

**L. E. College, Morbi**  
**Mechanical Engineering Department**  
**B. E. Sem 6 Mechanical**  
**Applied Thermodynamics (3161910)**  
**Assignment 1 (CO1)**

**Psychrometry and psychrometric process:**

1. Define the following psychrometric terms: (a) DBT (b) WBT (c) DPT (d) specific humidity (e) relative humidity (f) degree of saturation (g) adiabatic WBT
2. Explain the terms humidifying efficiency, dew point temperature, with a skeleton psychrometric represent.
3. While performing experiment with air cooler same WBT is measured at inlet and outlet to air cooler. What is your conclusion? What will be the water temperature in the sump?
4. How the water is cooled in earthen pot?
5. Justify the name 'Desert cooler'. Define its saturation efficiency.
6. Explain adiabatic saturation process with help of skeleton psychrometric chart. Show that adiabatic saturation process is a constant enthalpy process.
7. Show that as long as WBT remains constant, enthalpy of air vapor mixture is constant.
8. Show cooling and dehumidification process on skeleton psychrometric chart and explain the terms bypass factor, contact factor and sensible heat factor for the process. Also show the ADP.
9. What is psychrometric chart? Explain various lines drawn on the chart.
10. In an air washer water is recirculated. Air at 37°C DBT is forced through it and no drop in temperature is observed. Calculate WBT, DPT, RH and degree of saturation of entering and leaving air. What will be the water temperature in the sump? **(WS)**
11. The readings from a sling psychrometer are DBT = 30°C, WBT = 20°C, barometer reading 740 mm of Hg. Using psychrometric table, determine: (a) dew point temperature, (b) relative humidity, (c) specific humidity, (d) degree of saturation (e) vapor density and (f) enthalpy of mixture per kg of dry air.
12. For air having DBT of 34°C and specific humidity 24 g/kg of d.a. Without use of psychrometric chart, calculate: vapor pressure, dew point temperature, relative humidity, degree of saturation, enthalpy of moist air, specific volume for the air and wet bulb temperature. Use following modified Apjohn equation if required.

$$p_v = p'_v - \frac{1.8 \times p \times (t - t')}{2700}$$

13. 20 m<sup>3</sup>/min of air at 30°C DBT and 60% RH is cooled to 22°C DBT maintaining specific humidity constant. Calculate the following using psychrometric tables only: heat removed from the air, RH of cooled air, WBT of the cooled air. Take air pressure = 1.01325 bar.
14. 10 m<sup>3</sup>/min of air at 40°C DBT and 23°C WBT passes over a coil maintained at 19°C having BPF equals to 0.15. Calculate temperature, specific humidity and RH of exit air and capacity of coil. Take barometric pressure = 101.325 kPa. **(WS)**
15. 120 m<sup>3</sup>/min of air at 29°C DBT and 20°C WBT flows through a cooling coil. The air leaves cooling coil at 12°C DBT and 8 gm/kg of d.a. Calculate (1) ADP (2) Contact Factor (3) Mass of air flow (4) Capacity of coil in kW (5) SHF
16. Atmospheric air 35°C DBT and 65% relative humidity enters a cooling coil at the rate of 35m<sup>3</sup>/min. The dew point temperature of the cooling coil is 11°C and bypass factor of the coil is 0.12. Determine: (a) The cooling capacity of the coil, kW (b) The temperature of air leaving the coil (c) The amount of moisture condensed, kg/h (d) Sensible heat removed per min and (e) Latent heat removed per min.
17. Air at 40°C DBT and 35% RH enters a humidifier in which water is recirculated. Its saturation efficiency is 80%. Determine the state of air leaving the humidifier. If this air is allowed a sensible temperature rise of 2.5°C in a room what conditions will be maintained in the room? For a sensible heat load of 5.25 kW, determine the handling capacity of the fan? What will be the effect in the room if same air is recalculated through the humidifier? Discuss.

18. 12 m<sup>3</sup>/min of air at 27°C DBT and 50% relative humidity is mixed with 2.4 m<sup>3</sup>/min of air at 43°C DBT and 29°C WBT. Determine the state of mixture.
19. 25 m<sup>3</sup>/min air at 45°C DBT and 27°C WBT passes over a cooling coil maintained at 23°C. If coil BPF is 0.12 using table only calculate the capacity of the coil. Show the process on skeleton psychrometric chart. **(BS)**
20. Air from 30°C DBT and 60% RH is reduced to 20°C DBT and 15°C WBT by cooling and dehumidification and then heating. If the plant handles 100 m<sup>3</sup>/min of air calculate (a) cooling coil capacity and its ADP (b) heating capacity and surface temperature of heating coil if BPF equals to 0.2 (c) moisture condensed. Use tables only. **(BS)**

