KINGS
COLLEGE OF ENGINEERING

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DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

SUBJECT CODE & NAME : ME 1209 – THERMAL ENGINEERING

YEAR / SEM : II / III

UNIT – I

THERMODYNAMICS

PART – A

01. What is thermodynamic system? (2)
02. Define surrounding and universe. (2)
03. What is an isolated system? (2)
04. Distinguish between intensive properties and extensive properties. (2)
05. Differentiate between Heat and Work. (2)
06. Indicate the relation between the specific heats Cp and Cv. (2)
07. What is internal energy? (2)
08. What is enthalpy? (2)
09. State the Zeroth law of thermodynamics. (2)
10. State the First law of thermodynamics. (2)
11. State the second law of thermodynamics – Kelvin Plank statement. (2)
12. State the second law of thermodynamics – Rudolf Clausius statement (2)
13. What is defined as the Perpetual motion machine of first kind? (2)
14. What is defined as the Perpetual motion machine of second kind? (2)
15. Differentiate between Heat pump and Refrigerator. (2)
16. What is meant by entropy of a gas? (2)
17. Define Clausius inequality. (2)

PART – B

1. The following data refer to a closed system, which undergoes a thermodynamic cycle consisting of four processes. (16)

Process	Heat transfer kJ/min	Work transfer kJ/min
a - b	50,000	-----
b – c	-5,000	34,200
c – d	-16,000	-2,200
d – a	----	-3,000

Show that the data is consistent with the first law of Thermodynamics and calculate: a) Net rate of Work output in MW, b) Efficiency of the cycle

2. 15kg of air in a piston cylinder device is heated from 25°C to 90°C by passing current through a resistance heater inside the cylinder. The pressure inside the cylinder is held constant at 300kPa during the process and a heat loss of 60kJ occurs. Determine the electrical energy supplied in kW-hr and change in internal energy. (16)
3. A certain gas of volume 0.4m^3, pressure 4.5 bar and temperature of 130°C is heated in a cylinder to 9 bar when the volume remains constant. Calculate a) temperature at the end of the process, b) the heat transfer, c) Change in internal energy, d) Work done by the gas, e) Change in enthalpy, e) mass of the gas. Assume Cp = 1.005kJ/kgK and Cv = 0.71 kJ/kgK. (16)
4. i) What is a thermodynamic system? Explain the classification of thermodynamic system with suitable examples. (8)
   ii) Establish the inequality of Clausius. (8)
5. A gas of mass 0.35 kg pressure 1535 kN/m² and temperature of 335°C is expanded adiabatically to a pressure of 126 kN/m². The gas is then heated at constant volume until it reaches 335°C, when its pressure is found to be 275kN/m². Finally the gas is compressed isothermally until its original pressure of 1535kN/m² obtained. Draw the p-V diagram and find out the following a) the value of adiabatic index b) change in internal energy during the adiabatic process, and c) heat transfer during constant volume process. Take Cp = 1.005 kJ/kgK. (16)
6. A cylinder contains 1 m^3 of gas at 100 kPa and 100°C, the gas is polytropically compressed to a volume of 0.25 m^3. The final pressure is 100 kPa. Determine a) mass of the gas, b) the value of index 'n' for compression, c) change in internal energy of the gas d) heat transferred by the gas during compression. Assume R = 0.287 kJ/kgK and γ = 1.4. (16)
7. An ideal gas of molecular weight 30 and specific heat ratio 1.4 is compressed according to the law $pV^{1.25} = C$ from 1 bar absolute and 27°C to a pressure of 16 bar. Calculate the temperature at the end of compression, the heat received or rejected, work done on the gas during the process and change in enthalpy. Assume mass of the gas as 1kg. (16)
8. 50 kg/min of air enters the control volume in a steady flow system at 2 bar and 100°C and at an elevation of 100m above the datum. The same mass leaves the control volume at 150m elevation with a pressure of 10 bar and temperature of 300°C. The entrance velocity is 2400m/min and the exit velocity is 1200m/min. During the process, 50,000kJ/hr of heat is transferred to the control volume and the rise in enthalpy is 8 kJ/kg. Calculate the power developed. (16)
9. A turbine operates under steady flow conditions receiving steam at the following state: Pressure = 1.2MPa, temperature = 188°C, enthalpy = 2785 kJ/kg, velocity =

