

II B.Tech II Semester Supplementary Examinations, Apr/May 2008  
MECHANICAL ENGINEERING  
(Chemical Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions  
All Questions carry equal marks

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1. (a) Define thermodynamic work and prove that work is a path function.  
(b) Define 'closed system', 'open system' and 'isolated system' and explain with suitable examples. [8+8]
2. (a) What is the difference between an isentropic process and throttling process? Explain.  
(b) One kg of air is compressed according to the law  $p v^{1.25} = C$  from a pressure of 105 kPa and temperature of  $18^{\circ}\text{C}$  to a pressure of 1680 kPa. Calculate the temperature at the end of compression, the heat received or rejected by the air and change in entropy. Assume for air  $C_p = 1.005 \text{ kJ/kg.K}$  and  $R = 0.287 \text{ kJ/kg.K}$  [6+10]
3. (a) What will be the ideal efficiency of an Otto cycle petrol engine working at a compression ratio of 6:1.  
(b) A Carnot engine operates on air between high and low pressures of 3 MPa and 100 kPa with a low temperature of  $20^{\circ}\text{C}$ . For a compression ratio of 15, calculate the thermal efficiency, the MEP and the work output. [6+10]
4. (a) What are the different methods of governing of steam turbines? Explain any one method with the help of neat sketches.  
(b) Determine the enthalpy required to produce 6 kg of dry saturated steam at a pressure of  $750 \text{ kN/m}^2$  from water at  $30^{\circ}\text{C}$ . Take specific heat of water as  $4.2 \text{ kJ/kg.K}$ . [8+8]
5. (a) Draw a neat diagram of an IC engine and explain the functions of different parts.  
(b) A two stroke cycle internal combustion engine has a piston diameter of 110 mm and a stroke length of 140 mm. The mean effective pressure exerted on the head of the piston is  $600 \text{ kN/m}^2$ . If it runs at a speed of 1000 rpm, find the indicated power developed. [10+6]
6. (a) Describe with a neat sketch the working of a single acting, single stage compressor.  
(b) A reciprocating compressor is to deliver 20 kg/min of air at 1600 kPa. It receives atmospheric air at  $20^{\circ}\text{C}$ . Calculate the required power if the compressor is assumed to be 90 percent efficient. No cooling is assumed. [8+8]
7. (a) Enumerate the advantages and disadvantages of chain drive over belt drive.

- (b) A flat belt is required to transmit 35kW from a pulley of 1.5m effective diameter running at 300rpm. The angle of contact is spread over  $11/24$  of the circumference and the coefficient of friction between belt and pulley surface is 0.3. Determine taking centrifugal tension into account, width of the belt required. It is given that belt thickness is 9.5mm, density of its material is  $1.1 \text{ Mg.m}^3$  and the related permissible working stress is  $2.5 \text{ N/mm}^2$ . [6+10]
8. (a) With the help of neat sketch explain the following terms in connection with spur gear.
- i. Pitch circle radius
  - ii. Root circle radius
  - iii. Tip circle radius
  - iv. Thickness
- (b) Select appropriate type of rolling contact bearing under the following condition of loading and explain the reasons for the choice.
- i. Heavy axial and radial load with shock
  - ii. Light load where radial space is very limited. [8+8]

