Reg. No. :

Question Paper Code : 50025

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Fourth Semester

Aeronautical Engineering

AE6404 – PROPULSION – I

(Regulations 2013)

Time : Three Hours　　　　Maximum : 100 Marks

Answer ALL questions

(Gas tables permitted)

PART – A　　　　(10×2=20 Marks)

1. What are the factors which affects the thrust production in a gas turbine engines ?
2. Classify the turboprop engine.
3. Consider an isentropic fixed-geometry C – D inlet, which is designed for $M_D = 2$. Calculate the over speed Mach number that will start this inlet.
4. Mention some of the limitations of aircraft nozzle design.
5. Define slip factor and slip velocity for centrifugal compressor.
6. Sketch the T-S diagram for fifty percent degree of reaction in axial flow compressor.
7. State the conditions which should be satisfy for the free vortex design of turbine blades.
8. What are the non-dimensional parameters helps to design gas turbine blades ?
9. Sketch the T-S diagram of ideal and real ramjet cycle operations.
10. What are the various modes of inlet operations in ramjet engine ?

PART – B　　　　(5×13=65 Marks)

11. a) i) Discuss the important observations made from the specific work output and thermal efficiency variation when the simple gas turbine combines with following combinations.

a) Heat exchanger

b) Reheater

c) Intercooler　　　　(6)

ii) A turbofan engine has the following characteristics : Flight Mach number 0.8, Altitude 10 km, Ambient temperature 223.2 K, Ambient pressure 26.4 KPa, Fuel heating value 42,800 kJ/kg, Thrust force 24 kN, Air mass flow rate 125 kg/s, Fuel mass flow rate 0.75 kg/s, Bypass ratio 5, Aircraft gross weight (65,000 ft) 156 kN, Aircraft takeoff weight 173.3. Assume that the optimum expansion in both the nozzle and the thrust generated from the fan is 75 % of the total thrust. Calculate :

a) The specific thrust
b) TSFC
c) The exit velocity of the cold air and hot gases
d) The thermal efficiency
e) The propulsive efficiency
f) The overall efficiency. (7)

(OR)

b) Using control surface approach obtain the expression for the thrust equation of a turbojet engine. (13)

12. a) Explain successive steps in the acceleration and over speeding of a one dimensional supersonic inlet with sketches. (13)

(OR)

b) i) An aero engine is using octane $C_{12}H_{24}$ as a fuel. The temperature of the working fluid at the inlet and outlet of combustion chamber are T_{01} = 650 K and T_{02} = 1600 K. The fuel heating value is Q_{HV} = 42,800 kJ/kg. The specific heats of cold and hot streams are C_{pc} = 1.005 kJ (kg . K) and C_{ph} = 1.23 kJ/(kg . K). Calculate the equivalence ratio. (7)

ii) A converging-diverging nozzle with an area ratio of 3.0 exhausts into a receiver where the pressure is 1 bar. The nozzle is supplied by air at 22°C from a large chamber. At what pressure should the air in the chamber be for the nozzle to operate at its design condition ? What will the outlet velocity be ? What pressure should the air in the chamber be for first and second critical point ? (6)

13. a) A centrifugal compressor running at 9000 rpm. Delivers 6000 m^3/min of free air. The air is compressed from 1 bar and 20°C to a pressure ratio of 4 with an isentropic efficiency of 82 %. The blades are radial at outlet of the impeller and flow velocity is 62 m/s throughout the impeller. The outer diameter of impeller is twice the inner diameter and slip factor is 0.9. Find :

a) Final temperature of air.
b) Theoretical power.
c) Impeller diameter at inlet and outlet.
d) Breadth of impeller at inlet.
e) Blade angles at inlet and outlet. (13)

(OR)

b) The condition of air at the entry of an axial compressor stage are $P_1 = 1.024$ bar and $T_1 = 314$ k. The air angle are $\beta_1 = 51°$, $\beta_2 = 9°$, $\alpha_1 = \alpha_3 = 7°$ respectively. The mean diameter and peripheral speed are 50 cm and 100 m/s respectively. Mass flow rate through stage is 25 kg/s. Work done factor is 0.95 and mechanical efficiency is 92 %. Assume force vortex flow. Determine :

a) Rotor blade air angles.
b) The specific work.
c) The flow co-efficient.
d) Degree of reaction.
e) The loading co-efficient. **(13)**

