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Ref no: EX/PG/ME/T/127D/2018

MASTER OF MECHANICAL ENGINEERING 2nd SEM EXAMINATION 2018

TURBO MACHINERY II

Time: 3 hours

Full Marks: 100

Answer any five questions

1. a) Explain the terms design flow coefficient and stage loading coefficient in relation to turbine stage design. *8*

   b) A low pressure turbine within a turbofan jet engine consists of five repeating stages. The turbine inlet stagnation temperature is 1200 K and the inlet stagnation pressure is 213 kPa. It operates with a mass flow of 15 kg/s and generates 6.64 MW of mechanical power. The stator in each turbine stage turns the flow from 15^0 at stator inlet to 70^0 at stator outlet. The turbine mean radius is 0.46 m and the rotational shaft speed is 5600 rpm. Calculate the turbine stage loading coefficient and flow coefficient. Hence show that the reaction is 0.5 and sketch the velocity triangles for one complete stage. Also calculate the annulus area at inlet to the turbine. Use this to estimate the blade height and the hub-to-tip radius ratio for the stator in the first turbine stage. *12*

   Take $\gamma = 1.33$, $R = 287.2$ J/kg.K and $c_p = 1150$ J/kg.K

2. a) Explain how relative stagnation enthalpy remains unchanged through the rotor of a

purely axial turbo machine. *10*

b) Deduce the relationship between stage loading flow coefficient and reaction of a repeating stage turbine. *10*

3. a) Define the various loss coefficient with respect to an axial flow compressor stage.

b) Represent the mean line flow through a high speed compressor rotor and hence show how static pressure at rotor exit can be determined.

c) Draw the velocity diagram for degree of reaction greater or less than 50% for a compressor stage. *6+8+6*

4. a) Define degree of reaction for a compressor. What do you mean by stage loading for a compressor and deduce the equation where stage loading is related with degree of reaction. *8*

b) A single stage transonic compressor operates with axial flow at inlet. The inlet absolute stagnation temperature is 288 K and the inlet absolute stagnation pressure is 101 kPa. The relative flow angle at inlet to the rotor is 45^0 and inlet relative Mach number is 0.9. Calculate the rotor blade speed and the inlet relative stagnation pressure. *12*

5. a) What are the advantages of high Mach number compressor stages? Discuss any disadvantage associated with this. *10*

b) Discuss the phenomenon of stall and surge in a compressor. *10*

6. a) Represent the diffusion process of a compressor on a Mollier diagram. Obtain an expression for diffuser efficiency in terms of pressure ratio. *8*

b) Air enters the diffuser of a compressor with a velocity of 300 m/s at a stagnation pressure of 200^0 C and leaves the diffuser with avelocity of 50 m/s. Using compressible flow relations and assuming the diffuser efficiency to be 0.9, determine the static temperatures at inlet and outlet of the diffuser and the inlet Mach number. Also determine the static pressure at diffuser inlet and the increase in entropy caused. *12*