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1. (a) Discuss the macroscopic and microscopic point of view of thermodynamics.  
(b) Enumerate the differences between closed cycles and open cycles giving examples. [8+8]
2. (a) A Carnot engine operates between reservoirs at temperatures  $T_1$  and  $T_2$  and a second Carnot engine operates between reservoirs maintained at  $T_2$  and  $T_3$ . Express the efficiency  $\eta_3$  of the third engine operating between  $T_1$  and  $T_3$  in terms of the efficiencies  $\eta_1$  and  $\eta_2$  of the other two engines.  
(b) Calculate the increase in entropy of 1 kg of mercury when its temperature is raised from  $27^\circ\text{C}$  to  $327^\circ\text{C}$ . Take specific heat of mercury as 0.033 kcal/kgK. [8+8]
3. (a) Prove that the efficiency of an Otto cycle depends upon its compression ratio.  
(b) A spark ignition engine operates on an Otto cycle with a compression ratio of 9 and temperature limits of  $30^\circ\text{C}$  and  $1000^\circ\text{C}$ . If the power output is 500kW, calculate the thermal efficiency and the mass flux of air. [8+8]
4. (a) Explain the main advantages and disadvantages of fire tube boiler over water tube boilers.  
(b) A power plant is to be operated on an ideal Rankin cycle with the superheated steam exiting the boiler at 4 MPa and  $500^\circ\text{C}$ . Calculate the thermal efficiency and the quality at the turbine outlet if the condenser pressure is
  - i. 20 kPa
  - ii. 10 kPa, and
  - iii. 8 kPa[8+8]
5. (a) Describe the operation of a four stroke cycle diesel engine with a pressure-volume diagram and necessary sketches.  
(b) The indicated power of a six cylinder four stroke cycle IC engine is 150 kW at an average piston speed of 320 m/min. The stroke bore ratio is 1.2:1. If the mean effective pressure is  $650 \text{ kN/m}^2$ , determine the crank shaft speed. [8+8]
6. (a) Describe a reciprocating air compressor with a neat sketch.  
(b) A single stage air compressor receives air at  $100 \text{ kN/m}^2$  abs and  $27^\circ\text{C}$  and delivers it to  $650 \text{ kN/m}^2$  abs. The compression follows the law  $pv^{1.2} = \text{constant}$  and the clearance volume is 5 percent of the stroke volume. Calculate the volumetric efficiency. [8+8]

7. (a) What type of drive is required for a positive drive without precise timing? Explain with help of neat sketch.
- (b) A leather belt 125mm wide and 6mm thick transmits power from a pulley 750 mm diameter which runs at 500rpm. The angle of lap is  $150^\circ$  and  $\mu = 0.3$ . If the mass of  $1m^3$  of leather is 1Mg and the stress in the belt is not to exceed  $2.75 \text{ MN}/m^2$ , find the maximum power that can be transmitted. [6+10]
8. (a) Define helical gear. Explain advantages and limitations of helical gears.
- (b) Draw the neat sketch of collar bearing and explain briefly. [8+8]

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1. (a) Discuss briefly giving suitable examples about closed system, open system and isolated system.  
(b) Show that work is a path function and not a state function. [8+8]
2. (a) What is the difference between an isentropic process and throttling process? Explain.  
(b) One kg of air is compressed according to the law  $pv^{1.25} = C$  from a pressure of 105 kPa and temperature of  $18^\circ\text{C}$  to a pressure of 1680 kPa. Calculate the temperature at the end of compression, the heat received or rejected by the air and change in entropy. Assume for air  $C_p = 1.005 \text{ kJ/kg.K}$  and  $R = 0.287 \text{ kJ/kg.K}$  [6+10]
3. A diesel engine is designed to operate with a compression ratio of 16 and air entering the compression stroke at 110 kPa and  $20^\circ\text{C}$ . If the energy added during combustion is 1800 kJ/kg, calculate  
(a) the cutoff ratio,  
(b) the thermal efficiency and  
(c) the MEP. [16]
4. (a) Explain the following terms:
  - i. Dry saturated steam
  - ii. Wet steam
  - iii. Superheated steam
  - iv. Dryness fraction of steam  
(b) A Rankin cycle operates between pressures of 2 MPa and 10 kPa with a maximum temperature of  $600^\circ\text{C}$ . If the insulated turbine has an efficiency of 80 percent, calculate the cycle efficiency and the temperature of steam at the turbine outlet. [8+8]
5. (a) Explain briefly with a sketch the working principle of a jet propulsion unit.  
(b) A six cylinder petrol engine working on four stroke Otto cycle runs at a speed of 2000 rpm. Each cylinder is 100 mm in diameter and the stroke is 150 mm. If the mean effective pressure is  $500 \text{ kN/m}^2$ , find the indicated power of the engine. [8+8]

