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ME 1818 PE 24 9/6/23

Roll No. of candidate | | | | | | | | | | |

2023

B.Tech. 8th Semester End-Term Examination

Mechanical Engineering

COMPRESSORS AND GAS TURBINES

New Regulation (w.e.f 2017 – 18) & New Syllabus (w.e.f 2018 – 19)

Full Marks – 70 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer Question No.1 any four from the rest.

1. Answer the following MCQs : (10 × 1 = 10)

(i) The gas turbine was invented by

(a) John Barber (b) Brayon

(c) Otto (d) Atkinson

(ii) The performance of a simple gas turbine depends on

(a) efficiency of the compressor

(b) efficiency of the turbine

(c) efficiency of the compressor and turbine

(d) efficiency of heater or cooler

(iii) The energy transfer in a rotating machine is given by

(a) Steady flow energy equation

(b) Unsteady flow energy equation

(c) Euler's energy equation

(d) Gibb's energy equation

(iv) The efficiency of modern compressor is

(a) 70% (b) 75%

(c) 80% (d) 85%

(v) Adding heat exchanger to a simple ideal cycle

(a) Improves work output (b) Improves efficiency

(c) Reduces work output (d) Both (a) and (b)

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(vi) It is better to operate a centrifugal compressor with reference to mass flow rate

(a) close to the surge line

(b) left side of the surge line

(c) right side of the surge line

(d) both the left and right side of the surge line

(vii) In the axial flow compressor the absolute velocity in the rotor

(a) Increases

(b) Decreases

(c) Initially increases then decreases

(d) Remains constant

(viii) The combustion process in a combustor is

(a) Isobaric (b) Isochoric

(c) Isentropic (d) Isothermal

(ix) Air-fuel ratio in a gas turbine is in the range of

(a) 20 to 30 (b) 30 to 40

(c) 40 to 60 (d) 60 to 100

(x) Multi-stage reaction turbines are employed to achieve

(a) a large pressure drop (b) a large mass flow rate

(c) a large volume flow rate (d) a small pressure drop

2. (a) With a neat sketch explain the essential parts of a centrifugal compressor. (6)

(b) A centrifugal compressor compresses 30 kg air per second at a rotational speed of 15,000 rpm. The air enters the compressor axially and the conditions at the exit sections are: radius = 0.3 m, relative velocity of air at the tip = 100 m/s at angle of 80° with respect to plane of rotation. Take total head pressure at inlet, P_{t1} = 1 bar and total head temperature at inlet, T_{t1} = 300K. Find the torque and power required to drive the compressor and also the head-developed. (9)

3. Define the degree of reaction and explain its significance. For 50% reaction, prove that $\frac{U}{V_f} = (\tan\beta_1 + \tan\beta_2)$ where U = blade velocity, V_f =axial velocity and β_1 and β_2 are angles made by relative velocity at inlet and exit with axial direction.

(3 + 2 + 10 = 15)

4. (a) What are the basic requirement of a combustion chamber? (5)

(b) (i) What are the factors to be considered in the selection of gas turbine blades?

(ii) Explain the various materials that can be used for turbine blade (6 + 4 = 10)

5. A single stage gas turbine rotates at 9000 rpm. The total head temperature and pressures of the gas at the entry the nozzle are 750° C and 5 bar. The static pressure at the outlet from the nozzle is 2.5 bar. At the turbine outlet the static pressure is 1.5 bar. The gas leaves in an axial with Mach number 0.5. The nozzle angle is 70° and the friction loss is considered to be 3.7%of the isentropic temperature drop from total head at entry to static conditions at outlet nozzle pressure. Determine (a) the gas angle at entry and outlet from wheel showing them on velocity diagrams for mean blade section. (b) output shaft power of the turbine.

Assume mean blade diameter is 60cm, gas mass flow rate as 20 kg/s, turbine efficiency as 98%, $C_p = 1.14\,\text{kJ/kgK}$ and $\gamma = 1.33$. (15)

6. (a) Draw the schematic diagram of a simple gas turbine cycle and explain briefly the working of the cycle. (5)

(b) A gas turbine operates on a pressure ratio of 5. The inlet air temperature to the compressor is 300 K and the air entering the turbine is at a temperature of 577° C. If the volume rate of air entering the compressor is 240 m^3/s. Calculate the efficiency and net power output of the cycle operates under ideal conditions. (10)

7. (a) Explain the principle of jet propulsion and mention how the jet propulsion engines are classified. (5 + 3 = 8)

(b) With the aid of a neat diagram, explain the working principle of a ramjet engine. (7)