NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
MECHANICAL ENGINEERING PROGRAM

MN116 –THERMODYNAMICS II

I. GENERAL INFORMATION

COURSE CODE	**:**	MN116 Thermodynamics II
SEMESTER	**:**	6
CREDITS	**:**	3
HOURS PER WEEK	**:**	4 (Theory – Practice - Laboratory)
PREREQUISITES	**:**	MN114
CONDITION	**:**	Mandatory

II. COURSE INTRODUCTION

This course prepares the student in the application of concepts of combustion, gas and steam compression processes, thermodynamics of mechanical steam compression, introduction to the study of thermodynamic cycles, Clausius - Rankine cycle, Joule - Brayton cycle, theoretical cycles of internal combustion engines, cogeneration and fuel cells.

III. COURSE OUTCOMES

The student:

1. Applies the principles of thermodynamics to the analysis of power cycles.
2. Determines the maximum possible work of the system-atmosphere combination, analyzes dry gas mixtures and mixtures with condensable steam for application in processes for industry.

IV. LEARNING UNITS

1. INTRODUCTION / 4 HOURS

Combustion / combustión mechanism: fuel and oxidant / fuel: mineral coall, oil, natural gas, alcholes, bagasse, fuelwood, charcoal / fuel analysis.

2. ANALYSIS OF COMBUSTION PRODUCTS / 4 HOURS

Combustion processes / reaction equation: reagents and products / ideal combustion / complete combustion and incomplete combustion / stoichiometric air / stoichiometric mixture / air-fuel ratio / ideal combustion with oxygen / combustion with air / atmospheric air: ideal composition / combustion with air / Ideal combustion with excess air / real combustion / combustion with air deficiency / real combustion with excess air.

3. GASES AND STEAM COMPRESSION PROCESSES / 4 HOURS

Introduction / polytropic processes: polytropic analysis / polytropic compression processes / isentropic compression processes / adiabatic efficiency / isothermal compression processes / isothermal efficiency / multi stage compression / intermediate cooling / minimum working condition: optimum compression / efficiency pressure Energy of the process.

4. THERMODYNAMICS OF COMPRESSION PROCESSES / 4 HOURS

Introduction / compressors: basic notions / positive displacement compressors: type of compressors / isentropic and polytropic analysis in compressors / the compressor station / economic station operation / reciprocating compressors / operating principle / ideal compressor without dead volume / ideal compressor with dead volume / conventional volumetric efficiency / actual volumetric efficiency / work and power in a compressor with dead volume / indicated power / power to the axis / mechanical efficiency / definitions: diagram of a compressor / compression ratio / indicated mean pressure / single phase compressors / compressors biphasic: single-acting and double-acting / performance indicators.

.

5. CENTRIFUGAL AND AXIAL COMPRESSORS / 4 HOURS

Principle of operation / stages of the compressor / power and compressor efficiency / single-phase compressors and biphasic compressors / performance indicators / rotary compressors / operating principle / types of compressors / compressor power and efficiency / economizers / performance indicators.

6. THERMODYNAMICS OF STEAM MECHANICAL COMPRESSION / 4 HOURS

Introduction / basic principles of turbocharging and mono-compression / simple evaporation and evaporation in multiple effect: general characteristics / description of equipment / compressors and conventional heat exchangers / special heat exchangers: thermal tubes, sheet, thermal plates, bi-transfer / energy efficiency and substitution coefficient / basic applications: distillation, evaporation, drying, rational use of energy / performance indicators.

7. INTRODUCTION TO THE STUDY OF THE THERMODYNAMIC CYCLES / 4 HOURS

Introduction / thermodynamic cycle / cycle elements / thermal machine / thermal source: source, sump / proper thermal machine / efficiency / cooling machine / performance coefficient / first law and cycle analysis: Pv and Ts / Thermodynamic average temperatures / work ratio / mean pressure / fundamental formulas / gas tables / carnot cycle with moist steam and with superheated steam.

8. CLAUSIUS - RANKINE CYCLE / 4 HORAS

Introduction / the clausius - rankine cycle / characteristic parameters / processes / thermal efficiency / efficiency improvement: influence of overheating, influence of steam pressure, influence of discharge pressure, influence of reheating / energy analysis / modeling of steam power plants / plant cycle with steam turbines / main

components: steam generator, turbine, condenser, pump / the real cycle: internal losses and external cycle losses / boiler efficiency / turbine efficiency / regenerative cycle Ideal / regenerative cycle with steam bleeding / feed water heaters / maximum feed water temperature / optimization of the number of bleeding.

