NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering Honours Degree Industrial and Manufacturing Engineering

INTRODUCTION TO THERMAL SYSTEMS

TIE 3108

First Semester Supplementary Examination Paper

August 2015

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Steam tables

Examiner's Name: Eng. D. Zimwara

INSTRUCTIONS AND INFORMATION TO CANDIDATE:

1. Answer any five(5) questions
2. Each question carries 20 marks
3. Use of calculators is permissible

QUESTION 1

Discuss the energy situation in Zimbabwe and possible ways of improving the situation. [20]

QUESTION 2

a) Draw a schematic diagram of a Thermal Power Station showing paths of coal, steam, water, air, ash and flue gases. [10]

b) Explain the function of the following in thermal power plant and explain the principle of operation of each:

i) Economiser, [2]

ii) Electrostatic precipitator, [2]

iii) Condenser, [2]

iv) Superheater, [2]

v) Cooling tower. [2]

QUESTION 3

a) What is solar heating? [2]

b) What are the basic components of a solar thermal system? [5]

c) How have solar systems improved? [5]

d) With the aid of sketches distinguish between a passive system and an active system in solar water heating. [8]

QUESTION 4

a) What are the two methods that are used to classify compressors? [2]

b) A two stage, single acting, reciprocating compressor takes air at the rate of 0.25 m^3/s. in take pressure and temperature are 0.10 MN/m^2 and 15 °C respectively. The air is compressed to a final pressure of 0.8 MN/m^2. The immediate pressure is ideal and intercooling is perfect. The compression index is 1.3 and the compressor runs at 900 rpm. Neglecting clearance, determine:

i) The immediate pressure, [4]

ii) The total volume of each cylinder, [4]

iii) The cycle power. [4]

c) What are the maintenance problems associated with air compressors? [6]

QUESTION 5

An air conditioned lecture venue is to be maintained at 18 °C, percentage saturation is 40%. The curtains and all fabric heat gains are 3000W and there are 19 students and 1 lecturer in the room at a particular time. Neglecting all other heat gain or losses.

Calculate the required volume flow rate of air to be supplied to the room at its percentage saturation when the air supply temperature is 10 °C. [20]

Data:

Sensible heat per person =100W
Latent heat gain per person=30W
Barometric pressure =1.01325bar

QUESTION 6

A combined power plant consists of a gas turbine unit and a steam turbine unit, the exhaust gas from the gas turbine being supplied to the steam generator. Using the data below, neglecting the mass flow rate of fuel, feed pump work, and all pressure losses.

Calculate:

a) The cycle efficiency of the gas turbine. [4]
b) The cycle efficiency of the steam cycle if the heat supplied in the generator is by external fuel supply. [4]
c) The mass flow rates of air to the gas turbine and steam and steam to the steam turbine [4]
d) The overall efficiency of the combined cycle . [4]
e) Draw the Sankey diagram to represent the energy flow in the plant . [4]

Data:

Pressure ratio for gas turbine, 7
Inlet air temperature to compressor 15 °C
Maximum cycle temperature for gas turbine 750 °C
Temperature of gases leaving the steam generator 160 °C
Steam conditions at entry to the turbine, 20 Bar and 500 °C
Condenser pressure, 0.08 Bar
Total power output 50 MW.
Isentropic efficiencies of air compressor, gas turbine and steam turbine are 83%, 85% and 87% respectively; c_p and γ for the combustion are 1.11 kJ/kgK and 1.33

QUESTION 7

a) Discuss the impact of some of the refrigerants on Global warming and their Ozone depletion potential. [5]

b) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapour-compression refrigeration cycle between 0.14 and 0.8 MPa. If the mass flow rate of the refrigerant is 0.05 kg/s, determine:

   i) The rate of heat removal from the refrigerated space and the power input to the compressor. [5]

   ii) The rate of heat rejection to the environment, [5]

   iii) The COP of the refrigerator. [5]