14. a) In a single-stage gas turbine, gas enters and leaves in axial direction. The nozzle efflux angle is 68°, the stagnation temperature and stagnation pressure at stage inlet are 800°C and 4 bar, respectively. The exhaust static pressure is 1 bar, total-to-static efficiency is 0.85 and mean blade speed is 480 m/s, Determine :

a) The work done,
b) The axial velocity which is constant through the stage,
c) The total-to-total efficiency and
d) The degree of reaction.

Assume $\gamma = 1.33$ and $C_{pg} = 1.147$ kJ/kgK. **(13)**

(OR)

b) i) Mention the classification of gas turbine cooling methods. Explain any two them with neat sketches. **(7)**

ii) Mention the losses which are associated to define the overall blade loss co-efficient. Explain them. **(6)**

15. a) A ramjet is travelling at Mach 3 at an altitude of 4572 m, the external static temperature is 258.4 K, and the external static pressure is 57.1 KPa. The heating value of the fuel is 46,520 kJ/kg. Air flows through the engine at 45.35 kg/s. The burner exit total temperature is 1944 K. Find the thrust, fuel ratio, and TSFC. The specific heat ratio can be assumed to be 1.40. **(13)**

(OR)

b) A ramjet is being flown at a velocity of 2000 ft/s (610 m/s) and is burning a hydrocarbon fuel with a heating value of 44,200 kJ/kg. The uninstalled specific thrust F/m is 736 N.s/kg and the specific fuel consumption S is 62.3 g/kN.s. Determine the following engine performance.

a) Thrust
b) Specific impulse
c) Overall efficiency
d) Propulsive efficiency
e) Thermal efficiency. **(13)**

PART – C (1×15=15 Marks)

16. a) A single-spool turbojet engine has the following data :

Compressor pressure ratio	8
Turbine inlet temperature	1200 K
Air mass flow rate	15 kg/s
Aircraft flight speed	260 m/s
Flight altitude	7000 m
Isentropic efficiency of intake	0.9
Isentropic efficiency of compressor	0.9
Isentropic efficiency of turbine	0.9
Combustion chamber pressure loss	6% of delivery pressure
Combustion chamber efficiency	0.95
Isentropic efficiency of propelling nozzle	0.9
Fuel heating valve	43000 kJ/kg

Calculate the propelling nozzle area, the thrust developed, and the TSFC. Assume at an altitude of 7000 m $T_a = 242.7$ K, $P_a = 41.06$ KPa.

(OR)

b) A two-ramp external compression inlet in a supersonic flow is shown in Fig. 16 (b). Calculate the total pressure recovery of this inlet assuming the best back pressure has placed the normal shock on the lip. Also compare this inlet to a Normal Shock-inlet at Mach 2.0.

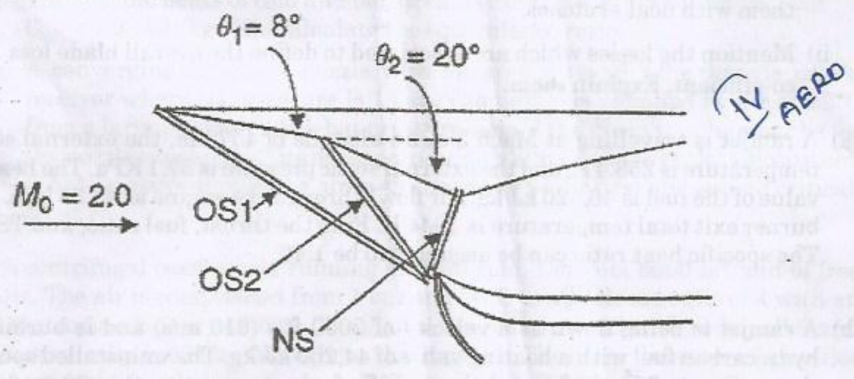

Figure 16 (b)