33.3m/s and elevation = 3m. The steam leaves the turbine at the following state: Pressure = 20 kPa, enthalpy = 2512 kJ/kg, velocity = 100m/s and elevation = 0m. Heat loss to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW? (16)

10. 12Kg of a fluid per minute goes through a reversible steady flow process. The properties of fluid at the inlet are Pressure = 1.4bar; Density = 25Kg/m^3; Velocity = 120m/sec; Internal energy = 920KJ/Kg and at exit section are Pressure = 5.6bar; Density = 5Kg/m^3; Velocity = 180 m/sec; Internal energy = 720 KJ/Kg. During the process the fluid rejects 60KJ/sec and raises through 60m, Determine i) Change in enthalpy ii) Work done during the process. (16)

11. Derive an expression for work transfer and heat transfer for an polytropic process. (16)
12. i) Give the steady flow energy equation and explain the various terms. (8)
    ii) Explain carnot cycle with a neat sketch and a p-V diagram. (8)
13. Apply the first law of thermodynamics to steam nozzle, turbine, compressor and boiler and obtain the final expression. (16)
14. Define the terms thermodynamic equilibrium, properties, cycle, heat transfer, enthalpy and work done. (16)

UNIT – II

STEAM GENERATION

PART – A

1. Indicate the steps involved in formation of steam in a boiler. (2)
2. What is meant by dryness fraction? (2)
3. What is called total heat of water or sensible heat of water? (2)
4. What is meant by latent heat of steam? (2)
5. What is meant by internal energy of steam (2)
6. What is meant by throttling expansion of steam? (2)
7. What are the process involved in Rankine cycle? (2)
8. Name the few boiler mountings? (2)
9. Why compounding is necessary in simple impulse turbines? (2)
10. What is meant by governing of steam turbines? (2)
11. What are the different methods of compounding? (2)
12. Differentiate between wet steam and super heated steam. (2)
13. Why there is condenser in a power plant? (2)
14. What is pressure compounding? (2)
15. Name any two boiler accessories and state their functions? (2)
16. Mention any two advantages of Modern High Pressure Boilers. (2)

PART – B

1. Draw the T-s diagram and schematic of rankine cycle and explain the various processes. (16)
2. Mention the principle of operation of an impulse and a reaction turbine. (16)
3. Dry saturated steam at 10bar expands in a turbine to 0.1bar. Calculate ideal cycle efficiency. (16)
4. i) Find the saturation temperature, the changes in specific volume and entropy during evaporation and the latent heat of vaporization of steam at 1 MPa. (8)
   ii) Mention the function of various types Condensers and Cooling towers. (8)
5. Identify the type of steam in following three cases, i) 2kg of steam at 8bar with enthalpy 5535kJ at 170.4°C. ii) 1kg of steam at 2550kPa occupies a volume of 0.2742 m^3. Also find steam temperature. iii) 1kg of steam at 60bar with enthalpy of 2470.73kJ/kg. (16)
6. 2kg of steam is at 8bar pressure and 0.8 dry. Determine its enthalpy, volume, external work of evaporation, internal energy and entropy. (16)
7. Steam at 20bar and 360°C expands in a steam turbine to 0.08 bar. It is then condensed in a condenser to saturated water. The pump feedback the water to boiler. Assume ideal Rankine cycle and determine: i) Net work done/kg of steam ii) Rankine efficiency. (16)
8. A steam boiler generates steam at 30bar, 300°C at the rate of 2 kg/s. This steam is expanded isentropically in a turbine to a condenser pressure of 0.05 bar, condensed at constant pressure and pumped back to boiler. i) Draw the schematic arrangement of the above plant and T-s diagram of Rankine cycle ii) Estimate the rankine efficiency with pump work and without pump work. (16)

UNIT – III

AIR COMPRESSORS

PART – A

1. What is a single acting compressor and a double acting compressor? (2)
2. Define isothermal efficiency of a compressor. (2)
3. Indicate the methods by which work of compression can be reduced. (2)
4. Why multistage compression with inter-cooling used? (2)
5. What is perfect inter-cooling? (2)
6. What are the advantages of multistage compression? (2)
7. What is the difference between perfect inter-cooling and imperfect inter-cooling? (2)
8. Give two merits of rotary compressors over reciprocating compressors. (2)
9. What is meant by free air delivered? (2)
10. Differentiate between Isothermal efficiency and Isentropic efficiency. (2)
11. Define Clearance ratio. (2)
12. Mention the important applications of compressed air. (2)

