FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL & MANUFACTURING ENGINEERING

INTRODUCTION TO THERMAL SYSTEMS - TIE 3108

SUPPLEMENTARY EXAMINATIONS OCTOBER 2009

Time : 3 hours
Instructions
Answer any five questions

QUESTION 1

One kilogram of air is taken through a Carnot cycle. The initial pressure and temperature of the air are 1.73MN/m^2 and 300^0 C respectively. From the initial conditions, the air is expanded isothermally to three times its initial volume and then further expanded adiabatically to six times its initial volume. Isothermal compression followed by adiabatic compression, completes the cycle, determine,

a) the temperature, volume and pressure at each corner of the cycle. [5]
b) the thermal efficiency of the cycle [5]
c) the work done per cycle [5]
d). the work ratio [5]

take R =0.26kJ/kgK and $\gamma = 1.4$

QUESTION 2

A steam turbine plant operates on the rankine cycle. Steam is delivered from the boiler to the turbine at a pressure of 3.5MN/m^2 and with a temperature of 350^0C. Steam from the turbine exhausts into the condenser at a pressure of 10KN/$m^{2.}$ Condensate from the condenser is returned to the boiler by means of feed pump. Neglecting losses, determine,

a). The energy supplied in the boiler/kg of the steam generated. [6]
b). Dryness fraction of steam entering the condenser [6]
c). The Rankine efficiency [8]

QUESTION 3

A furnace wall consists of 125-mm wide refractory brick and 125-mm wide insulating firebrick separated by an air gap. The outside wall is covered with a 12mm thickness plaster. The inner surface wall is at 1100^0C and the room temperature is 25^0C.The heat transfer coefficient from the outside wall surface to the air in the room is 17W/m^2K, and the heat resistance to the flow of the air gap is 0.16K/W. The thermal conductivities of the refractory brick, insulating fiber and plaster are 1.6, 0.3 and 0.14W/mK, respectively

Calculate:

a) the rate of heat loss per unit area of the wall surface [6]
b) the temperature at each interface throughout the wall [6]
c) the temperature at the outside of the wall [8]

QUESTION 4

A gas turbine unit has a pressure ratio of 10/1 and a maximum cycle temperature of 700^0C. The isentropic efficiencies of the compressor and turbine are 0.82 and 0.85 respectively. Calculate the power output of an electric generator coupled to the turbine when the air enters at 15^0C at the rate of 15kg/s. Take Cp =1.005kJ/KgK and $\gamma = 1.4$ for the compression process and Cp =1.11kJ/kgK and $\gamma = 1.333$ for the expansion process **[20]**

QUESTION 5

An oil engine takes air at 1.01 bar, and 20 ^{0}C. The maximum pressure in the cycle is 69 bar, the compressor ratio is18/ 1. Calculate the air standard thermal efficiency based on the dual combustion cycle. Assume that the heat added at constant volume is equal to the heat added at constant pressure, take $\gamma = 1.4$
Cv =0.718kJ/kgK **[20]**

QUESTION 6

The velocity of steam leaving the nozzles of an impulse turbine is 900m/s and the nozzle angle is 20^0. The blade velocity is 300m/s and the blade velocity coefficient is 0.7. Calculate for a mass flow rate of 1kg/s and symmetrical blading:

a). The blade inlet angle [4]
b). The driving force on the wheel [4]
c) The axial thrust [4]
d) The diagram power [4]
e) The diagram efficiency [4]

QUESTION 7

a) Describe the major components of a refrigerator

b) In a refrigerating plant using freon 12, the vapour leaves the evaporator dry saturated at 1.826 bar and is compressed to 7.449 bar, the temperature of the vapour leaving the compressor is 45^0C and the liquid leaves the condenser at 25^0C and is throttled to the evaporator pressure. Calculate:

i. The refrigerating effect [6]
ii. The specific work input [6]
iii. The COP ref [8]

END OF EXAM