6. A single stage single acting compressor 20 cm in diameter and 20 cm in stroke delivers air at  $2000 \text{ kN/m}^2$ . The temperature and pressure at the suction are  $27^\circ\text{C}$  and  $100 \text{ kN/m}^2$ . Assuming compression and expansion follow the law  $p v^{1.2} = \text{Constant}$  and clearance is 20% stroke volume, find
- (a) the volumetric efficiency and
  - (b) power of the compressor if the compressor runs at 200 rpm. [16]
7. (a) Derive the condition for the maximum power transmitted by a belt from one pulley to another.
- (b) A pulley is driven by a flat belt running at a speed of 750 m/min. The coefficient of friction between the pulley and the belt is 0.27 and the angle of lap is  $155^\circ$ . Find the power transmitted by the belt, if the maximum tension in the belt is 550N. [8+8]
8. (a) Explain any one type of thrust bearing with the help of neat sketch.
- (b) In a compound train of wheels the numbers of teeth on the wheels 1,2,3,4,5 and 6 are 80,40,50,25,30 and 12 respectively. Find the speed of wheel 6 when the wheel 1 is running at 20 rpm. [8+8]

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1. (a) With a suitable example, explain the concept of 'cyclic process'. Indicate its importance in thermodynamics.  
(b) Derive the governing equation for the adiabatic process. [6+10]
2. (a) Show that the efficiency of a Carnot engine operating between two reservoirs is independent of the working substance used by the engine  
(b) A piston allows air to expand from 6 MPa to 200 kPa. The initial volume and temperature are 500 cm<sup>3</sup> and 800°C. If the temperature is held constant, calculate the heat transfer and the entropy change. [8+8]
3. The compression ratio of an air standard dual cycle is 18 and the temperature and pressure before the compression are 320 K and 0.12 MPa respectively. The pressure ratio for the constant volume part of the heating process is 1.5:1. The volume ratio for the constant pressure part of the heating process is 1.2:1. Determine  
(a) the thermal efficiency and  
(b) the mean effective pressure. [16]
4. (a) What are the different methods of compounding of steam turbine stages? Describe any one method briefly.  
(b) A power plant operating on an ideal Rankin cycle has steam exiting the turbine at 500°C and 2 MPa. If the steam enters the pump at 10 kPa, calculate  
i. the thermal efficiency with pump work included,  
ii. the thermal efficiency neglecting pump work, and  
iii. the percentage error in efficiency neglecting pump work [8+8]
5. (a) How the internal combustion engines are classified?  
(b) A gas turbine power plant is to produce 800 kW of power by compressing atmospheric air at 20°C to 800 kPa. If the maximum temperature is 800°C, calculate the minimum mass flux of the air. [6+10]
6. (a) Describe a reciprocating air compressor with a neat sketch.  
(b) A single stage air compressor receives air at 100 kN/m<sup>2</sup> abs and 27°C and delivers it to 650 kN/m<sup>2</sup> abs. The compression follows the law  $pv^{1.2} = \text{constant}$  and the clearance volume is 5 percent of the stroke volume. Calculate the volumetric efficiency. [8+8]

7. (a) State the applications, advantages and disadvantages of chain drives.
- (b) Power is transmitted between two shafts by a V - belt whose mass is 0.9 kg/m length. The maximum permissible tension in the belt is limited to 2.2 kN. The angle of lap is  $170^\circ$  and the groove angle is  $45^\circ$ . If the coefficient of friction between the belt and pulley is 0.17, find the maximum power transmitted by the belt. [8+8]
8. (a) Define “module” and “pressure angle”. Obtain the following relations.
- i. Relation between module and diametral pitch
  - ii. Relation between diametral pitch and circular pitch
- (b) What are the principal types roller bearings? Discuss their characteristics. [8+8]

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