### Properties of Gases and Gas Mixtures:

1. Explain Dalton's law of partial pressures. How evaporation happens in atmosphere?
2. Explain the reduced properties of gas and critical compressibility factor.
3. Explain generalized compressibility chart and compressibility factor with neat sketch.
4. What are reduced properties?
5. What is law of corresponding state?
6. Explain Vander Waals equation of state. Derive an expression for evaluation of constants 'a' and 'b'.
7. Determine the specific volume of superheated water vapor at 10 MPa and 400°C, using (a) the ideal-gas equation, (b) the generalized compressibility chart, and (c) the steam tables. Also determine the error involved in the first two cases

### Assignment 2 (CO2)

#### Refrigerant and Refrigeration cycles:

1. Explain thermodynamic, chemical and physical properties of ideal refrigerant.
2. Explain Ozone Depletion Potential and Global Warming Potential of CFC refrigerants.
3. Write chemical formula for R134a. Write designation for C<sub>2</sub>ClF<sub>3</sub>. **(WS)**
4. What do you mean by NBP of refrigerant? What is its significance?
5. What is secondary refrigerant? State its significance.
6. Describe the advantages of compound compression with inter cooler over single stage compression refrigeration system.
7. With schematic diagram and p-h diagram explain compound compression with flash intercooler.
8. With schematic diagram and p-h diagram explain compound compression with flash gas removal.
9. Following data is available for 10 TR, R134a VCR system with flash gas removal. Condenser temperature = 40°C, Evaporator temperature = -30°C, Intermediate pressure = 3 bar, Temperature at exit to condenser = 30°C, Temperature at exit to evaporator = -25°C, Temperature at suction of compressor = -20°C. Volumetric efficiency of both compressors is 0.9 and compression is isentropic. Calculate mass flow through HP and LP compressor, total work done and COP.
10. Following data is available for 10 TR, R134a VCR system with flash intercooler. Condenser temperature = 40°C, Evaporator temperature = -30°C, Intermediate pressure = 3 bar, Temperature at exit to condenser = 30°C, Temperature at exit to evaporator = -25°C, Temperature at suction of compressor = -20°C. Volumetric efficiency of both compressors is 0.9 and compression is isentropic. Calculate mass flow through HP and LP compressor, total work done and COP.
11. Calculate the maximum COP of a vapor absorption system with t<sub>g</sub> = 105°C, t<sub>e</sub> = -10°C, and t<sub>c</sub> = t<sub>a</sub> = 40°C. **(WS)**
12. With neat sketch explain single effect LiBr-H<sub>2</sub>O vapor absorption system.
13. With neat sketch explain single effect NH<sub>3</sub>-H<sub>2</sub>O vapor absorption system.

### Assignment 3 (CO3)

#### Fuel-air and Actual cycle, IC Engine performance:

1. What are the assumptions in fuel–air cycles? Explain effect of variation of specific heats and dissociation losses on analysis of fuel–air cycle.
2. How does the specific-heat vary with temperature? What is the physical explanation for this variation?
3. Explain dissociation loss and its effect on maximum temperature and pressure of the cycle.
4. What are the different losses in actual cycle? Explain any two with neat sketch.
5. Give a comparison between air standard cycle, fuel-air cycle and actual cycle.
6. Explain time loss, spark timing loss and heat loss in actual cycle.
7. Write brief note on Euro Norms and Testing of IC engine as per IS.
8. Describe heat balance sheet in details with your comment.
9. Explain the procedure of Willan's Line method and Morse test for IC engine.
10. Following observations were recorded during a test on a single cylinder 4-stroke oil engine: Bore =300mm; Stroke = 450mm; Speed =300rpm; imep = 6bar; Net brake load = 1.5 kN; Brake drum diameter = 1.8m; Brake rope diameter = 2 cm. Calculate: (a) Indicated Power (b) Brake Power (c) Mechanical Efficiency
11. The following data refers to a petrol engine working on Otto four stroke cycle. Brake Power = 14.7 kW, Suction Pressure = 0.9 bar, Mech. Efficiency = 80%, Compression Ratio = 5, Index of Compression curve = 1.35, Index of expansion curve = 1.3, Maximum Explosion pressure = 24 bar, Engine Speed = 1000 RPM, Ratio of stroke to bore = 1.5, Find the diameter and stroke of piston.
12. A four-cylinder two stroke cycle petrol engine develops 30 KW at 2500rpm. The mean effective pressure on each piston is 8 bars and mechanical efficiency is 80%. Calculate the diameter and stroke of each cylinder with stroke bore ratio 1.5. Also calculate the fuel consumption of the engine, if brake thermal efficiency is 28%. The calorific value of fuel is 43900 kJ/ kg.
13. A four-cylinder engine running at 1200 rpm delivers 20 kW. The average torque when one cylinder was cut is 110 Nm. Find the indicated thermal efficiency if the calorific value of the fuel is 43 MJ/kg and the engine uses 360 grams of gasoline per kWh.

