University of Anbar

College of Engineering

Mechanical Engineering Department

Subject: Air Conditioning

Class: Fourth Year

Course Tutor: Assist.Prof.Dr.Obaid T.Fadhil

ME 4302-Air Conditioning (3-2-1-2)

Course Definition:

Air conditioning part of the curriculum of Mechanical Engineering Program. This course covers the key aspects of air conditioning, including the calculation of the moist air properties, the use of the psychrometric chart, the estimation of the heating and cooling loads, as well as the design of air ducts.

Course Topics:

1. Introduction to air conditioning. 2. Moist air properties. 3. Psychrometric chart and psychrometry processes. 4. Thermal comfort. 5. Indoor and outdoor design conditions. 6. Heating load calculation. 7. Cooling load calculation. 8. Air conditioning systems. 9. Air distribution systems and duct design.

Course Description:

History of air conditioning, units and dimensions, review of basic principles, vapour pressure, moisture content, relative humidity, dry and wet bulb temperatures, specific volume, dew point, enthalpy, psychrometric chart, mixtures, sensible heating and cooling, dehumidification, humidification, cooling & dehumidification with reheat, heat balance equation, comfort charts, prediction of thermal comfort, indoor & outdoor design conditions, overall heat transfer coefficient, heat loss in building, ventilation heat loss, infiltration heat loss, air required for heating space, heat gain from external & internal sources, space cooling load, cooling coil load, cooling load calculation, functions of air conditioning systems, unitary systems, central-station systems, system selection & applications, economic evaluation, basic principles of air flow in ducts, duct sizing, duct design methods, supply air outlets and air distribution patterns.

Chapter One

Introduction

1.1 Brief History of Air Conditioning

The need for air-conditioning was first realized when it was found that certain products could be produced better in the right environment. With air-conditioning, there was no dependence of the product quality on the uncertainties of the weather and the factory sites were not limited to areas with a suitable climate. First to realize the importance of treatment of air was the textile industry. Industrial air conditioning later spread to various other areas such as manufacture of rayon and plastics, colour printing, pharmaceuticals, tobacco industry, manufacture, development, reproduction of photographic materials, electrical equipment, and many hygroscopic products.

Although sporadic attempts have been recorded for improving the ventilation and thermal conditions of indoor spaces, the first use of air-conditioning by mechanical means for human comfort was introduced in the United States of America at the turn of the twentieth century. There were few comfort cooling installations before 1920, but in the mid-twenties theatres all across the country were air conditioned to draw more customers. This was followed by the use of air conditioning in other commercial premises such as restaurants, night clubs, office blocks, etc.

In the 1930s, air conditioning was introduced in transportation systems such as trains, airplanes, buses and trolleys. After the Second World War, with the rising family income there was a boom in domestic air conditioning. This trend of use in the United States was subsequently repeated in the developing countries as more and more countries achieved higher standards of living.

1.2 System International Unites (SI Units)

SI or the International System of Units is the purest form and an extension and refinement of the traditional metric system. There are six basic SI units as given in Table 1.1. The units of other thermodynamic quantities may be derived from these basic units. The unit of temperature is kelvin which measures the absolute temperature given by

$$T = t + 273.15$$

where **t** is the Celsius temperature in ^{o}C.

Table 1.1 Basic SI units

Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electrical current	ampere	A
Luminous intensity	candle	cd

1.2.1 Unit of Force

Force **F** is proportional to mass **m** and acceleration **a**, so that

$$F = C(m)(a)$$

Where C is a proportionality constant, and it's value is taken as equal to the standard gravitational acceleration as (9.80665 m/s^2). The SI unit of force is Newton denoted by the symbol **N**.

$$1\ N = 1\ kg.m/s^2$$

1.2.2 Units of Pressure

The SI unit of pressure **P** can also be derived from its definition as force per unit area

$$P = F / A \quad (N/m^2)$$

The unit is also called **Pascal** and is denoted by the symbol **Pa**.

Another common SI unit of pressure is **bar** which is equivalent to a pressure of 10^5 N/m^2 or 0.1 MN/m^2 or 100 kN/m^2.

One standard atmosphere is given by

1 atm = 1.01325 bar = 760 mm Hg = 760 torr

1 torr = 1 mm Hg = 1/760 atm = 133 N/m^2

1.2.3 Unit of Energy (Work and Heat)

The SI unit of work is Newton meter (Nm) or Joule (J). Thus

$$1\ Nm = 1\ J = 1\ kg\ m^2/s^2$$

Since both heat and work are energy, the SI unit of heat is the same as the unite of work (J).

1.2.4 Units of Power

The SI unit of power is Watt (W). It is defined as the rate of doing 1 Nm of work per second. Thus 1 W = 1 J/s = 1 Nm/s

It may also be noted that Watt also represents the electrical unit of work defined by

1 W = 1(Volt) x 1(ampere) = 1 J/s

Further, the units of energy can be derived from those of power. Thus

1 J = 1 W.s

1 kWh = 3600000 J = 3600 kJ = 860 kcal = 3410 Btu

1.2.5 Units of Enthalpy

The SI unit of specific enthalpy is J/kg or kJ/kg

1 kJ/kg = 0.239 kcal/kg = 0.42 Btu/lb

1.2.6 Units of Entropy and Specific Heat

These are expressed as

1 kJ/kg.K = 0.239 kcal/kg ^oC = 0.239 Btu/lb ^oF

1.2.7 Units of Refrigerating Capacity

The standard unit of refrigeration in vogue is ton refrigeration or simply (TR). It is equivalent to the production of cold at the rate at which heat is to be removed from one US tone of water at 32^oF to freeze it to ice at 32^oF in one day or 24 hours. Thus

1 TR = (1 x 2000 lb x 144 Btu/lb)/24 hr = 12000 Btu/hr = 200 Btu/min

Also, 1 Btu = 1.055 kJ

1 TR = 12000 x 1.055 = 12660 kJ/hr = 211 kJ/min = 3.5167 kW