Master of Mechanical Engineering Examination, 2017
Subject: Turbomachinery II

Time: Three hours **Full Marks: 100**

Answer any four questions

1. (a) What is an actuator disc? Discuss about actuator disc approach in 3 dimensional flow theory in turbomachines in contrast with radial equilibrium theory.

b) Discuss about blade row interaction effect showing that when δ/r is fairly small, interaction effects are strong. δ is the distance between two actuator discs and r, the radius of the disc.

[12+13]

2. a) Stating the assumptions made, work out the theoretical efficiency of a wind turbine.

(b) A wind turbine operates at sea level in a wind of 20 m/s. The wake velocity is measured at 8 m/s. Estimate the thrust on the turbine and power generated by it.

(c) For rocket propulsion in the absence of gravity, air or other resistances, show that the propulsive force is $\dot{m}u_r + \sum F = M\frac{dv}{dt}$

where u_r is the velocity of the jet relative to the rocket and the other symbols have their usual meaning.

[10+7+8]

3 (a) Discuss about secondary flow as evidenced in axial flow turbomachines?

(b) With neat sketch show the performance characteristics of radial flow, mixed flow and axial flow pump and highlight the specific features for each of them.

(c) Plot typical efficiency versus percentage load curves for different types of hydraulic turbine highlighting any specific features for each of them.

(10+8+7)

4. (a) Discuss about radial equilibrium flow and hence deduce the radial flow equilibrium equation for an incompressible fluid in an axial-flow trubo-machine.

(b) The whirl distribution at entry to and exit from a compressor rotor is given by

$C_{\theta 1} = ar - a/r$
$C_{\theta 2} = ar + a/r$
where, a and b are constants.

Verify that, if the axial velocity remains unchanged in passing through the rotor, the degree of reaction is constant at all radii.

[12+13]

5. (a) Explain the importance of inlet velocity at the eye of pumps and compressors.

(b) Deduce the optimum conditions for the inlet velocity triangle in terms of hub-tip ratio.

(c)Arrive at the optimum design condition at inlet of a centrifugal pump in terms of suction specific speed, blade cavitation coefficient, inlet hub radius and inlet blade tip radius.

[6+10+9]

6. (a) Discuss about slip phenomenon and slip factor in pumps and compressors with particular reference to Stodola's slip factor.

(b) Air enters the diffuser of a compressor with a velocity of 300 m/s at a stagnation pressure of 200 kPa and a stagnation temperature of 200^0 C and leaves the diffuser with a velocity of 50 m/s. Using compressible flow relations and assuming the diffuser efficiency of 0.9, determine

i) the static temperatures at inlet and outlet of the diffuser

ii) the inlet Mach number and the static pressure at diffuser outlet and

iii) the increase in entropy caused by the diffusion process

Take suitable value for γ and C_p for air.

[13+3x4]

7. Write short notes on the following

i) a) Centrifugal compressor stage and velocity diagrams at impeller entry and exit of the impeller and b) Radial-flow pump and velocity diagrams at impeller entry and exit

ii) Thermodynamic analysis of a centrifugal compressor impeller

iii) .Cavitation in turbo machines

iv) Shock at compressor inlet

[8+8+4+5]