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B TECH
(SEM IV) THEORY EXAMINATION 2018-19
APPLIED THERMODYNAMICS

Time: 3 Hours *Total Marks: 100*

Note: Attempt all Section. If required any missing data, then choose suitably. Use of steam table and Mollier chart is allowed.

SECTION A

1. Attempt all questions in brief. **2 x 10 = 20**

a. Define Joule Thomson coefficient.
b. What do you mean by isothermal compressibility?
c. What is enthalpy of formation?
d. Discuss adiabatic flame temperature.
e. How equivalent evaporation is used for comparison of boilers?
f. What is cogeneration?
g. Define propulsive power and propulsive efficiency.
h. Why Rankine cycle is modified?
i. What do you mean by perfect intercooling?
j. Define degree of reaction.

SECTION B

2. Attempt any *three* of the following: **10x3=30**

a. Derive the relation for calculating chimney height. Calculate the height of chimney required to generate a pressure difference of 100 mm of water column. The temperature of outside air is 30 °C and the average temperature of flue gases in the chimney is 150 °C.
b. An impulse steam turbine of 180 kW has steam flowing at rate of 165 kg/min and leaving axially. Steam turbine blade speed is 175 m/s and it leaves nozzle at 400 m/s. For the blade velocity coefficient of 0.9, find nozzle angle, blade angles at inlet and exit, axial thrust and diagram efficiency.
c. A sample fuel has the percentage composition by weight as Carbon = 84%, Hydrogen = 10%, Oxygen = 3.5%, Nitrogen = 1.5% and Ash = 1%. Determine: (i) The stoichiometric air fuel ratio by mass, (ii) If 20% excess air is supplied, find percentage composition of dry flue gas by volume.
d. Define critical pressure ratio for nozzle of the steam turbine. Obtain analytically its value in terms of the index of expansion.
e. What do you mean by inversion curve? Prove that Joule Thomson coefficient for a perfect gas is zero.

SECTION C

3. Attempt any *one* part of the following: **10x1=10**

a. A steam power plant operates on the regenerative cycle. Steam form boiler at 30 bar and 400°C is expanded in a turbine. A part of the steam is bled at 2 bar pressure in to the feed water heater and the remainder are condensed at 0.07 bar. Neglecting pump work, determine the work done per kg of steam and the efficiency of the cycle.
b. Air enters the compressor of a gas turbine plant operating on Brayton cycle at 101.325 kPa, 27°C. The pressure ratio in the cycle is 6. Calculate the maximum temperature in the cycle and the cycle efficiency. Assume $W_T = 2.5 \times W_C$, where W_T and W_C are the turbine and the compressor work respectively. Take $\Upsilon = 1.4$.

4. Attempt any *one* part of the following: 10x1=10

a. Determine the pressure an ice skate blade must exert to allow smooth ice skate at -10 °C. Take
Latent heat of fusion of ice = 334 kJ/kg,
Specific volume of water = 1×10^{-3} m^3/kg,
Specific volume of ice = 1.01×10^{-3} m^3/kg

b. Discuss in details the significance of reheating, inter-cooling and regeneration on the performance of gas turbine by making suitable layout and T-s diagram.

5. Attempt any *one* part of the following: 10x1=10

a. A boiler generates 7.5 kg of steam per kg of coal burnt at a pressure of 11 bar, from feed water having a temperature of 70°C. The efficiency of boiler is 75% and factor of evaporation 1.15. Specific heat of steam at constant pressure is 2.3. Calculate:
(i) Degree of superheat and temperature of steam generated;
(ii) Calorific value of coal in kJ/kg;
(iii) Equivalent evaporation in kg of steam per kg of coal.

b. A gas turbine plants consists of two-stage compressor with perfect intercooler and a single stage turbine. If the plants work between the temperatures limits 300 K and 1000 K and 1 bar and 16 bar. Find the net power of the plant per kg of air. Take specific heat at constant pressure 1 kJ/kgK.

6. Attempt any *one* part of the following: 10x1=10

a. What is the principle of jet propulsion? Classify the jet propulsion engines. Explain the working of turbo jet engines by making neat sketch.

b. Explain the construction and working of Babcock-Wilcox Boiler with neat diagram.

7. Attempt any *one* part of the following: 10x1=10

a. Draw velocity diagram of velocity compounded turbine and find equation for maximum work done and efficiency.

b. Define the blade efficiency. Derive an expression for maximum blade efficiency for an impulse turbine. $(\eta_{blade})_{max} = Cos^2\alpha$.