BT MRE – III – 08 – 043

B.Tech Degree III Semester Examination in Marine Engineering, December 2008

MRE 303 THERMO DYNAMICS AND HEAT TRANSFER

Time : 3 Hours Maximum Marks : 100

I (a) State the Kelvin – Planck statement and Clausius statements of second law of thermodynamics and prove their equivalence. (10)

(b) Air at 20°C and 1.05 bar occupies 0.025 m^3. The air is heated at constant volume until the pressure is 4.5 bar, and then cooled at constant pressure back to original temperature. Calculate:

(i) The net heat flow from the air.

(ii) The net entropy change.

Sketch the process on T-s diagram. (10)

OR

II (a) Explain the Carnot cycle and derive an expression for the efficiency of Carnot cycle. (10)

(b) An engine working between the temperature limits of 750°C and 25°C receives 1000kJ/min of heat. Calculate:

(i) the efficiency of the engine

(ii) Work done

(iii) COP if it is working as a refrigerator

(iv) COP if it is working as a heat pump. (10)

III (a) Sketch the Rankine cycle on T-s and h-s diagram for wet dry and super heated steam. (6)

(b) A Turbine supplied with steam at 32 bar pressure and 410°C temperature. The steam is expanded isentropically to pressure of 0.08 bar. Find the dryness fraction at the end of expansion and the cycle efficiency.

If the steam is reheated at a pressure 5.5 bar to a temperature of 395°C and then expanded isentropically to the pressure of 0.08 bar, Calculate the efficiency of the reheat cycle. (14)

OR

IV (a) Derive an expression for the mean effective pressure of a steam engine working on modified Rankine cycle with clearance volume. (10)

(b) The following are the average readings taken during a test on a steam engine:

Engine stroke	--- 30 cm
Cylinder diameter	--- 20 cm
Piston rod diameter	--- 5 cm
Mean speed	--- 139.9 r.p.m
Area of indicator card (head end)	--- 6.5 cm^2
Area of indicator card (crank end)	--- 6.8 cm^2
Length of indicator card (head end)	--- 6.8 cm
Strength of indicator spring	--- 1.5 bar / cm
Load on brake	--- 444 N
Spring balance reading	--- 68 N
Radius of brake wheel	--- 0.6 m
Steam used per minute	--- 2.7 kg (dry saturated)
Steam pressure (absolute)	--- 3 bar
Back pressure (absolute)	--- 1.04 bar

Calculate Indicated Power, Brake Power, mechanical efficiency and brake thermal efficiency. (10)

(Turn Over)

V (a) Derive an expression for the critical pressure ratio of steam flowing through a nozzle, considering the effect of friction and neglecting the initial velocity. (10)

(b) An adiabatic steam nozzle is to be designed for a discharge rate of 10 kg/sec of steam from 10 bar and 400°C to a back pressure of 1 bar. The nozzle efficiency is 0.92 and the frictional loss is assumed to take place in the diverging portion of the nozzle only. Assume a critical pressure ratio of 0.5457. Determine the throat and exit areas. (10)

OR

VI (a) Derive an expression for the velocity ratio of an impulse turbine for maximum work. (10)

(b) A single stage impulse steam turbine rotor has a diameter of 1.2 m running at 3000 r.p.m. The nozzles angle is 18° and issues steam at a velocity of 1000 m/sec. The blades are symmetrical. The mass flow rate is 1000 kg/hr. Friction factor is $0.8_{\text{nozzle}} = 0.95$. Determine

(i) Blade angle
(ii) Axial thrust on the rotor turbine
(iii) Work done per kg of steam
(iv) Power developed
(v) Blade efficiency
(vi) Stage efficiency (10)

VII (a) Derive an expression for the heat transfer through a thick plane homogeneous wall with conductivity varying with temperature. (8)

(b) A composite insulating wall has three layers of material held together by 3cm diameter aluminium rivet per $0.1 m^2$ of surface. The layers of materials comprise 10 cm thick brick with hot surface at 200°C, 1 cm thick timber with cold surface at 10°C. These two layers are interposed by a third layer of insulating material 25cm thick. Thermal conductivities for brick, insulation, wood and aluminium are 0.95 W/m°K, 0.115 W/m°K , 0.175 W/m°K and 200 W/m°K respectively. If the heat transfer is assumed to take place only in one direction normal to the layers, determine the percentage increase in heat transfer rate due to revets. (12)

OR

VIII (a) Derive an expression for the heat transfer through the walls of a hollow cylinder. (10)

(b) A steam pipe of 10 cm outside diameter is covered with two layers of insulating material each of 2.5 cm thick, one having thermal conductivity thrice the other. Show that the effective conductivity of two layers is approximately 15% less when better insulating material is inside than when it is on the outside. (10)

IX (a) Derive an expression for the LMTD of a parallel flow heat exchanger. (10)

(b) In a counter-flow double pipe heat exchanger; water is heated from 25°C to 65°C by an oil with a specific heat of 1.45 kJ / kg K and mass flow rate of 0.9 kg /s. The oil is cooled from 230°C to 160°C. If the overall heat transfer coefficient is 420 $W/m^2\,°C$, calculate the following:

(i) The rate of heat transfer
(ii) The mass flow rate of water, and
(iii) The surface area of the heat exchanger. (10)

OR

X (a) Explain with figures the shell and tube heat exchanger. (8)

(b) Explain any three of the following:

(i) Reynolds Number
(ii) Prandelt Number
(iii) Nusselt Number
(iv) Grashof Number (12)

***