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BIME-013

B.Tech. – VIEP – MECHANICAL ENGINEERING (BTMEVI)

Term-End Examination

00492

December, 2016

BIME-013 : TURBO MACHINES

Time : 3 hours *Maximum Marks : 70*

Note : *Answer any **five** questions. All questions carry equal marks. Use of steam tables is allowed. Use of scientific calculator is permitted.*

1. (a) What is a surge tank and a forebay and what are their functions ? Describe with neat sketches any one type of surge tank.

(b) A Kaplan turbine produces 60000 kW under a net head of 25 m with an overall efficiency of 90%. Taking the value of speed ratio K_u as 1·6, flow ratio ψ as 0·5 and the hub diameter as 0·35 times the outer diameter, find the diameter and speed of the turbine. *7+7*

2. (a) Describe briefly the components of a gas turbine power plant.

(b) A centrifugal pump has the following characteristics :

Outer diameter of impeller = 800 mm; width of impeller vanes at outlet = 100 mm; angle of impeller vanes at outlet = 40°. The impeller runs at 550 rpm and delivers 0·98 cubic metres of water per second under an effective head of 35 m. A 500 kW motor is used to drive the pump. Determine the manometric, mechanical and overall efficiencies of the pump. Assume water enters the impeller vanes radially at inlet. 7+7

3. (a) Describe in brief the phenomenon of cavitation in turbines.

(b) A gas turbine has an overall pressure ratio of 5 : 1 and a maximum cycle temperature of 550°C. The turbine drives the compressor and an electric generator, the mechanical efficiency of the drive being 97%. The ambient temperature is 20°C, and the isentropic efficiencies of the compressor and turbine are 0·80 and 0·83 respectively. Calculate the power output in kilowatts for an air flow of 15 kg/s. Also calculate the thermal efficiency. Neglect changes in kinetic energy and the loss of pressure in combustion chamber. 7+7

4. (a) What are the advantages of a gas turbine plant over diesel and steam power plants of the same capacity ?

(b) Find the required air-fuel ratio in a gas turbine whose turbine and compressor efficiencies are 85% and 80% respectively. Maximum cycle temperature is 875°C. The working fluid can be taken as air (C_p = 1·0 kJ/kg-K, γ = 1·4) which enters the compressor at 1 bar and 27°C. The pressure ratio is 4. The fuel used has a calorific value of 42000 kJ/kg. There is a loss of 10% of calorific value in the combustion chamber. 7+7

5. (a) A centrifugal compressor delivers 16·5 kg/sec of air with a total head pressure ratio of 4 : 1. The speed of the compressor is 15000 rpm. Inlet total head temperature is 20°C, slip factor 0·9, power input factor 1·04 and 80% isentropic efficiency.

Calculate :

(i) Overall diameter of the impeller

(ii) Power input

(b) In a constant pressure open cycle gas turbine, air enters at 1 bar and 20°C and leaves the compressor at 5 bar.

Using the following data :

Temperature of gases entering the turbine = 680°C,

pressure loss in the combustion chamber = 0·1 bar,

$\eta_{compressor}$ = 85%, $\eta_{turbine}$ = 80%, $\eta_{combustion}$ = 85%,

γ = 1·4 and C_p = 1·024 kJ/kg-K for air and gas.

Find :

(i) The quantity of air circulation if the plant develops 1065 kW

(ii) Heat supplied per kg of air circulation

(iii) The thermal efficiency of the cycle.

Mass of fuel may be neglected. 7+7

6. (a) Describe briefly an axial flow compressor.

(b) In an axial flow compressor, the overall stagnation pressure ratio achieved is 4 with overall stagnation isentropic efficiency 86%. The inlet stagnation pressure and temperature are 1 bar and 320 K. The mean blade speed is 190 m/s. The degree of reaction is 0·5 at the mean radius with relative air angles of 10° and 30°, at rotor inlet and outlet respectively. The work done factor is 0·9. Calculate :

(i) Stagnation polytropic efficiency

(ii) Number of stages

(iii) Inlet temperature and pressure 7+7

7. (a) The resistance R, to the motion of a supersonic aircraft of length L, moving with a velocity V in air of density ρ, depends on the viscosity μ, and bulk modulus of elasticity K of air. Obtain, using Buckingham's π-theorem, the following expression for the resistance R :

$$R = (\rho L^2 V^2)\, \phi \left[\left(\frac{\mu}{\rho LV} \right), \left(\frac{K}{\rho V^2} \right) \right].$$

(b) Obtain an expression for the critical depth y_c in a triangular channel which depends on discharge Q, gravitational acceleration g and angle of channel θ. 7+7