63

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THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 05
FINAL EXAMINATION– 2007/2008

MEX5231 – APPLIED THERMODYNAMICS

DATE : 21st MAY 2008
TIME : 1330 HRS. – 1630 HRS.
DURATION : THREE HOURS

ANSWER FIVE QUESTIONS ONLY. ALL QUESTIONS CARRY EQUAL MARKS.

Density of water = 1000kg/m^3. Acceleration due to gravity = 9.81m/s^2

1. Refrigerant 134a enters the compressor of a refrigerator as superheated vapour at 0.14MPa and -10°C at a rate of 0.05kg/s and leaves at 0.8MPa and 50°C. The refrigerant is cooled in the condenser to 26°C and throttled to 0.15MPa. Disregarding any heat transfer and pressure drops in the connecting lines between the components, determine:
   i. the rate of heat removal from the refrigerated space and the power input to the compressor
   ii. the isentropic efficiency of the compressor
   iii. the coefficient of performance

P (MPa)	T °C	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kg.K)	s_g (kJ/kg.K)
0.14	-10	-	246.36	-	0.9724
0.8	40	-	276.45	-	0.9480
0.8	50	-	286.69	-	0.9802
0.8	26	87.83	176.85	0.3290	0.9202
0.15	-17	29.14	240.14	0.1189	0.9432

2. In a stage of an impulse reaction turbine provided with single row wheel, the mean diameter of the blades is 1m. It turns at 3000rev/min. The steam discharges from the nozzle at a velocity of 350m/s and nozzle angle is 20°C. The rotor blades are equiangular. The blade friction factor is 0.86. Determine the power developed if the axial thrust on the end bearing of a rotor is 118N.

3. A steam turbine is supplied with steam at a pressure of 85 bar and 450°C. The steam is reheated to its original temperature in a reheater at 10 bar. The expansion then takes place at condenser pressure of 0.08 bar. Find the efficiency of the reheat cycle and work output if the flow of steam is 1kg/s. Consider the pump work and assume that the expansion in the turbine is isentropic.

4. A closed cycle gas turbine plant takes in air at a temperature T_a and compresses it through a pressure ratio ρ. After compression heat is added at constant pressure and the air enters the turbine at a temperature T_b. Air is expanded in the turbine and finally heat rejection takes place at a constant pressure.
The isentropic efficiencies of compression and expansion are η_C and η_T respectively. If an ideal regenerator is employed in this cycle show that the thermal efficiency of the cycle (η) is given by

$$\eta = 1 - \frac{\rho^{\alpha}}{\theta}$$

where $\alpha = \left(\frac{\gamma - 1}{\gamma}\right)$, and γ being the ratio of specific heats,

$$\theta = \eta_c \eta_T \beta \text{ and } \beta = \frac{T_b}{T_a}$$

If $T_a = 27°C$, $T_b = 1000°C$, $\rho = 4$, $\gamma = 1.4$ and $\eta_C = \eta_T = 1$, show that the thermal efficiency of the cycle is approximately two times the thermal efficiency of an ideal Brayton cycle working with the same pressure ratio but without regeneration.

5. A small gas turbine uses liquid Octane (C_8H_{18}) for fuel and 400% theoretical air. The air and fuel enter at 25 °C, and the products of combustion leave at 900K. The power output of the turbine and the fuel consumption are measured, and it is found that the specific fuel consumption is 0.25kg/s of fuel per Megawatt output. Determine the heat transfer from the turbine per kilomole of fuel. Assume complete combustion.

6. A nozzle is required to pass an air flow of 2kg/s. The inlet conditions are zero velocity, a pressure 3.5bar and a temperature 450°C. The air is expanded isentropically to 1.4bar. Determine the throat area required if the coefficient of discharge is assumed to be 0.98.Also calculate the exit velocity and exit area.

7. Calculate the overall heat transfer coefficient and heat transfer per square meter between a fluid with a bulk temperature of 160°C and another with a bulk temperature 15°C with a wall separating them and the wall is made out of two layers *A* and *B* both 50mm thick. The surface heat transfer coefficient for the hot fluid is 5W/m^{2}K and for the cold fluid 3W/m^{2}K. The thermal conductivity of layer *A* is 20 W/m.K and for *B* it is 0.5 W/m.K.

8. An exhaust pipe of 75mm outside diameter is cooled by surrounding it by an annular space containing water. The exhaust gas enters the exhaust pipe at 350°C, and the water enters from the mains at 10°C. The heat transfer coefficients for the gases and water may be taken as 0.3 and 1.5kW/m^2 K, and the pipe thickness is negligible. The gases are required to be cooled to 100°C and the mean specific heat capacity at constant pressure is 1.13kJ/kg.K. The gas flow rate is 200kg/h and the water flow rate is 1400kg/h. Taking the specific heat capacity of water 4.19kJ/kg K, calculate the required pipe length for parallel flow and counter flow.

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