Registration no:

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

2nd Semester Regular/BackExamination – 2015-16
GAS TURBINE AND JET PROPULSION
Q Code : W936
Time: 3 Hours
Max marks: 70

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) Define Engine Pressure Ratio (EPR) and Ram Pressure Ratio (RPR)

b) Why is the gas turbine cycle called a mechanical cycle.

c) Write the simple thrust equation for propelling a gas turbine?

d) Why a slip factor is introduced to nearly make the whirl velocity at impeller tip equal to the tip speed in a centrifugal compressor.

e) Write down three main advantages of axial flow compressors over the centrifugal compressors.

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) Define combustion efficiency.

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

j) Draw a free hand graph to show the variation of pressure ratio with efficiency for an ideal gas turbine cycle taking different specific heats of air, such as $\gamma = 1.4$ and 1.66, respectively.

Q2 a) A gas which has a molecular mass of 39.9 and specific heat ratio of 1.67 is discharged through a nozzle. A normal shock wave occurs at section of the flow at which the Mach number is 2.5, the pressure is 40 kPa and temperature is -20^{o}C. Find Mach number down steam of the normal shock. (5)

b) For the above case, find the pressure and temperature downstream of normal shock (5)

Q3 In a gas turbine plant, air is compressed from state (p_1, T_1) to a pressure $r_p p_1$ and then heated to T_3. The air is then expanded in two stages with reheat to T_3 between the turbines. The isentropic efficiencies of compressor and each turbine are η_c, and η_t. If xp_1 is the intermediate pressure between the turbines, show that, for given values of $p_1, T_1, T_3, \eta_c, \eta_t$ and r_p, the specific work output is (10) a maximum when $x = \sqrt{r_p}$.

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 (η_t) and compressor (η_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

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

(5)

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

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

(5)

Q5 a) An auxiliary turbine for use on a large airliner uses a single shaft configuration with air bled from compressor discharge for aircraft services. The unit must provide 1.5 kg/s bleed air and a shaft power of 200 kW. Calculate the total compressor air mass flow rate. (5)

b) Calculatethe power available with no bleed flow, assuming the following: (5)

Compressor pressure ratio	3.8
Compressor isentropic efficiency	0.85
Turbine inlet temperature	1050 K
Combustion pressure loss	0.12 bar
Turbine isentropic efficiency	0.88
Mechanical efficiency (compressor rotor)	0.99
Mechanical efficiency (driven load)	0.98
Ambient condition	1 bar, 288 K

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

Q7 a) A centrifugal compressor compresses 30 kg of air per second at a rotational speed of 15,000 rpm. The air enters the compressor axially, and the conditions at exit sections are radius=0.3 m, relative velocity of air at tip =100 m/s at the exit angle of 80^o. Find the torque required to drive the compressor. (5)

b) Find thepower required to drive the compressor and ideal head developed. (5)

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

a) Turboprop and turbo shaft engines
b) Procedure for turbine and compressor matching in turbojet engine. Your answer should be precise and step by step procedure.
c) Operating characteristics for centrifugal compressor

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