NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

B-Eng Hons Industrial and Manufacturing Engineering

Main Examination

COURSE	**:**	**INTRODUCTION TO THERMAL SYSTEMS**
CODE	**:**	**TIE 3108**
DATE	**:**	**JANUARY 2013**
DURATION	**:**	**3 HOURS**

INSRTUCTIONS AND INFORMATION TO CANDIDATES

1. Answer any other **five (5) questions**
2. All other questions carry **20 marks** each
3. This paper contains seven **(7)** questions

REQUIREMENTS

1. Steam Tables

Question One

a) Describe how power is generated in a steam power plant and explain the role of each major component [12]
b) What are the maintenance problems associated with boilers? What are their solutions [8]
[20]

Question Two

In a steam turbine power plant, water at 0.08bar flowing at a rate of 50 kg/s is compressed by the pump to 70bar. The compressed water is fed to the steam generator where it is converted to superheated steam at 450^{o}C at the same pressure. The superheated steam expanding through the turbine, leaves the turbine at 0.08 bar. Condensed to saturated water state in the condenser, thus completing the cycle, assuming the feed pump work is negligible. Calculate

a) The power production at the turbine [4]
b) The heat input in the steam generator [4]
c) Thermal efficiency of the steam turbine plant [4]
d) The heat rejected by the condenser [3]
e) Calculate the cooling water mass flow rate if the cooling water temperature is raised from 32^{o}C to about 2.5^{o}C less than the temperature of the wet steam condensing in the condenser. Take cooling water *Cp* as 4.2 kJ/kgK. [5]
[20]

Question Three

a) Identify and explain the principles of operation of any three types of Recuperators [8]
b) A surface condenser operating at a pressure of 24KN/m^2 condenses 1.8 tones of steam of 0.98 and is condensed, but not undercooled. Cooling water enters the condenser at a temperature of 21^{0}C and leaves at 57^{0}C. Determine the flow rate of the cooling water [12]
[20]

Question Four

A two stage, single acting, reciprocating compressor takes air at the rate of 0.2m^3/s. in take pressure and temperature are 0.1MN/m^2 and 16^0 C respectively. The air is compressed to a final pressure of 0.7MN/m^2. The immediate pressure is ideal and intercooling is perfect. The compression index is 1.25 and the compressor runs at 10rev/s.

Neglecting clearance, determine:

a) The immediate pressure [4]
b) The total volume of each cylinder [4]
c) The cycle power [4]
d) Identify the maintenance problems associated with compressors. [8]
[20]

Question Five

A combined power plant consists of a gas turbine unit and a steam turbine unit. The exhaust gas from the open-cycle gas turbine is the supply gas to the steam generator of the steam turbine cycle at which additional fuel is burnt in the gas. The pressure ratio for the gas-turbine cycle is 7, the air inlet temperature is 15^{O}C, and the maximum cycle temperature is 750^{O}C. Combustion in the steam generator raises the gas temperature to 750^{O}C and the gas leaves the generator to the chimney at 100^{O}C. Steam is supplied to the steam turbine at 50Bar, 600^{O}C, and the condenser pressure is 0.1 Bar.

The isentropic efficiencies of the air compressor, gas turbine and the steam turbine are 80%, 85% and 80% respectively.

Taking C_P =1.11KJ/Kg K and γ =1.33 for the combustion gases and neglecting the effect of the mass flow rate of fuel, feed pump work, and all pressure losses, calculate:

a) The required flow rates of air and steam for a total power output of 100MW [5]
b) The power output of each unit [5]
c) The cycle efficiency of each unit [5]
d) The overall efficiency of the plant [5]

[20]

Question Six

Air is heated by passing it through a 25mm bore copper tube which is maintained at 280^{0}C. The air enters at15^{0}C and leaves at 270^{0}C at a mean velocity of 30m/s. using Reinolds analogy.

Calculate:

a) The length of the tube [10]
b) The pumping power required [10]

For turbulent flow in the tube take f =0.0791(Re) $^{-1/4}$ and all properties at mean film temperature.

[20]

Question Seven

Air is required to be delivered to a room at dry bulb temperature of 17^{0}C and with relative humidity of 60% . The calculation to be based on an air flow of 0.5m/s into the room and it can be assumed that the corresponding fan in put is1.125kW. Calculate the condition at which the air must leave the heater. Assume the pressure throughout the plant is constant at1.013 bar

[20]