9. THE BOILER PLANT / 4 HORAS

Principle of operation / description of systems / thermal balance / performance indicators / steam thermal plant / operating principle / systems description / boiler as controlled process / steam turbine / reheat factor and turbine condition curve / condenser / plant control / thermal balance / performance indicators / binary cycle / operating principle / system description / thermal efficiency / thermal balance.

10. JOULE - BRAYTON CYCLE / 4 HOURS

Introduction / the joule - brayton cycle / characteristic parameters / processes / thermal efficiency / efficiency improvement: stage compression, regeneration, intermediate reheat / work relationship: net specific work / modeling of gas power plants / gas turbines plant cycle / main components: compressor, heater, turbine, cooler / energy analysis / pressure ratio for maximum net work / gas turbine open cycle / ideal regenerative cycle / intermediate reheating cycle / reheating cycle and regeneration,

11. REAL CYCLE OF THE GAS TURBINE / 4 HOURS

Internal losses and external cycle losses / compressor efficiency / turbine efficiency / actual single cycle: regenerator / cycle efficiency with multi stage compression and expansion / two-axis gas turbine / gas turbine for aeronautical use: processes In diffuser and nozzle / turbojet / turbojet / thermal balance / performance indicators / combined cycle / principle of operation / description of systems / thermal efficiency / thermal balance.

12. THEORETICAL CYCLE OF INTERNAL COMBUSTION ENGINES / 4 HOURS

Otto cycle / processes / Otto cycle and reciprocating machine / characteristic parameters / energy analysis / efficiency / external losses / thermal balance / performance indicators / four-stroke engine / components / diesel cycle / processes / diesel cycle and reciprocating machine / characteristic parameters / energy analysis / efficiency / external losses / balance / comparison between Otto cycle and Diesel cycle / dual cycle / other definitions for analysis of Otto and Diesel cycles / fuels for ICE.

13 COGENERATION / 4 HOURS

Conventional and cogeneration system / cogeneration system with pure backpressure steam turbine, backpressure steam turbine with extraction, condensate steam turbine with extraction / combined cycle: gas turbine and steam turbine / cogeneration with generator set / cogeneration and Refrigeration by mechanical compression of steam and by absorption.

14. FUEL CELLS / 4 HOURS

Direct energy conversion / fuel cells / fuel cell operation description / analysis of the operation of a fuel cell / fuel cell real efficiency.

V. METHODOLOGY

The course will develop in theory and practice sessions. In theory sessions, the teacher presents the concepts, deduces the equations and explains the applications. In the practical sessions, various problems are solved and their solution is analyzed. In all the sessions the active participation of the student is promoted.

VI. GRADING FORMULA

Evaluation system “F”. Calculation of final grade: FG = (ME + 2FE + QA)/4
MT: Midterm exam FT= Final exam QA: Quizzes average
There will be four quizzes, the quiz with the lowest grade will not be taken in consideration.

VII. BIBLIOGRAPHY

1. GORDON VAN WYLEN / RICHARD SONNTAG / CLAUS BORGNAKKE, “Fundamentals of classical thermodynamics” 4th edition - John Wiley and Sons Inc. 1994.
2. VIRGIL MORING FAIRES / CLIFFORD MAX SIMMANG, “Thermodynamics” 6th edition - MacMillan Publishing Co., 1990
3. J. B. JONES / R. E. DUGAN, “Thermodynamics engineering”, 1st edition Prentice Hall, 1990.
4. M. DAVID BURGHARDT, “Thermodynamics engineering”, 2nd edition - Harla SA, 1984.
5. M. J . MORAN / H. N. SHAPIRO, “Fundamentals of technical thermodynamics” 2nd edition, John Wiley and Sons, 1993.
6. RUSSEL & ADEBIYI, “Classic thermodynamics”, 1st edition - Addison Wesley Iberoamericana Corp., 1993.
7. OCTAVE LEVENSPIEL, “Fundamentals of Thermodynamics” 1st edition, Prentice Hall, 1997