PART –B

1. i) Explain the construction and working principle of centrifugal compressors. (8)
   ii) A multistage air compressor is to be designed to elevate the pressure from 1bar to 100bar such that the stage pressure ratio will not exceed 4. Determine the number of stages, exact stage pressure ratio and intermediate pressures. (8)
2. i) With neat sketches explain the principle of operation of centrifugal and axial flow compressors. (16)
3. i) Differentiate between centrifugal compressor and axial flow compressor. (8)
   ii) Compare reciprocating and rotary air compressors. (8)
4. A single cylinder single acting reciprocating compressor has a piston displacement of $0.01m^3$ at 100rpm. The suction pressure and temperatures are 1bar and 27°C respectively and the delivery pressure is 8bar. Calculate: i) temperature at the end of compression ii) the work required to compress the air in both adiabatic and polytrophic compression, take n= 1.2 for polytrophic index iii) The isothermal efficiency of compressor in both the cases. Assume R= 0.287KJ/kgK. Neglect clearance. (16)

5. The free air delivery of a single cylinder single stage reciprocating air compressor is 2.5 m^3/min. The ambient air is at STP conditions and delivery pressure is 7bar. The clearance volume is 5% of the stroke volume and the law of compression is $pV^{1.25}$ = C. If L = 1.2D and the compressor runs at 150rpm, determine the size of the cylinder and work required to compress the air. (16)
6. A two stage single acting air compressor takes in air at 1bar, 300K. Air is discharged at 10bar. The intermediate pressure is ideal and inter-cooling is perfect. The index of compression is 1.3 in both the stages. If the mass flow rate is 0.1 kg/s through the compressor, determine i) Power required to drive the compressor, ii) Saving in power required as compared with single stage compression for same pressure limit, iii) Heat rejected in the inter-cooler. (16)
7. A single cylinder single acting reciprocating compressor has a piston diameter of 250mm and a stroke of 350mm and runs at 400rpm. Air is drawn at 1bar pressure and is delivered at 7bar pressure. The law of compression is $pV^{1.3}$=constant and clearance volume is 5 percent of stroke volume. Determine the mean effective pressure and the power required to drive the compressor. (16)
8. i) Prove that the intercooler pressure is the Geometric mean of the initial and final pressure? (16)
9. ii) Derive an expression for volumetric efficiency. (16)
10. Derive an expression for workdone in single stage compressor with and without clearance volume. (16)
11. Explain the working of a Multistage air compressor with inter-cooling. State its advantages? (16)

UNIT – IV

IC ENGINES

PART – A

1. Define thermal efficiency of an cycle. (2)
2. What is an air standard cycle? (2)
3. What is mean effective pressure of an engine? (2)
4. What are the processes involved in Dual cycle? (2)
5. Define clearance volume, cylinder volume and stroke volume. (2)
6. Define top dead centre and bottom dead centre. (2)
7. Differentiate between compression ratio and cut off ratio in an diesel cycle (2)
8. Define the terms: i) Cut off ratio ii) Expansion ratio (2)
9. What do you mean by compression ratio of an engine? (2)
10. State any two assumptions made for air standard cycle analysis? (2)
11. Write any two major differences between Otto and Diesel cycle. (2)
12. What is the difference between two stroke engine and four stroke engine? (2)
13. What is meant by cycle efficiency and work ratio in gas turbine power plant? (2)
14. Indicate the difference between a open cycle and a closed cycle gas turbine. (2)
15. Why gas turbine is provided with an intercooler? (2)
16. What is meant by a gas turbine with reheating arrangement? (2)
17. What is turbine isentropic efficiency? (2)
18. State any two applications of gas turbine cycle. (2)

PART – B

1. An air standard engine working on Otto cycle has a volume of 0.5 m^3, pressure 1bar and temperature 27°C at the commencement of compression stroke. At the end of compression stroke, the pressure is 10bar. Heat added during the constant volume process is 200kJ. Determine i) Percentage clearance ii) Air standard efficiency iii) Mean effective pressure. (16)
2. An air standard diesel engine has compression ratio of 18 the heat transferred to the working fluid per cycle is 1800kJ/kg. At the beginning of compression stroke, the pressure is 1bar and the temperature is 300K. Calculate i) Thermal efficiency ii) Mean effective pressure. (16)
3. Consider an air standard cycle in which the air enters the compressor at 1bar and 20°C. The pressure of air leaving the compressor is 3.5bar and the temperature at turbine inlet is 600°C. Determine per kg of air, i) Efficiency of the cycle ii) Heat supplied to air iii) Work available at the shaft iv) Heat rejected in the cooler v) Temperature of air leaving the turbine. (16)
4. i) Explain the Diesel cycle. (8)
   ii) Derive an expression for the thermal efficiency of an ideal diesel cycle. (8)
5. Draw the sketch of a brayton cycle on p-V and T-s diagrams indicating the reheating, inter-cooling and regeneration processes. (16)

