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BIME-013

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

Term-End Examination

00260

June, 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) Explain with neat sketches, the construction and working of a single-stage centrifugal pump.

(b) A Pelton wheel has to be designed for the following data :

Power to be developed = 6000 kW

Net head available = 300 m

Speed = 550 rpm

Ratio of jet diameter to wheel diameter = $\frac{1}{10}$ and overall efficiency = 85%.

Find the number of jets; diameter of the jet; diameter of the wheel; and the quantity of water required. 7+7

2. (a) What is meant by 'priming' of a pump ? What are the different priming arrangements employed for small and big pumping units ?

(b) Find the power required to drive a centrifugal pump which delivers 40 litres of water per second to a height of 20 m through a 150 mm diameter and 100 m long pipeline. The overall efficiency of the pump is 70% and Darcy's f = 0·06 for the pipeline. Assume inlet losses in suction pipe equal to 0·33 m. 7+7

3. (a) Determine the efficiency of a Kaplan turbine developing 3000 kW under a net head of 5 m. It is provided with a draft tube with its inlet (diameter 3 m) set 1·6 m above the tail race level. A vacuum gauge connected to the draft tube indicates 5 m of water. Assume draft tube efficiency as 78%.

(b) A single-stage steam turbine is supplied with steam at 5 bar, 200°C at the rate of 50 kg/min. It expands into a condenser at a pressure of 0·2 bar. The blade speed is 400 m/s. The nozzles are inclined at an angle of 20° to the plane of the wheel and the outlet blade angle is 30°. Neglecting friction losses, determine the power developed, blade efficiency and stage efficiency. 7+7

4. (a) Explain the working principles of a closed cycle gas turbine plant with the help of a block diagram.

(b) A gas turbine unit receives air at 1 bar and 300 K and compresses it adiabatically to 6·2 bar. The compressor efficiency is 88%. The fuel has a heating value of 44186 kJ/kg and the fuel-air ratio is 0·017 kJ/kg of air. The turbine internal efficiency is 90%. Calculate the work of the turbine and compressor per kg of air compressed and thermal efficiency. 7+7

5. (a) A centrifugal compressor used as a supercharger for aero-engines handles 150 kg/min of air. The suction pressure and temperature are 1 bar and 290 K. The suction velocity is 80 m/s. After compression in the impeller the conditions are 1·5 bar, 345 K and 220 m/s.

Calculate :

(i) Isentropic efficiency

(ii) Power required to drive the compressor

It may be assumed that KE of air gained in the impeller is entirely converted into pressure in the diffuser.

(b) What do you mean by 'Combination gas turbine cycles' ? Explain briefly combined gas turbine and steam power plants. 7+7

6. (a) What is a centrifugal compressor ? How does it differ from an axial flow compressor ?

(b) An axial flow compressor hâving eight stages and with 50% reaction design compresses air in the pressure ratio of 4 : 1. The air enters the compressor at 20°C and flows through it with a constant speed of 90 m/s. The rotating blades of the compressor rotate with a mean speed of 180 m/s. Isentropic efficiency of the compressor may be taken as 82%. Calculate the work done by the machine. 7+7

7. (a) Assuming that the rate of discharge Q of a centrifugal pump is dependent upon the mass density ρ of fluid, pump speed N (rpm), the diameter of impeller D, the pressure p and the viscosity of fluid μ, show using the Buckingham's π-theorem that it can be represented by

$$Q = (ND^3)\,\phi\left[\left(\frac{gH}{N^2D^2}\right),\left(\frac{\nu}{ND^2}\right)\right]$$

where H = head, and

ν = kinematic viscosity of the fluid.

(b) For laminar flow in a pipe, the drop in pressure Δp is a function of pipe length l, its diameter d, mean velocity of flow V, and viscosity of fluid μ. Using Rayleigh's method, obtain an expression for Δp. 7+7