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**INDIAN INSTITUE OF TECHNOLOGY**

Date: ………… FN/AN Time: 3 **hours** Full Marks: **100**

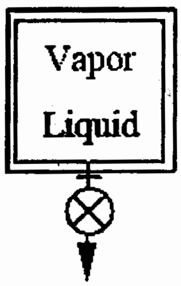
**End-Sem(Supplementary) Examination, 2013** Dept. **Mechanical Engineering**

2nd Year B.Tech (H) Subject No.: **ME22002** Subject Name: **Thermodynamics**

**Answer all the questions.** **Marks for the questions are shown on the margin.**

- Air can be assumed as an ideal gas with constant specific heats of $c_p$=1.005 kJ/kgK and $c_v$=0.718 kJ/kgK.
- Use of steam table, supplied with the question paper, is permitted.
- Answer to a particular question should be in one place. Otherwise, it would not be checked.
- Universal gas constant is 8.314 kJ/kmol-K

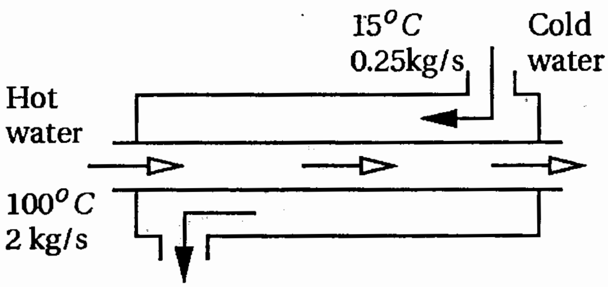
Q1. A 750-L rigid tank, as shown in Fig. below, initially contains water at 250°C, 50% liquid and 50% vapour, by volume. A valve at the bottom of the tank is opened, and liquid is slowly withdrawn. Heat transfer takes place such that the temperature remains constant. Find the amount of heat transfer required to the state where half the initial mass is withdrawn.




20 Marks

Q2. Cold water ($C_p$=4.18 kJ/kg-°C) enters a well insulated, double-pipe, counter-flow heat exchanger at 15°C at a rate of 0.25 kg/s and is heated to 45°C by hot water ($C_p$=4.19 kJ/kg-°C) that enters at 100°C at a rate of 2 kg/s. The density of water is 1000kg/m³. Determine

a) the rate of heat transfer between the hot and cold streams and
b) the rate of entropy generation in the heat exchanger




20 Marks

Q3. An ideal gas turbine cycle with two stages of compression and two stages of expansion has an overall pressure ratio of 8.0. Air enters each stage of the compressor at 300k and each stage of the turbine at 1300K.

i) Draw a block diagram of the ideal plant and show the cycle on T-s plane.
ii) Find out the back work ratio of the cycle.
iii) Determine the thermal efficiency of the cycle assuming (a) no regenerator and (b) a regenerator of 80% efficiency.

Assume air to be an ideal gas and entry of air at the beginning of the compression is at 1.0 atmospheric pressure.

3+3+4+4+6=20Marks

Q4. Consider a steam power plant working on the ideal reheat Rankine cycle. Steam enters the high pressure turbine at 15MPa, $600^0$C and condensed in a condenser at a pressure of 10KPa. If the moisture content at the low pressure turbine is not to exceed 10.4%, determine the reheat pressure and the thermal efficiency of the cycle. Draw the block diagram of the plant and the T-s diagram of the cycle. Assume steam temperature to be $600^0$C after reheating. What is the effect of reheating on the exit quality of steam?

6+6+3+3+2=20Marks

Q5.(a) In an air compressor, air enters at ambient condition of 100 kPa and $25^0$C. At the exit of the compressor, the pressure and temperature of the compressed air are 1 MPa and 540 K respectively. Since the air and compressor housing are hotter than the ambient surroundings, 50 kJ per kilogram air flowing through the compressor are lost. Find the (a) reversible work and (b) irreversibility in the process. Take gas constant 0.287 kJ/kg-K; $C_p$=1.005 kJ/kg-K; $C_v$=0.718 kJ/kg-K.

(b) In an adiabatic saturator device, the air-water vapour-mixture leaving the duct is saturated and the process is adiabatic. The pressure of the air-water vapor mixture entering and leaving an adiabatic saturator is 0.1 MPa. The entering temperature is $30^0$C, and the temperature leaving is $20^0$C, which is at the adiabatic saturation temperature. For the air-water vapor mixture entering, calculate (a) the humidity ratio and (b) relative humidity.

5+5+5+5=20Marks