UNICUSANO ROME

Code: ING-IND/09 **Credits: 9**
Matter: Fluid Machinery and Energy Systems
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Gino BELLA – gino.bella@unicusano.it

Introduction

1. *Objective of the course :*

   The Fluid Machinery and Energy Systems course is to provide the student with a good knowledge of the operating principles and the basis for the evaluation, verification, design and sizing simple components and thermal system. Students will be introduced to the main principles of energy conversion systems, with particular reference to steam and gas turbine power plants
   The E-tivity associated with the course, to be developed through the writing and presenting of reports, favour the development of the skills necessary for solving application problems relating to these systems.

Objectives

2. *Course Structure:*

The course has the following objectives:

1. Review of the fundamental principles of thermodynamics and illustrate their application in the energy system fields

2. Illustrate the basics of operation of steam thermoelectric plants and provide the elements necessary for performance analysis

3. Illustrate the basics of the operation of gas turbine thermoelectric plants and provide the elements necessary for performance analysis

4. Illustrate the implementation of the Matlab software for the study of energy systems

Competencies:

A. Knowledge and understanding.

Knowledge of the main energy conversion systems (steam, gas cycles) and their components. Ability to understand and describe their operation, the design parameters and the operating conditions that influence their performance.

B. Applying knowledge and understanding.

Ability to solve practical problems related to the single components and main energy conversion systems (steam, gas cycles), with particular reference to the calculation of performance depending on the main design parameters, based on energy balances, taking into account the relative characteristics of the machines and fluids used.

C. Making judgements.

Ability to choose the appropriate solving procedures and methodologies for verifying and designing the studied devices. Ability to evaluate, explain and compare the results obtained from the assessment with respect to the expected results on the basis of the theoretical study.

D. Communication skills.

Development of a correct scientific language that allows the knowledge learned to be expressed clearly and without ambiguity. Ability to accurately communicate and describe the solving procedure and the methodologies used to carry out the assigned problems also through the normally used means of communication (discussion of the results obtained, report on the performed activity, PowerPoint presentations, etc.).

E. Learning skills.

Ability of autonomously studying additional in-depth details related to the subject.

Syllabus

3. *Programme of the course:*

Module 01 – Applied Thermodynamics, part 1: Fundamental concepts. Work for closed systems. Pulse work. Work for control volumes. First law of thermodynamics. Machinery and energy balances. Energy analysis of steady flow systems. Specific heat. Ideal gas.

Exercises carried out - Module 01 First Law of Thermodynamics for open systems.

Module 02 – Applied Thermodynamics, part 2: Substance properties. Second Law of Thermodynamics. Entropy. Carnot cycle. Cyclic transformations. Thermodynamic diagrams: P-v, T-s, H-s, P-h. Transformations of ideal gases. Compression of an ideal gas and the counter-recovery phenomenon. Expansion of an ideal gas and recovery phenomenon. Liquid-vapour systems. Introduction and approach to Matlab software in the field of energy machines and systems.

Exercises carried out - Module 02: Use of diagrams and steam tables. Use of the Coolprop database within Matlab software. Representation of real adiabatic expansion and compression on thermodynamic diagrams.

E-tivity 1 – Module 02: In this E-tivity some exercises concerning the basic concepts of thermodynamics are proposed and, in particular, some exercises concerning liquid-vapour systems are proposed. At the end of the exercises the student must formalize a written report, in electronic format, to be sent to the teacher for evaluation.

Module 03 – Steam thermal engine systems: Introduction. Steam power plants. Energy analysis of the steam power cycle. Performance optimization. Condenser pressure. Conditions at the steam generator. Superheated Rankine cycle. Reheat Rankine cycle. Regeneration in steam plants. The mixture regenerator. The surface regenerator. The degasser. Steam generators. Boiler schemes. Characteristic technical parameters. Calculation of the efficiency of the steam generator. Air/fume circulation. Water/steam circuit.

Exercises carried out - Module 03 Calculation of the performance of a simple steam cycle. Calculation of the performance of a superheated steam cycle. Calculation of the performance of a steam cycle with one draw.

E-tivity 2– Module 03. In this E-tivity an exercise is proposed concerning the development of a Matlab code and the analysis and comparison of the performance of a basic, superheated, reheated and regenerated steam turbine engine plant. At the end of the exercise, the student must formalize a written report, in electronic format, to be sent to the teacher for evaluation.

