mònica
Martínez Molina, Miquel
Garcia Rovira, Aitor

PRIOR SKILLS

The students should have a previous knowledge of Fluid Mechanics

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMEI05. Knowledge and ability for the design and analysis of thermal machines and engines, hydraulic machines and heating and cooling plants.

TEACHING METHODOLOGY

Theory classes once a week (two hours) and laboratory sessions once a week in alternate weeks throughout the semester.

LEARNING OBJECTIVES OF THE SUBJECT

The subject aims to provide basic knowledge on the principles of operation and utilization of hydraulic machines for incompressible flow: pumps, fans and hydraulic turbines. The fundamental equations that govern their operation, the basic design parameters and the main applications will be studied.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	24.00
Hours small group	13,5	12.00
Self study	72,0	64.00

Total learning time: 112.5 h

CONTENTS

1 INTRODUCTION TO TURBOMACHINERY

Description:
1.1 DEFINITION OF TURBOMACHINERY
1.2 CLASSIFICATION
1.3 APPLICATIONS
1.4 TURBOMACHINERY STUDIED IN THE PRESENT COURSE
1.5 CURRENT TRENDS IN TURBOMACHINERY
Hydraulic energy is introduced like an alternative energy and their importance in the real world is emphasized
Fluid machines are classified and their most important applications.

Full-or-part-time: 3h
Theory classes: 3h

2 ANALYSIS OF INCOMPRESSIBLE FLOW TURBOMACHINERY

Description:
2.1 CONSERVATION OF ENERGY EQUATION, TOTAL HEAD AND PIEZOMETRIC LINES
2.2 KINEMATICS OF ROTATING SYSTEMS
2.3 EULER'S EQUATION FOR TURBOMACHINERY
2.4 SIMILARITY AND DIMENSIONLESS COEFFICIENTS
2.5 COMPUTATIONAL FLUID DYNAMICS (CFD)
The equacion of the energy conservation in flows and the kinematics in rotating frames of reference are introduced. Euler's equation is demonstrated, the dimensionless coefficients are developed to apply similarity rules and CFD is introduced as a methology to study turbomachinery.

Full-or-part-time: 3h
Theory classes: 3h

3 CINEMÁTICA DE TURBOMÁQUINAS GENERADORAS

Description:
3.1 KINEMATICS IN CENTRIFUGAL RUNNERS/IMPELLERS
3.2 APPLICATION OF EULER'S EQUATION TO CENTRIFUGAL RUNNERS/IMPELLERS
3.3 KINEMATICS IN AXIAL RUNNERS
3.4 APPLICATION OF EULER'S EQUATION TO CENTRIFUGAL RUNNERS
The velocity field inside the centrifugal and axial turbomachines is explained. The velocity triangles at the inlet and outlet of the centrifugal and axial runners are developed and studied. Based on the kinematics, Euler's equation is developed and discussed for both types of runners and the theoretical curve of specfic energy is determined.

Full-or-part-time: 4h
Theory classes: 4h

4 HYDRAULIC PUMPS

Description:
4.1 PUMP TYPES AND APPLICATIONS
4.2 HYDRAULIC LOSSES (HYDRAULIC EFFICIENCY)
4.3 VOLUMETRIC LOSSES (VOLUMETRIC EFFICIENCY)
4.4 MECHANICAL LOSSES (MECHANICAL EFFICIENCY)
4.5 TOTAL EFFICIENCY
4.6 HYDRAULIC FORCES AND TRANSIENT PHENOMENA
4.7 ACTUAL CARACTERISTIC CURVES
4.8 PUMP-SYSTEM INTERACTION AND OPERATING POINT
4.9 PUMPS' ASSOCIATIONS
4.10 OPERATING POINT REGULATION SYSTEMS
The different types of pumps and the main benefits of each of them are introduced, also defining all their most important components. The differences between the theoretical and the actual curves are presented based on all the losses that occur inside the pump. Hydraulic forces and transient phenomena are discussed. The pump-system interaction is then defined to find the operating point and the different systems to regulate it are explained.

Full-or-part-time: 6h
Theory classes: 6h

5 CAVITATION IN HYDRALIC SYSTEMS

Description:
5.1 CAVITATION PHENOMENON
5.2 CAVITATION EFFECTS
5.3 TYPES OF CAVITATION
5.4 CAVITATION IN PUMPS. NPSH
The basic phenomenon of cavitation is defined and its main effects and types are explained. The behavior and calculation of cavitation in pumps using the concept of available and required NPSH is detailed.

Full-or-part-time: 4h
Theory classes: 4h

6 FANS

Description:
6.1 INTRODUCTION
6.2 CENTRIFUGAL FANS
6.3 AXIAL FANS
6.4 SECONDARY FLOWS
The different types of fans are described, seeing their application according to the design. It is also studied the regulation of the flow in fans. Finally, the dimensional analysis is used for the sizing and pre design of fans.

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

7 HYDRAULIC TURBINES

Description:
7.1 INTRODUCTION
7.2 FRANCIS TURBINES (CENTRIFUGAL)
7.3 KAPLAN TURBINES (AXIAL)
7.4 PELTON TURBINES
7.5 OUTPUT POWER AND EFFICIENCY
The importance of hydraulic turbines in the current electricity market is introduced. The different types of turbines are defined and the velocity fields are described, The operation limits and the problems of working out of design are also studied for each one.

Full-or-part-time: 4h
Theory classes: 4h

8 AEROGENERADORS

Description:
8.1 Kinematics of wind turbines
8.2 Energy transfer in wind turbines

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

GRADING SYSTEM

The qualification method will be based on:
1) The NP mark (out of 10) for taking and evaluation of practices.
2) The NEP grade (out of 10) for the midterm exam.
3) The NEF grade (out of 10) for the final exam.
And the final grade (NF) will be calculated according to:
NF = max [(0.2*NP + 0.3*NEP + 0.5*NEF); (0.2*NP + 0.8*NEF)]

Reevaluation: The grade of this exam is directly the grade of the subject and replaces the previous grade if it is higher.

EXAMINATION RULES.

Exams: The partial and final exam consist of a problem and a test with a weight that will be a minimum of 40% and a maximum of 60% for each part. The test consists of approximately 10 questions in the partial exam and 20 questions in the final exam with 4 answers. 3 wrongly answered questions cancel one good one. The reevaluation exam will consist of a test with 20 questions with theoretical questions and small exercises.

In all parts of the exams, the student can use a non-programmable scientific calculator and the formulae paper provided by the department without annotations.
The exams must be handed at the time established by the teacher during the test. Failure to do so may result in penalties.

Practices: Attendance (20%) and a brief presentation of the practices in front of the teacher (80%) will be taken into account for the practices grade. Each student will present at least one of the practices carried out.

BIBLIOGRAPHY

Basic:
- Egusquiza, Eduard. Comportament dinàmic de màquines hidràuliques [on line]. Barcelona: Edicions UPC, 2003 [Consultation: 08/09/2014]. Available on: http://hdl.handle.net/2099.3/36745. ISBN 9788498800494.
- Csanady, G.T. Theory of turbomachines. New York: McGraw Hill, 1964.
- Balje, O.E. Turbomachines: A guide to design, selection and theory. New York: John Wiley & Sons, 1981. ISBN 0471060364.