

Code: 9A03805

B. Tech IV Year II Semester (R09) Regular Examinations, March/April 2013

GAS TURBINES & JET PROPULSION

(Mechanical Engineering)

Time: 3 hours

Max. Marks: 70

Answer any FIVE questions

All questions carry equal marks

- 1 (a) Derive the expression for specific work output and the efficiency of a simple cycle. Draw their trends as a function of pressure ratio.
- (b) In a gas turbine the pressure ratio to which air at 15°C is compressed is 6. The same air is then heated to a maximum permissible temperature of 750°C . First in a heat exchanger and then combustion chamber. It is then expanded in two stages such that the expansion work is maximum. The air is heated to 750°C after the first stage. Determine the cycle thermal efficiency, the work ratio and net shaft work per Kg of air.
- 2 (a) What are the various assumptions made in practical cycle analysis?
- (b) In a gas turbine the compressor taken in air at a temperature of 27°C and compresses it to five times the initial pressure with an isentropic efficiency of 85%. The air is then passed through a regenerator heated by the turbine exhaust before reaching the combustion chamber. The effectiveness of the regenerator is 80%. The maximum temperature after constant pressure combustion is 677°C and the efficiency of the turbine is 80%. Neglecting all losses except mentioned and assuming the working fluid throughout the cycle to have the characteristics of air,
 - (i) Sketch the cycle on the T-S diagram
 - (ii) Calculate the efficiency of the cycle
- 3 (a) What is meant by jet propulsion? What are the basic differences between jet propulsion cycle and shaft power cycle?
- (b) Explain the principle of jet propulsion and mention how the jet propulsion engines are classified.
- 4 (a) With the aid of the schematic diagram and thermodynamic cycle, explain the working of a turbo prop engine.
- (b) Mention the various advantages and disadvantages of a turbo prop engine and also bring out the applications.
- 5 (a) With the aid of a neat diagram, explain the working principle of a ramjet engine.
- (b) What are the advantages and disadvantages of a ramjet engine and what are its applications?
- 6 (a) How rockets are classified? What is the stage of development of each type?
- (b) Briefly describe the two types of solid propellant rockets.
- 7 (a) Explain the different types of injectors used in rocket technology.
- (b) What are applications of rocket technology?
- 8 Write a short notes on:
 - (a) Plasma arc propulsion
 - (b) Advanced propulsion systems
 - (c) Testing and instrumentation

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- 1 (a) Draw the schematic diagram of a simple cycle and explain briefly the working of the cycle. Draw the P-V and T-S diagrams of the cycle.
(b) A gas turbine plant operates between 5°C and 839°C .
Find :
 - (i) Pressure ratio at which cycle efficiency equals Carnot cycle efficiency
 - (ii) Pressure ratio at which maximum work is obtained
 - (iii) Efficiency under conditions giving maximum work
- 2 For a gas turbine operating at a pressure ratio of 8.7 the maximum temperature ratio to be maintained such that the turbine just supports the compressor, which is given by $t_{\min} = 3.0$. If the compressor inlet total temperature and the turbine efficiency are respectively 300 K and 0.75.
Find :
 - (i) The compressor efficiency
 - (ii) The temperature ratio at which the compressor work is 80% of the power produced by turbine. Also find the corresponding heat addition and network output per unit mass flow in the gas turbine. Take $C_{P_a} = 1.147 \text{ KJ/Kg K}$.
- 3 (a) Explain the need for thermal jet engines and applications.
(b) Explain the classification of energy flow.
- 4 (a) With a neat sketch and T-S diagram, explain the working of turbo jet engine and also derive the expression for thrust developed.
(b) Explain with suitable graphs the performance of a turbo jet engine. What are the advantages and disadvantages of turbojet engine?
- 5 (a) Draw the thermodynamic cycle of the ramjet and derive the equation for thrust.
(b) Mention the various advantages and disadvantages of the pulse jet engine.
- 6 (a) What are the desirable requirements of a liquid propellant for rockets?
(b) Compare the advantages and disadvantages of solid and liquid propellants.
- 7 (a) What do you understand by staging of rockets?
(b) What is a need for feed systems in rocket technology?
- 8 (a) What is a need for cryogenics?
(b) What are the applications of cryogenics?

