Subject: Air – conditioning and Refrigeration

الموضوع : تكييف وتجميد

Weekly Hours :Theoretical: 2
Tutorial:1
Experimental : 1
UNITS: 5

الساعات الاسبوعية: نظري:2
مناقشة:1
عملي :1
عدد الوحدات:5

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Subject: Principles of Refrigeration and Air Conditioning

Lecturer: Assistant Professor Dr. Waheed Shaty Mohammed

Refrences:

1- C. P. Arora " Refrigeration and Air Conditioning " .Tata McGraw Hill 1984 .

٢ـخالد الجودي " مبادى هندسة تكييف الهواء والتثليج " كلية الهندسة جامعة البصرة ١٩٨٦

First Term :

Chapter one: Introduction and definitions:

Lecture No. 1

1.1: Review of basic principles

Air conditioning : Is the science and practice of controlling the indoor climate in term of temperature air motion , humidity , air purity and noise.

Refrigeration :Is the process of removing the undesirable heat from a given body to maintain it at a desired lower temperature .

1.2: Moist air :

Working substance in air conditioning is the moist air which is a mixture of two gases . One of these is dry air which itself is a mixture of a number of gases and the other is water vapor which may exist in a saturated or super heated state . Both are treated as perfect gases since both exist in the atmosphere at low pressures . In addition Gibbs-Dalton laws for non reactive mixture of gases can be applied to the dry air part only to obtain its properties as a single pure substance .

$T_1 = T_2 = T$

$V_1 = V_2 = V$

$P_1 + P_2 = P$

$m_1 + m_2 = m$

$P_1 V_1 = m_1 R T_1$ & $P_2 V_2 = m_2 R T_2$

$P_t = P_a + P_v$

$m_1 h_1 + m_2 h_2 = mh$

1.3: Properties of moist air : The properties of moist air are called psychrometric properties and the subject which deals with the behavior of moist air is known as psychrometry . In air conditioning practice all calculations on the dry air part since the water vapor part is continuously variable . The actual temperature of moist air is called the dry bulb temperature DBT . The total pressure which is equal to the barometric pressure is constant . The other relevant properties are :

Humidity ratio, RH, DPT, h, C_{ph} and WBT.

Humidity ratio or moistur cntent (ω) = $m_v/m_a = V/V_v/V/V_a = V_a/V_v$

$\omega = 0.622\ P_v/P_a = 0.622\ P_v/(P_t - P_v)$

However the vapor pressure may be given by the following equation :

$P_V = P_S - P_{at}\ A\ (DBT - WBT)$

Where A is constant =6.66 E-4 $^oC^{-1}$ & P_{at} = atmospheric pressure

Relative humidity (RH) :

(RH = Φ %) = $V_s/V_v = P_v/P_s$

DPT (T_d) : Is the temperature of saturated moist air at which the first drop of dew will be formed the moist air is cooled at constant pressure i.e. the water vapor in the mixture will start condensing .

Enthapy of moist air (h) : $h = h_a + \omega\ h_v$

$h_a = C_{pa}\ T = 1.005\ T$

$h_v = C_{pw}\ T_d + h_{fg} + C_{pv}\ (T - T_d)$ at $T_d = 0.0$

$h_v = 2501 + C_{pv}\ T = 2501 + 1.84\ T$

$h = 1.005\ T + \omega\ (2501 + 1.84\ T)$

Humid specific heat (C_{ph}) = $C_{pa} + w\ C_{pv}$

Wet bulb temperature (WBT) : Is the temperature of moist air reads by a wicked bulb thermometer with its wick is thoroughly wetted by water .

1.4: Sensible and latent heats :

Sensible heat (Q_s) : Is the heat added or removed from the moist air at constant moisture content (ω) .

Latent heat (Q_l) : Is the heat added or removed from the moist air at constant DBT i.e. inceases or decreases its moisture contents .

1.5: Examples :

1- Calculate the vapor pressure of moist air at a state of DBT = 20 ċ , WBT = 15 ċ and P_{at} = 95 kPa

Solution : from steam tables for P_{at} = 101.3 kPa the saturation pressure P_s = 1.704 kPa at WBT = 15 ċ.

Use the equation of vapor pressure :

P_v =1.704 -6.66 E-4 * 95. * (20 -15)

= 1.388 kPa

2- Calculate the relative humidity of moist air the state condition of example 1 .

Solution : at DBT = 20 ċ the saturated pressure P_s = 2.337 kPa therefore

Φ % = P_v / P_s = 1.338/ 2.337 = 59.5 % .

3- Calculate the moisture content of moist air at the same state condition of example 1.

Solution : $\omega = 0.622 (P_v / P_a)$ and $P_a = P_{at} - P_v = 95. - 1.388$

Then ω = 0.00923 kg water vapor / kg dry air .

3- Calculate the dew point of moist air at the same state condition of example 1.

Solution : the vapor pressure of moist air at this state has already been calculated as 1.388 kPa . At its dew point temperature the moist air must have a saturation pressure Equal to this value .Therefore from steam table at this value (i.e 1.388 kPa) the saturation temperature is approximately 12 ċ which represent the dew point temperature of the moist air the accurate value by interpolation is (11.57 ċ) .

4- Calculate the specific volume of moist air at similar state of previous examples .

Solution : use the ideal gas law to the dry air alone .

$V_a = m_a R_a T_a / P_a$

$P_a = P_{at} - P_v$; P_a =95000-1388 =93612 Pa

Then V_a = 1. * 287 *(273+20) / 93612

= 0.898 m^3

Alternatively we can consider water vapor mixed with the dry air .

$V_v = m_v R_v T_v / P_v$

V_v = 0.00923 *461 * (273 + 20) / 1388 = 0.898 m^3 ;
where for one kg of dry air $\omega = m_v$ = 0.00923 kg water vapor / kg dry air

It can be seen that the volume of dry air and that of water vapor are the same as expain earlier $V = V_a = V_v$.

5- Calculate the approximate enthalpy of humid air at DBT = 20 ċ and WBT = 15 ċ and 101.325 kPa .

Solution : h = 1.005 * 20. + 0.00923 * (2501. + 1.84 * 20.) = 43.5 kJ/kg .