Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 90070

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Fourth Semester

Aeronautical Engineering

AE 8404 — PROPULSION – I

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define optimum power split between propeller and jet in a turboprop.
2. What is the effect of compressor pressure ratio on thermal efficiency of a gas turbine
3. What is meant by thermal choking?
4. Why do majority of the jet aircraft are equipped with axi-symmetric nozzles?
5. Define equivalence ratio.
6. State the advantages of annular combustor.
7. What is the effect of axial velocity on work absorbing capacity of an axial compressor?
8. Define blade loading co-efficient.
9. What is the function of nozzle guide vanes?
10. Define enthalpy loss coefficients for the nozzle and rotor of an axial turbine.

PART B — (5 × 13 = 65 marks)

11. (a) A 4-cylinder two-stroke cycle petrol engine develops 30kW at 2500 rpm. The mean effective pressure on each piston is 8 bar and the mechanical efficiency is 80%. Calculate the diameter and stroke of each cylinder of stroke to bore ratio 1.5. Also calculate the fuel consumption of the engine, if brake thermal efficiency is 28%. The calorific value is 43900 kJ/kg.

Or

(b) Draw the T-s diagram and explain the processes of a turbojet engine employing an afterburner. Derive the expression for specific thrust produced by the engine.

12. (a) Explain in detail about the types of flow in an external compression intake and discuss about stall characteristics of a subsonic diffuser.

Or

(b) A C-D nozzle operates with a normal shock downstream of the throat. Derive an expression to calculate the shock Mach number in terms of nozzle inlet and exit total pressures.

13. (a) Explain about flame stability limits at different airspeeds and fuel-to-air ratios with necessary graphs.

Or

(b) Explain in detail the effect of operating variables on gas turbine combustion chamber performance.

14. (a) Derive the expression for degree of reaction of an axial compressor stage in terms of various velocities and air angles, with suitable assumptions.

Or

(b) A centrifugal compressor has a pressure ratio of 4:1 and an isentropic efficiency of 80%. It runs at 15000 rpm and induces air at 293K. The curved vanes present at the inlet give the air a pre-whirl of 25° to the axial direction at all radii. The impeller eye tip diameter is 250mm. The absolute velocity at inlet is 150m/s and the impeller diameter is 600mm. Determine the slip factor.

15. (a) A multi-stage axial turbine is to be designed with impulse stages and is to operate with an inlet pressure and temperature of 6 bar and 900K and an outlet pressure of 1 bar. The isentropic efficiency of the turbine is 85%. All the stages are to have a nozzle outlet angle of 75° and equal inlet and outlet rotor blade angles. Mean blade speed is 250 m/s. The axial velocity is 150 m/s and is constant across the turbine. Estimate the number of stages required.

Or

(b) A single stage turbine is running at 15000 rpm. The total head condition at the inlet are 4 bar and 1150K. The total head temperature drop in the turbine is 140°C. The mass flow rate is 900kg/min. The degree of reaction is 50%. Overall static head efficiency is 85%, nozzle efficiency is 96%, mean blade speed is 400m/s, exit velocity of gas from turbine is 300m/s Take C_p = 1 kJ/kgK and ratio of specific heats as 1.33 for the gas. Determine the following:

(i) Axial velocity of the gas (6)

(ii) Diameter ratio of the annulus in the space between the nozzle and blades (7)

PART C — (1 × 15 = 15 marks)

16. (a) An axial flow compressor is to be designed to generate a total pressure ratio of 4 with an overall isentropic efficiency of 0.85. The inlet and outlet blade angles of the rotor blades are 45° and 10° respectively. The compressor stage has a degree of reaction of 50%. The blade speed is 220 m/s and the work done factor is 0.86. The ambient air static temperature is 290 K and the air enters the compressor through guide vanes. Find the number of stages required and will there be any shock losses in the compressor?

Or

(b) An ideal turbofan with an exhausted fan operates at sea level at a Mach number of 0.75 The primary flow is 72 kg/s and the bypass ratio is 1.2. The compressor pressure ratio is 15, fan pressure ratio is 3. The fuel heating value is 42,000 kJ/kg and the burner exit total temperature is 1389 K. Find the thrust developed and the TSFC. Assume both the hot and cold nozzles expand the flow to ambient pressure and take ratio of specific heats as 1.4.

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