Ref. No. : Ex/PG/MEC/PC/T/111B/2025

M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER – 2025

ADVANCED TURBOMACHINERY

Time : 3 hours Full Marks 100

Part 1

Answer any 2 (two) questions

1. a) Explain the concept of "rothalpy" in a compressor or a pump. *5*

   b) What do you mean by "small stage efficiency" for a compression process? Show that the isentropic efficiency is less than the small stage efficiency. *10*

   c) Establish the relation between polytropic efficiency, reheat factor and turbine isentropic efficiency. *10*

2. a) With a neat sketch explain the basic parameters of a compressor cascade nomenclature. *10*

   b) Obtain an expression of lift-drag ratio in terms of compressor cascade angles. *8*

   c) Show that the maximum efficiency of a compressor cascade is obtained when the mean flow angle is 45^0. *7*

3. a) Deduce expressions for the ratio of stagnation and static temperatures, pressure and density in terms of Mach number of flow. *12*

   b) Obtain a functional relationship among the non-dimensional parameters which are essential in predicting the performance of a turbomachine handling a compressible flow. *13*

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Ex/PG/MEC/PC/T/111B/2025

M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER EXAM 2025

SUBJECT: ADVANCED TURBOMACHINERY

Time: Three hours Full Marks 100

Use separate sheets for each part

PART II

Answer any 2 (two) questions

1. a) Explain the concept of "rothalpy" in a compressor or a pump. 5

b) What do you mean by "small stage efficiency" for a compression process? Show that the isentropic efficiency is less than the small stage efficiency. 10

c) Establish the relation between polytropic efficiency, reheat factor and turbine isentropic efficiency. 10

2. a) With a neat sketch explain the basic parameters of a compressor cascade nomenclature. 10

b) Obtain an expression of lift-drag ratio in terms of compressor cascade angles. 8

c) Show that the maximum efficiency of a compressor cascade is obtained when the meanflow angle is 45°. 7

3. a) Deduce expressions for the ratio of stagnation and static temperatures, pressure and density in terms of Mach number of flow. 12

b) Obtain a functional relationship among the non-dimensional parameters which are essential in predicting the performance of a turbomachine handling a compressible flow. 13

PART 2

Answer any 2 (two) questions

4. a) Draw velocity triangles at entry and exit for the following stages for maximum utilization factor in case of turbine:

i. single stage impulse

ii. three-stage velocity-compounded impulse and

iii. fifty percent reaction stage

and show the relations between the value of maximum utilization factor and work for these cases in the absence of cascade losses. 10

b) The data for an axial turbine stage is given below:

air angle at nozzle exit = 75°

air angle at rotor entry = 45°

air angle at rotor exit = 76°

hub diameter = 450mm

tip diameter = 750mm

rotor speed = 6000 rpm

Assuming radial equilibrium and free vortex flow in the stage determine for the hub, mean and tip sections: i. the relative and absolute air angles, ii. Degree of reaction, iii. Blade-to-gas speed ratio, iv. Specific work and v. the loading co-efficient. 15

5.a) What is secondary flow in the compressor cascades? How does it lead to a loss in energy? How is it estimated? 10

b) A compressor cascade has the following data:
velocity of air at entry = 75m/s
air angle at entry = 48°
air angle at exit = 25°
pitch chord ratio = 1.1
stagnation pressure loss = 11 mm W.G.
density of air = 1.25kg/cum
Determine loss co-efficient, drag and lift co-efficient, ideal and actual pressure recovery co-efficient, diffuser efficiency and maximum diffuser efficiency. 15

6.a) A fan delivers $2m^3/s$ (at 10 mm W.G.) of air while running at 1470 rpm. Determine the discharge of a geometrically similar blower which runs at 360 rpm developing the same head. What is the specific speed of these fans? 10

b) What are the different variables involved in determining the performance of axial and centrifugal fans? Develop the dimensionless parameters that are used to describe the performance of these class of turbomachines. Show graphically typical performance curves for these machines. 15