Ref. No.: Ex/ME/5/T/524I/2023

BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
FIFTH YEAR SECOND SEMESTER - 2023

Subject: GAS TURBINE THEORY

Time: 3 hours **Full Marks: 100**

(Answer any five questions)

Q.1 (a) With a neat sketch, explain the cycle for gas power plant incorporating ideal regeneration. Plot the cycle in T-s plane. Hence, find an expression for efficiency of the cycle. (2+1+5)

(b) A gas turbine unit has a pressure ratio of 6:1and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 0.80 and 0.82, respectively. Find net power output and efficiency of the unit when air enters the compressor at 15°C and at a rate of 16 kg/s. Assume any necessary data, if required. (12)

Q.2 (a) Explain variation of net work output for a gas power plant with its pressure ratio. (2)

(b) A gas turbine power plant operates at an optimum pressure ratio for maximum net work output. Derive an expression for net work output per kg of air and corresponding efficiency of the cycle in terms of maximum and minimum temperatures. (12)

(c) If the maximum and minimum temperatures are 800°C and 30°C, respectively; then compute the optimum value of pressure ratio, maximum net work output per kg of air and corresponding cycle efficiency. (6)

Q.3 (a) Explain possible incompressible flows through a nozzle (isentropic subsonic/supersonic /any other type), and formation of possible shocks (normal/oblique / any other type) with a neat sketch (using variation of pressure along axis of the nozzle). (4)

(b) In case of a steady 1-D compressible isentropic flow, derive the following expression

$$\frac{dA}{A} = \frac{dP}{\rho V^2}(1 - M^2)$$ (6+2)

All symbols carry usual meaning. Hence, find a shape (converging / diverging) for a nozzle delivers supersonic flow.

(c) An aircraft flies at a velocity of 520 km/hr at an altitude of 8000m where density of air is 0.525 kg/m^3. The diameter of the aircraft engine is 2.4m, and the ratio of flight velocity to jet velocity is 0.74. Calculate the rate of air flow through the engine, thrust produced, specific thrust and thrust power. (8)

Q.4 (a) Explain the working principle of a turbo-jet engine with neat sketch. State disadvantages of the turbo-jet engine. (6+2)

(b) A turbo-jet engine consumes air the rate of 60.2 kg/s when flying at a speed of 1000 km/hr. Calculate (i) exit velocity of the jet when enthalpy change for the nozzle is 230kJ/kg and velocity coefficient is 0.96, (ii) fuel flow rate in kg/s when air-fuel ratio is 70:1, (iii) thrust specific fuel (12)

consumption, (iv) thermal efficiency of the plant when the combustion efficiency is 92% and calorific values of the fuel used is 42000kJ/kg, (v) propulsive power, and (vi) propulsive efficiency.

Q.5 (a) Explain working principle of a turbo-prop engine with its neat sketch. State its basic differences from a turbo-jet engine. (6+2)

(b) A centrifugal compressor used as a supercharger for aero-engines handles 150kg/min of air. The suction pressure and temperature are 1 bar and 290K. The suction velocity is 80m/s. After compression in the impeller, the conditions are 1.5 bar, 345K and 220 m/s. Calculate (i) isentropic efficiency, (ii) power required to drive the compressor, (iii) overall efficiency of the unit. It may be assumed that K.E. of air gained in the impeller is entirely converted into pressure in the diffuser. (12)

Q.6 Write short notes (any four). (5×4=20)

(a) A simple gas turbine cycle and its efficiency
(b) Rocket engine
(c) Losses in an axial flow compressor
(d) Air conditioning in an aircraft
(e) Methods of increasing the gas cycle efficiency