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- 1 (a) Explain the important observations from the specific work output and efficiency variation as a function of pressure ratio for the simple cycle with reheat and heat exchange.
(b) A gas turbine unit operates at a mass flow of 30 Kg/s. Air enters the compressor at a pressure of 1 bar and temperature 15°C and is discharged from the compressor at a pressure of 10.5 bars. Combustion occurs at constant pressure and results in a temperature rise of 420 K. If the flow leaves the turbine at a pressure of 1.2 bars, determine the net power output from the unit and also the thermal efficiency. Take $C_p = 1.005 \text{ KJ/Kg K}$ and $\gamma = 1.4$.
- 2 The following data refer to a closed cycle gas turbine plant using helium as working fluid and incorporating two stage compression with inter-cooling and two stage expansion with reheating; temperature at entry to each compression stage is 270°C . Pressure at entry to first compression stage and exit from the second turbine stage is 1bar; first compression stage pressure ratio is 6, each compressor stage isentropic efficiency is 0.85; temperature at inlet to each expansion stage is 1150°C ; isentropic efficiency of each expansion stage is 0.9; reheat pressure is 6 bar; for helium polytropic index n is 1.24 and R is 10.05 KJ/Kg K. Calculate the cycle thermal efficiency.
- 3 (a) Derive the expression for thrust, thrust power and propulsion efficiency of jet propulsion engine.
(b) Explain historical sketch of jet propulsion engine.
- 4 (a) What is meant by thrust augmentation and explain how it is affected?
(b) Explain the principle of after burner in thrust augmentation.
- 5 (a) With the aid of a schematic diagram, explain the working principle of pulse jet engine and also draw the ideal and actual P-V diagram.
(b) Explain the plant layout of ramjet engine.
- 6 (a) Draw a schematic diagram of a solid propellant rocket and explain its working.
(b) What are the applications of this type of rocket?
- 7 (a) Explain different types expansion nozzles used in rocket technology.
(b) What are the advantages and disadvantages of rocket technology?
- 8 (a) What do you understand by elementary treatment of electrical nuclear?
(b) What are the advantages and disadvantages of plasma arc propulsion?

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- 1 (a) Draw the schematic diagram of a simple cycle with intercooler and explain briefly the working principle. Draw also the P-V and T-S diagrams of the cycle.
(b) In a gas turbine plant, air enters the compressor at 1 bar and 27°C . The pressure ratio is 6. The temperature at turbine inlet is 1000 K. The mass flow rate of air is 10 Kg/s. Determine:
 - (i) Power required to drive the compressor and the turbine power output
 - (ii) The ratio of the turbine to compressor work
 - (iii) The net power developed by the plant and
 - (iv) The thermal efficiency
- 2 In the gas turbine plant shown, each compressor operates on a pressure ratio of 3 and an isentropic efficiency of 82%. After the low pressure compressor, sum of the air is extracted and passed to a combustion chamber from which the products leave at a temperature of 650°C and expand in power turbine. The remainder of the air passes through the high pressure compressor and into a combustion chamber from which it leaves at a temperature of 540°C and expands in a turbine which drives both the compressors. The isentropic efficiency of each turbine is 87%. If the temperature of the air at inlet to the low pressure compressor is 15°C . Determine the percentage of total air intake that passes to the power turbine and the thermal efficiency of the plant. For compression assume $C_p = 1.005 \text{ KJ/Kg K}$ and $\gamma = 1.4$
For heating and expansion $C_p = 1.147 \text{ KJ/Kg K}$ and $\gamma = 1.33$
- 3 (a) What are the essential features of propulsion devices?
(b) What do you understand by thermal jet engines?
- 4 (a) Explain the working of a turbo jet engine.
(b) What are the advantages and disadvantages of a turbo prop engine and also list out the applications.
- 5 (a) What are the basic characteristics of the ram jet engine?
(b) Explain the working principle of a serqu jet with a neat sketch.
- 6 (a) What is the basic difference between rocket propulsion and jet propulsion? Can rockets work in vacuum?
(b) Explain the basic principle of operation in rocket engines.
- 7 (a) What do you understand by flight mechanics?
(b) Write a short notes on rocket transfer and ablative cooling.
- 8 (a) What is testing and instrumentation? And explain the significance of testing and instrumentation.
(b) What are the applications of plasma arc propulsion?
