UNIVERSITY OF NAIROBI

DEPARTMENT OF MECHANICAL ENGINEERING

FME 523 – AIR-CONDITIONING AND REFRIGERATION

Tutorial No. 1 - Psychrometrics

1. Moist air exists at a dew point temperature of 18°C, a relative humidity of 60 percent and a pressure of 0.084556 MPa. Determine:
   (a) The humidity ratio
   (b) The specific volume in $m^3 \cdot kga^{-1}$.

2. Moist air exists at 0.2 MPa, dew point temperature 20°C and relative humidity 70 percent. Determine:
   (a) The specific humidity
   (b) The dry bulb temperature
   (c) The volume per kg of dry air
   (d) The enthalpy per kg of dry air

3. Moist air exists at 0.09 MPa, dry bulb temperature 27°C and wet bulb temperature 18°C. Determine:
   (a) The specific humidity
   (b) The relative humidity
   (c) The dew point temperature
   (d) The volume per kg of dry air
   (e) The enthalpy per kg of dry air.

4. The temperature of a certain room is 22°C and the relative humidity is 50 percent, while the barometric pressure is 0.1 MPa. Calculate:
   (a) The partial pressure of (i) the dry air and (ii) the water vapour
   (b) The vapour density
   (c) The humidity ratio of the mixture.

5. Air at 10°C dry bulb and 5°C wet bulb is mixed with another stream at 25°C and 18°C wet bulb in a steady flow process at standard atmospheric pressure. The volumetric flow rates are 10 $m^3 \cdot s^{-1}$ and 6 $m^3 \cdot s^{-1}$ respectively.
   (a) Compute the mixture conditions
   (b) Determine the mixture conditions graphically using the psychrometric chart.

6. Air at 70°C and relative humidity 3 percent is required for crop processing at the rate of 2.0 $m^3 \cdot s^{-1}$. Outdoor air at 0.101325 MPa, 32°C dry bulb and 28°C wet bulb temperature, has to be conditioned by first being cooled and then dehumidified to 15°C, and the final specific humidity and then heated sensibly to the final temperature.

   (a) Determine the capacity and the sensible heat factor of the cooling coil.

   (b) Determine the capacity of the heating coil.

   (c) The condenser of the chiller operates 50°C. If the COP of the chiller is 2.5 and a heat exchanger of 70 percent effectiveness is installed to recover some of the heat rejected at the condenser for heating, by what percentage is the externally supplied heat reduced?

7. Moist air at standard atmospheric pressure, 32°C dry bulb temperature and 70 percent relative humidity is to be conditioned for a process requiring 500 $l.s^{-1}$ of air at 50°C and 10 percent relative humidity by first being cooled and dehumidified to 90 percent relative humidity and the final humidity ratio. It is then heated sensibly to the final condition.

   (a) Determine:

      (i) The capacity and the sensible heat factor of the cooling and dehumidifying coil.

      (ii) The heating capacity of the heater.

   (b) If the chiller has a coefficient of performance of 3, and the condenser temperature is 45°C, suggest an energy saving scheme.

8. A meeting hall is to be maintained at 25°C dry bulb and 18°C wet bulb temperature. The barometric pressure is 101.325 kPa while the space has a cooling load of 58.6 kW sensible and 58.6 kW latent. The temperature at which conditioned air is introduced to the room is 18°C dry bulb.

   (a) What is the required mass flow rate of the conditioned air?

   (b) What is the wet bulb temperature of the air as it is supplied to the room?

   (c) What is the room sensible heat factor?

9. A room to be maintained at 24°C and 50 percent relative humidity has a cooling load of 100 kW of which 25 kW is latent. Ten percent by volume of the air supplied to the space is originally outdoor air at 38°C dry bulb and 50 percent relative humidity and is not to be below 13°C dry bulb. Determine:

   (a) The minimum amount of air supplied to the room.

   (b) The amount of return and outdoor air in $l \cdot s^{-1}$.

   (c) The condition and volumetric flow rate of air entering the cooling coil.

   (d) The capacity and SHF of the cooling coil.

10. An air-conditioned space is to be maintained at 22°C and 40 percent relative humidity. The space cooling load is 60 kW sensible and 40 kW latent. The requirement of the outdoor air, which is at 32°C and 60 percent relative humidity is 1000 $l \cdot s^{-1}$. The air circulation fan, which is upstream of the cooling and dehumidification coil, transfers 10 kW to the air, while the coil has a sensible heat factor of 0.63. Standard atmospheric pressure prevails and conditioned air enters the space at 12°C. Determine:

    (a) The air mass flow rate through the coil.

(b) The capacity of the coil.

(c) The capacity of the heater which is placed downstream of the coil.

(d) The volumetric capacity of the fan.

11. Calculate the humidity ratio, enthalpy and volume per kg of dry air at 36°C db with a degree of saturation of 0.4 using the Goff and Gratch tables. The barometric pressure is standard atmospheric pressure.

FML/October 14, 2013