### Assignment 4 (CO4)

#### Compressible Flow:

1. Define Stagnation temperature.
  - a) The temperature at zero velocity
  - b) The temperature at zero pressure
  - c) The temperature at zero heat transfer
  - d) The temperature at zero volume
2. Calculate the pressure at a height of 6500m above the sea level if the atmospheric pressure is 10.145 N/cm<sup>2</sup> and temperature is 25°C assuming air is incompressible. Take density of air as 1.2 kg/m<sup>3</sup>. Neglect variation of g.
  - a) 4.98 N/cm<sup>2</sup>
  - b) 2.49 N/cm<sup>2</sup>
  - c) 1.24 N/cm<sup>2</sup>
  - d) None of the mentioned
3. Pressure variation for compressible fluid is maximum for which kind of process?
  - a) Isothermal
  - b) Adiabatic
  - c) Quasi Static
  - d) None of the mentioned
4. Why can't the density be assumed as constant for compressible fluids?

- a) It shows variation with temperature and pressure
  - b) It remains constant with temperature and pressure
  - c) It becomes almost constant at very high temperature
  - d) None of the mentioned
5. For dynamic fluid motion in a pipe, the pressure measurement cannot be carried out accurately by manometer. True or false?
  6. A simple U tube manometer connected to a pipe in which liquid is flowing with uniform speed will give which kind of pressure?
    - a) Absolute Pressure
    - b) Vacuum Pressure
    - c) Gauge Pressure
    - d) None of the mentioned
  7. With the increase in pressure, the exit velocity \_\_\_\_\_
    - a) Decreases
    - b) Increases
    - c) Same
    - d) Independent
  8. Compressible flow is a flow that deals with \_\_\_\_\_
    - a) Fluid temperature
    - b) Fluid pressure
    - c) Fluid density
    - d) Fluid geometry
  9. Which among the following is an assumption of the compressible flow?
    - a) Resistance to flow of object
    - b) No-slip condition
    - c) Known mass flow rate
    - d) Resistance to flow of heat
  10. The definition of flow being compressible is \_\_\_\_\_
    - a)  $M > 0.3$
    - b)  $M > 0.5$
    - c) Depends on precision required
    - d) Another name for supersonic flows
  11. Differentiate between the compressible and incompressible flow. Mention some of the flow situations where compressibility of the fluid has to be considered.
  12. Explain the terms: Mach number, Mach cone, Mach Line and Mach angle in the context of compressible flow.
  13. Obtain Bernoulli's equation for compressible flow undergoing adiabatic process.
  14. Show that for steady, one-dimensional, isentropic compressible flow through a duct
 
$$\frac{dA}{A} = \frac{dV}{V}(M^2 - 1)$$
  15. Explain compressibility correction factor
  16. The speed of supersonic aircraft flying at an altitude of 1100 m corresponds to a mach number of 2.5. Estimate the time elapsed between the instant the aircraft was directly over head of an observer instant the observer feel the disturbance due to aircraft. Consider the following three cases and presume that the temperature at the given height is 208 K. (a) when the observer is stationary, (b) when the observer is moving in the direction of aircraft at  $M = 0.5$  c) when the observer is moving in the opposite direction with  $M = 0.5$ . Take  $\gamma = 1.4$  and  $R = 287 \text{ J/kgK}$
  17. A gas with a velocity of 300 m/s is flowing through a horizontal pipe at a section where pressure is  $7.8 \text{ kN/m}^2$  absolute and temperature  $40^\circ \text{C}$ . The pipe changes in diameter and at this section the pressure is  $11.7 \text{ kN/m}^2$  absolute. Find the velocity of the gas at this section if the flow of the gas is adiabatic. Take  $\gamma = 1.4$  and  $R = 287 \text{ J/kg K}$ .

## Assignment 5 (CO5)

### Compressors:

1. Brief multistage conditions for minimum work and intercooling in reciprocating compressors.
2. Draw a neat sketch and explain construction features as well as parts of centrifugal compressors in details.
3. What do you understand from velocity diagram of centrifugal compressor?
4. State phenomenon of surging and choking with its effects on centrifugal compressor.
5. Elaborate lift and drag in reference to axial flow compressor.
6. Write a note on performance characteristics for axial flow compressor.
7. A single stage double acting air compressor of 150 kW power takes air in at 16 bar and delivers at 6 bar. The compression follows the law  $pV^{1.4} = C$ . The compressor runs at 160 rpm with average piston speed of 150 m /min. Determine the size of the cylinder.
8. A single stage single acting reciprocating air compressor is required to handle 30m<sup>3</sup> of free air per hour measured at 1 bar. The delivery pressure is 6.5 bar and the speed is 450 RPM allowing volumetric efficiency of 75%; an isothermal efficiency of 76% and mechanical efficiency of 80%. Find the indicated mean effective pressure and the power required the compressor.
9. A two stage, single acting air compressor compresses air to 20 bar. The air enters the L.P cylinder at 1bar and 27oc and leaves it at 4.7bar. The air enters the H.P. cylinder at 4.5bar and 27oc. the size of the L.P cylinder is 400mm diameter and 500mm stroke. The clearance volume in both cylinder is 4% of the respective stroke volume. The compressor runs at 200rpm, taking index of compression and expansion in the two cylinders as 1.3, estimate the indicated power required to run the compressor.