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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth Semester B.Tech Degree Examination July 2021 (2019 Scheme)

Course Code: MET206
Course Name: FLUID MACHINERY

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1 Show that the angle of swing of a vertical hinged plate when a jet of water strike at its centre is given by $Sin\theta = \frac{\rho AV^2}{W}$

2 Show that the force exerted by a jet of water on a inclined fixed plate in the direction of jet is given by $F_x = \rho AV^2 Sin^2\theta$

3 Sketch the velocity triangles for the inlet and outlet of the buckets of a Pelton turbine and label all the salient velocities and angles.

4 Explain the terms manometric efficiency, mechanical efficiency and overall efficiency as applied to centrifugal pumps

5 What is an air vessel? Describe the function of the air vessel for reciprocating pumps

6 Explain the term negative slip of a reciprocating pump. Why and when negative slip occurs?

7 Explain the advantages of multistage compression of air.

8 Compare reciprocating compressor with a rotary compressor.

9 Describe with neat schematic and T-s diagrams, the working of a simple constant pressure combustion gas turbine cycle.

10 State the assumptions made in an ideal cycle analysis of gas turbines.

PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11 a) A 6.0 cm diameter free jet of water having a velocity of 10 m/s impinges on a plane, smooth plate at angle of 30° to the normal to the plate. 5

(a) What will be the force due to jet impingement on the plate and work done per second when the plate is (i) stationary and (ii) moving in the direction of the jet at 5.0 m/s velocity?

(b) What will be the force due to jet on the plate when the plate is moving against the jet direction at 5.0 m/s velocity?

b) A reaction turbine works under a head of 115 m and its speed is 450 rpm. The diameter of the inlet is 1.2 m and the flow area is 0.4 m^2. At the inlet, the absolute and the relative velocities make angles of 20° and 60° respectively with the tangential velocity. Determine the power developed and the hydraulic efficiency. Assume the velocity of whirl at the outlet is zero. 9

12 a) A Kaplan turbine has a runner diameter to hub diameter ratio of 3.0. The speed ratio is 1.61. If this turbine produces 6.5 MW of power at a head of 15 m under a speed of 150 rpm, calculate (a) the specific speed, (b) discharge, and (c) flow ratio. Assume overall efficiency as 92%. 7

b) A Pelton wheel has two jets and is designed to produce a power of 7500 kW with a net head of 400 m. The buckets deflect the jet by an angle of 165°. The reduction of the relative velocity due to friction in the buckets can be taken as 15%. Calculate 7

(a) total discharge through the turbine,

(b) diameter of each jet

(c) the total force exerted by the jets on the wheel in the tangential direction. Assume overall efficiency = 80%, coefficient of velocity = 0.98, and speed ratio = 0.47.

Module -2

13 a) Distinguish between: 6

(a) Semi-scroll case and full-scroll case

(b) Guide vanes and stay vanes

(c) Net head and Euler head

b) A centrifugal pump with 40 cm impeller diameter delivers 75 L/s of oil of relative density 0.85 at a tip speed of 25.1 m/s. The flow velocity is constant at 2.0 m/s and the outlet blade is curved backwards at an angle of 35^0. The overall efficiency is 0.88. 8

(a) Calculate the brake power and torque applied to the pump shaft.

(b) If the inlet diameter is 25 cm, calculate the inlet-blade angle.

14 a) Derive an expression for the minimum speed for starting a centrifugal pump 6

b) A centrifugal pump impeller is 40 cm in outer diameter and 2.5 cm wide at the 8

exit. Its blade angle at the outlet is 30^0. When run at a speed of 1500 rpm, the flow rate through the pump is 80 liters/s. (a) Calculate the radial, relative and absolute velocities at the impeller exit. (b) If there is no inlet whirl, what would be the theoretical head added to the water by the impeller?

Module -3

15 a) Considering the effect of acceleration and friction in suction and delivery pipes, draw the indicator diagram for a single acting reciprocating pump. Also, starting from the fundamentals, derive an expression for work done per second. 10

b) A single-acting reciprocating pump has a 15 cm diameter piston with a crank of 15 cm radius. The delivery pipe is of 10 cm diameter. At a speed of 60 rpm, a discharge of 310 litres/minute of water is lifted to a total height of 15 m. Find the slip, coefficient of discharge and theoretical power in kW required to drive the pump. 4

16 a) A single-acting reciprocating pump has a stroke length of 15 cm. The suction pipe is 7 m long. The water level in the sump is 2.5 m below the cylinder. The diameters of the suction pipe and the plunger are 7.5 cm and 10.0 cm. If the speed of the pump is 75 rpm, determine the pressure head on the piston at the (a) beginning, (b) middle, and (c) end of the suction stroke. Take Darcy–Weisbach friction factor f = 0.02. 9

b) With a neat sketch, explain the working of any one rotary displacement pump. Give two applications of this pump. 5

Module -4

17 a) Derive an expression for the work done in a reciprocating compressor with and without clearance volume 7

b) A single-stage, single-acting, reciprocating air compressor takes in 1 m^3 air per minute at 1 bar and 17°C and delivers it at 7 bar. The compressor runs at 300 rpm and follows the law $pV^{1.35}$ = constant. Calculate the cylinder bore and stroke required, assuming stroke-to-bore ratio of 1.5. Calculate the power of the motor required to drive the compressor, if the mechanical efficiency of the compressor is 85% and that of motor transmissions is 90 %. Neglect clearance volume and take R = 0.287 kJ/kg·K for air. 7

18 a) With a neat sketch, explain the principle of operation, construction and working of centrifugal compressor. Explain 'Surging' in centrifugal compressor 10

b) Define the term 'Free Air Delivered(F.A.D)'. Why free air delivered is less than the displacement of the compressor 4

Module -5

19 a) A gas turbine unit has a pressure ratio of 6 and maximum cycle temperature of 610^0C. The isentropic efficiency of the turbine and compressor are 0.82 and 0.8 respectively. Calculate the power output in kW of an electric generator, geared to the turbine when the air enters the compressor at 15^0C at a rate of 16 kg/s. Take C_p=1.005 kJ/kg.K and γ=1.4 for compression process and C_p=1.11 kJ/kg.K and γ=1.333 for expansion process. 9

b) Write the merits and demerits of gas turbine plant over internal combustion engines. 5

20 a) Differentiate between open, closed and semi closed gas turbine cycles. 5

b) Draw a neat sketch and T-s diagram of a regenerative gas turbine plant and deduce an expression for its thermal efficiency. 9

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