6. i) Sketch the p-V diagrams of Otto and diesel cycles and name the various processes.(16)
7. i)Derive the expression of optimum pressure ratio for maximum net work output in an ideal Brayton cycle. (8)
   ii) Explain the vapor compression cycle with the help of T-s diagram. (8)
8. i) Derive an expression for the thermal efficiency of an ideal Otto cycle. (8)
   ii) Differentiate clearly between a closed cycle gas turbine and open cycle gas turbine. (8)
9. i) Discuss the effect of sub-cooling and superheating on the performance of vapor compression refrigeration system with the help of T-s diagram. (8)
   ii) Explain the working of summer air conditioning system with a neat sketch (8)

UNIT – V

HEAT TRANSFER

PART – A

1. Indicate three modes of heat transfer. (2)
2. What is meant by conduction heat transfer? (2)
3. What is meant by convection heat transfer? (2)
4. What is called radiation heat transfer? (2)
5. Define thermal conductivity of material. (2)
6. What is the difference between free convection and forced convection? (2)
7. Define film heat transfer coefficient. (2)
8. Indicate the difference between laminar or stream lined flow and turbulent flow. (2)
9. What is called thermal boundary layer? (2)
10. Indicate the mechanism of energy transfer by radiation. (2)
11. Define reflectivity, absorptivity and transmissivity. (2)
12. What is called a perfect black body? (2)
13. What is Stefan Boltzmann's law? (2)
14. What is called emissivity of a body? (2)
15. State Kirchoff's law of radiation. (2)

PART – B

1. i) Explain conduction, convection and radiation heat transfer with examples. (8)
   ii) Obtain an expression for heat conduction through a cylinder with a neat sketch. (8)
2. What do you understand by black body and grey body? Explain. (16)
3. i) Derive an expression for the quantity of heat flow through a hollow sphere. (8)
   ii) Water flows inside a tube 5cm in diameter and 3m long at a velocity of 0.8m/s. Determine the heat transfer coefficient and the rate of heat transfer if the mean water temperature is 50°C and the wall is isothermal at 70°C. For water at 60°C, take k=0.66W/mK, $\nu = 0.478 \times 10^{-6}$ m²/s and Pr = 2.98. (8)

4. i) Water is heated while flowing through a 2cm diameter tube at a velocity of 1.2m/s. The entering temperature of the water is 40°C, and the tube wall is maintained at 85°C. Determine the length of the tube required to raise the temperature of the water to 60°C. (8)
   ii) What are radiation shape factor, black body and grey body? (8)
5. i) A 1.2m high and 2m wide double-plane window consists of two 3mm thick layers of glass(k = 0.78 W/mK) separated by a 12mm wide stagnant air gap(k= 0.026 W/mK). Determine the steady rate of heat transfer through this double-panned window and the temperature of its inner surface for a day during which the room is maintained at 24°C, while the temperature of the outdoors is -5°C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h_1 = 10W/m²K and h_2 = 25W/m²K and disregard any heat transfer by radiation. (8)
   ii) Explain the effect of extended surfaces on heat transfer. (8)
6. i) A steam 100mm inner diameter and 110mm outer diameter is covered with an insulating substance (k= 1W /mK). The steam temperature and the ambient temperatures are 200°C and 20°C respectively. If the convective heat transfer coefficient between the insulation surface and air is 8W/mK, fine the critical radius of insulation. For this value of radius calculate the heat loss per meter of pipe and the outer surface temperature. (8)
   ii) Define fin efficiency and fin effectiveness. (8)
7. An aluminium rod 2.5cm diameter and 10cm long protrudes from a wall maintained at 250°C. Rod is exposed to atmospheric air at 15°C with h = 15W/m^{2}K. Calculate the heat loss by the rod assuming fin with insulated and k aluminium = 200W/mK. Also calculate fin efficiency, fin effectiveness and fin end temperature. (16)

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