Module 04– Thermal engine systems with gas turbines: The elementary circuit. The combustion processes. Ideal cycle. Limit cycle. Real cycle. The overall efficiency of a heat engine plant with a gas turbine. Performance as a function of polytropic efficiencies. Regeneration in gas turbines. Interrefrigeration in the simple cycle, optimal compression ratio, performance of the useful work.

Exercises carried out - Module 04: Calculation of the performance of a simple gas turbine cycle. Performance calculation of a gas turbine cycle with regeneration. Performance calculation of a gas turbine cycle with reheating. Calculation of the performance of an intercooled turbogas cycle. Combustion and excess air. Performance calculation of a gas turbine cycle with and without regeneration.

E-tivity 3– Module 04: In this E-tivity an exercise is proposed concerning the development of a Matlab code and the analysis and comparison of the performance of a basic, regenerated and intercooled gas turbine engine plant. At the end of the exercise, the student must formalize a written report, in electronic format, to be sent to the teacher for evaluation.

Evaluation system and criteria

The exam of Fluid Machinery and Energy Systems s consists in carrying out one or two written tests (depending on the exam method chosen, as described below) lasting 90 minutes, aimed at ascertaining the ability to analyze and re-elaborate the acquired concepts and a series of activities (E-tivity) carried out during the course in the virtual classrooms. The written tests and the E-tivity contribute to the evaluation of the expected learning outcomes regarding knowledge of the subject, the ability to apply this knowledge, communication skills and the ability to draw conclusions.

The evaluation of the E-tivity from 0 to 5 points, overall, is carried out on an ongoing basis, during the duration of the course. E-tivity are optional, however they are strongly recommended. In the case of carrying out the E-tivity, the profit exam is evaluated, overall, for the remaining from 0 to 25 points and can be carried

out in written form both at the Rome office and at the educational centers upon reservation by the student. In the absence of E-tivity, the exam is evaluated from 0 to 30 points overall.
In any case, the examination task can be carried out in a single solution or divided into two exemptions, according to one of the following methods:

INTEGRAL EXAM

In this case, the exam will consist of 1 or 2 exercises and, possibly, 1 theoretical question, concerning the topics of the entire program; this test is evaluated from 0 to 25 points. (In the absence of E-tivity there will be an exercise and an additional theoretical question worth 5 points)

PARTIAL TESTS
In this case the exam is divided into two tests, to be carried out in two different sessions, each relating to a specific part of the programme:

PARTIAL TEST 1
The test is inherent to Modules 1, 2, 3 and consists of 1 to 3 exercises/theoretical questions. This exemption is evaluated from 0 to 12 points. The score for passing the test is 6/12, the minimum score that must be achieved in order to be able to access the second exemption. The mark attributed to the first exemption is kept for a maximum of 3 months. In case of failure to pass the overall exam or if the second exemption is taken within this time limit, the judgment reported for this test will be cancelled. (In the absence of E-tivity there will be an exercise and an additional theoretical question worth 3 points)

PARTIAL TEST 2
The test is inherent to Modules 4, and consists of 1 to 3 exercises/theoretical questions. This exemption is evaluated with a judgment from 0 to 13 points. (In the absence of E-tivity there will be an exercise and an additional theoretical question worth 2 points)

During the exam, the student must indicate the exam method chosen, without the need to communicate it in advance to the teacher. Only the selected part will then be corrected. A multiple choice or no choice will automatically lead to the correction of only the part relating to the integral exam mode.
It is reiterated that the student can take the second exemption only after passing the first. Therefore, if the student still takes the second test without passing the first, this test will be considered invalid.

It is emphasized that particular attention in evaluating the answers given is given to the student's ability to rework the material present on the platform.

During the written test, the use of handouts, notes, texts or forms in paper or digital format is NOT permitted. The use of only a non-programmable scientific calculator and any material provided by the teacher (tables of thermodynamic properties of substances) is permitted.

Bibliography and resources

4. *Materials to consult:*

Slides and teaching materials provided by the teacher.
The didactic material on the platform is divided into 4 modules. This material contains all the tools necessary to tackle the study of the subject.

5. *Recommended bibliography:*

Y. Cengel, Termodinamica e trasmissione del calore, McGraw-Hill.
A. Cavallini, L. Mattarolo, Termodinamica applicata, CLEUP editore
C. Caputo, Gli impianti convertitori di energia, CEA editore
G. Cornetti e F. Millo. “Macchine idrauliche”. Edizioni Il Capitello. 2015
G. Cornetti e F. Millo. “Macchine idrauliche”. Edizioni Il Capitello. 2015
G. Cornetti e F. Millo. “Macchine a gas”. Edizioni Il Capitello. 2015