Exam Date & Time: 01-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

FIFTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, DECEMBER 2023

TURBO MACHINES [MME 3154]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Develop the expression for mass parameter and speed parameter for a compressible flow machine using dimensional analysis. (4)

A)

B) Starting from Euler's Turbine equation, obtain the expression for energy transfer in terms of its components. (3)

C) An inward flow radial turbine has the rotor blades which are radial at entry. The radial velocity is constant throughout and there is no whirl velocity at rotor exit. Show that the max. utilization factor is a function of inlet flow angle only. (3)

2) Express the energy transfer of a forward bladed impeller in terms of head and flow rate. Draw the velocity triangles also. (2)

A)

B) Draw the velocity diagrams and determine the energy transfer per unit mass of the fluid for a radial flow turbine having Inlet radius of the runner = 2.25 m, Outlet radius of the runner = 1 m, Inlet blade angle = 120°, Outlet blade angle = 30°, Speed of the runner = 520RPM, Inlet absolute velocity = 200 m/s, Outlet absolute velocity = 60 m/s. (5)

C) Show that with the help of velocity triangle for maximum utilization and same amount of energy transfer in impulse and reaction axial flow turbine with no axial thrust, blade speed of 50% reaction turbine is $\sqrt{2}$ times that of impulse turbine. (3)

3) Gas flows through a turbine where its stagnation pressure is decreased in the ratio of 5:1. The total to total efficiency is 0.8 and the air flow rate is 5 kg/s. If the total power output is 500 kW, find, (i) Inlet total temperature (ii) The actual exit total temperature (iii) The actual exit static temperature, if the flow velocity is 100 m/s and (iv) the total to static efficiency of the device. (4)

A)

B) Develop an expression for the overall efficiency of a multi stage turbine in terms of stage pressure ratio and polytropic efficiency. (4)

C) Deduce an expression for minimum starting speed of a centrifugal pump. (2)

4) A centrifugal compressor compresses air at ambient stagnation temperature and pressure of 288 K and 101.3 kPa. respectively. The impeller tip speed is 365 m/s, the radial flow velocity at the exit of the impeller is 30 m/s, and the slip factor is 0.9. Calculate the

A) Mach number of the flow at the impeller tip. If the isentropic total-total efficiency is 90 % and the flow area at the impeller exit is 0.1 m^2, find the mass flow rate of air. Assume zero inlet whirl and that the blades are radial in nature. (4)

B) Develop an expression for stage stagnation pressure in terms of in terms of blade loading coefficient and polytropic efficiency. (4)

C) Draw the velocity triangles for the Pelton and Francis turbines. Show all the velocity components and angles in them. (2)

5) Derive an expression for rotor efficiency of a D'Laval turbine. Draw the velocity triangles also. (3)

A)

B) A Pelton Turbine produces 15 MW under a head of 300 m. The turbine speed is 500 rpm. Assuming a turbine efficiency of 84%, the coefficient of jet as 0.97, blade Speed ratio of 0.46, a bucket coefficient of 0.85, a jet ratio of 9.5, and assuming the deflection angle of the jet over the bucket as 165°, Compute the number of jets required and the diameter of each Jet as well as tangential force exerted by each jet on the bucket. (4)

C) The nozzle of a simple impulse turbine is inclined at an angle of 20º to the direction of path of moving blade and steam leaves the nozzle at 375 m/s. The blade speed is 165 m/s. Find suitable inlet and outlet blade angles so that there shall not be axial thrust on the blades. Allowing the velocity of steam in passing over the blades being reduced by 15%, determine the power developed for unit mass flow rate. (3)

-----End-----