Registration no: | | | | | | | | | | |

Total Number of Pages: 03 **M.TECH**
HTPE207

2nd Semester M.Tech Regular/Back Examination – 2014-15
SUBJECT NAME : GAS TURBINE AND JET PROPULSION
BRANCH(S): Thermal Engg. / Heat Power Engg.
Time: 3 Hours
Max marks: 70
Q.CODE:T432

Answer Question No.1 which is compulsory and any five from the rest.
The figures in the right hand margin indicate marks.

Q1 Answer the following questions: (2 x 10)

a) What is the name of testing required to provide experimental data on compressible effects. And also mention the significance of critical Mach number and maximum Mach number.

b) Can we apply isentropic relation in Normal shock? Justify your answer.

c) What is the function of auxiliary power unit (APU) in civil aircrafts?

d) What do you mean by prewhirl and how is it important for impeller?

e) What do you mean by rotational speed Mach number and flow Mach number?

f) Write two basic important requirements for blade design in an axial compressor.

g) Define De-Haller number. Why it is important for axial compressors.

h) What is combustion intensity and How it plays important role in combustion chamber performance

i) What are major difference between the land-based gas turbines and the gas turbines used for aircraft applications.

j) What is optimum pitch cord ratio

Q2 a) Air is expanded from a large reservoir in which the pressure and temperature are 500KPa and 35^{o}C through a variable area duct. A normal shock occurs at a point in the duct where the Mach number is 2.5. Find the pressure and temperature in the flow just downstream of the shock wave. Downstream of the shock wave, the flow is brought to rest in another large reservoir. Find the pressure and temperature in the reservoir. Assume that the flow is 1D and isentropic everywhere except through the shock wave (5)

b) Derive Rankine-Hugoniot equations for flow through a normal shock. How does a normal shock differ from an oblique shock? Mention two useful applications of a normal shock (5)

Q3 For Reheat joule cycle, Derive (10)

$$\frac{W_{net}}{C_p T_1} = 2\tau - \mathcal{R} + 1 - \frac{2\tau}{\sqrt{\mathcal{R}}}$$

$$\eta = \frac{2\tau - \mathcal{R} + 1 - \frac{2\tau}{\sqrt{\mathcal{R}}}}{2\tau - \mathcal{R} - \frac{\tau}{\sqrt{\mathcal{R}}}}$$

Where $\tau = \frac{T_{max}}{T_{min}}$, $\mathcal{R} = r_p^{\frac{\gamma-1}{\gamma}}$, r_p=overall pressure ratio

Q4 a) Usually, the thermal efficiency of ideal gas turbine cycle is given by $\eta_{th} = 1 - \frac{1}{r_p^{\gamma-1/\gamma}}$. The turbine ($\eta_t$) and compressor ($\eta_c$) efficiencies are introduced into the above efficiency. The compressor and turbine entry temperatures are T_1 and T_3, respectively. Taking account of the above component losses, Show that the modified thermal efficiency is (5)

$$\eta_{th} = \frac{\frac{T_3}{T_1}\left(1 - \frac{1}{R}\right)\eta_t - \frac{R-1}{\eta_c}}{\frac{T_3}{T_1}\frac{R-1}{\eta_c} - 1}.$$

b) Show the value of optimum pressure ratio is $r_{p,opt}^{\frac{\gamma-1}{\gamma}} = \frac{-B + \sqrt{B^2 + 4AC}}{2A}$, (5)

where $A = \frac{1}{\eta_c} - \frac{T_1}{T_3}\frac{1}{\eta_c} - \frac{\eta_t}{\eta_c}$, $B = 2\frac{\eta_t}{\eta_c}$, and $C = \frac{T_3}{T_1}\eta_t - \eta_t + \frac{\eta_t}{\eta_c}$.

Q5 a) Determination of the specific thrust and specific fuel consumption (SFC) for a simple turbojet engine, having the following component performance at the design point at which the cruise speed and altitude are M=0.7 and 12000m. (7)

Compressor pressure ratio=8, turbine inlet temperature=1500K, Isentropic efficiency of

Compressor η_C=0.85, Turbine η_T=0.9, intake η_i=0.93, propelling nozzle η_j=0.95

Mechanical transmission efficiency η_m=0.99, combustion efficiency η_B=0.98, combustion pressure loss=4% comp. delivery Pressure

b) Difference between Turbojet engine and Turbofan engine (3)

Q6 Define degree of reaction (Λ). Prove that for an axial flow compressor the degree of reaction is $\Lambda = \frac{C_a}{2U}(\tan\beta_1 + \tan\beta_2)$. The symbols have the usual meaning. (10)

Q7 a) For designing single sided centrifugal compressor, you may use following data (7)

Power input factor =1.05, slip factor=0.8, rotational speed=290 rps, overall diameter of impeller=0.5m, eye tip diameter=0.4m, eye root diameter=0.15m, air mass flow=9kg/s, inlet stagnation temperature=295K, inlet stagnation pressure=1.1bar, Isentropic efficiency=0.78. Find

i. The power to drive the compressor and its Pressure ratio. Assume velocity of air at inlet is axial

ii. Inlet angle of the impeller vanes at the root and tip radii of the eye
iii. Axial depth of the impeller channel at the periphery of the impeller

b) What is rotating stall and write it’s contribution to surge (3)

Q8 Write Short Notes (Any Two) (5 x 2)

a) Single shaft Vs twin shaft engines
b) Procedure for turbine and compressor matching in turbojet engine.
c) The cooled Turbine
d) Parameter responsible for combustion chamber performance