Chapter 6

Space heating load

Outdoor Design Conditions

- Heating systems should provide just enough heat to match the heat loss from the structure.
- Local knowledge should be obtained for design conditions.
- It would be optimal to design on the average seasonal temperature rather than sever weather conditions, which is rarely happen.
- Designing at the worst case scenario may result in excess energy consumption and extra price as the unit will not be run on full load all the time.

Indoor Design Conditions

- The indoor design temperature is mostly based on the comfort of the occupants, also on the need of the conditioned space such as factories, which need special atmosphere.
- ASHRAE has specified the lower limit for comfortable zone as 70 For 22 C and 30% relative humidity.
- The temperature in an unheated space is needed to compute the heat loss by calculating the overall heat transfer coefficient in the structure and making an energy balance on the space.
- The temperature of unheated basements is generally between the ground temperature (50 F, 10 C) and the inside design temperature unless there are many windows.

Transmission Heat Losses

- The heat transferred through walls, ceilings, roof, windows, floors and doors is all sensible heat transfer called transmission heat loss and can be calculated from:

$q= UA(t_i - t_o)$

- The overall heat transfer coefficient is determined from calculating the resistance for the required space, where A is the net area for the given component.

- The calculations can be done even manually or by using software.

Infiltration

- Infiltration is considered as a loss as extra heating load is needed to warm the cold outdoor air, also extra humidification is needed to humidify the dry cold outdoor air.
- The sensible heat required to increase the temperature is given by:

$$\dot{q}_s = \dot{m}_o c_p (t_i - t_o) \quad (6\text{-}2a)$$

where:

$\dot{m}_o$ = mass flow rate of the infiltrating air, lbm/hr or kg/s
c_p = specfic heat of the air, Btu/(lbm-F) or J/(kg-C)

Infiltration is usually estimated on the basis of volume flow rate at outdoor conditions. Equation 6-2a then becomes

$$\dot{q}_s = \frac{\dot{Q} c_p (t_i - t_o)}{v_o} \quad (6\text{-}2b)$$

where:

$\dot{Q}$ = volume flow rate, ft^3/hr or m^3/s
v_o = specfic volume, ft^3/lbm or m^3/kg

The latent heat required to humidify the air is given by

$$\dot{q}_l = \dot{m}_o (W_i - W_o) i_{fg} \quad (6\text{-}3a)$$

where:

$W_i - W_o$ = difference in design humidity ratio, lbmv/lbma or kgv/kga
i_{fg} = latent heat of vaporization at indoor conditions, Btu/lbmv or J/kgv

In terms of volume flow rate of air, Eq. 6-3a becomes

$$\dot{q}_l = \frac{\dot{Q}}{v_o} (W_i - W_o) i_{fg} \quad (6\text{-}3b)$$

- There are two common approaches in estimating infiltration in buildings; the crack method and the air change method.

Air Change Method

- It is based on an assumed number of air changes per hour based on experience.
- Experienced engineers can make assumption of the number of air changes per hour (ACH), based on their experience of the building type, construction, and use.
- The range will be from 0.5 ACH (very low) to 2 ACH (very high).
- The infiltration rate is related to ACH and space volume as:

$$\dot{Q} = (ACH)(V)/C_T \tag{6-4}$$

where:

$\dot{Q}$ = infiltration rate, cfm or m^3/s
ACH = number of air changes per hour, hr^{-1}
V = gross space volume, ft^3 or m^3
C_T = constant, 60 for English units and 3600 for SI

Crack Method

- It is named after the cracks around window sashes and doors.
- The infiltration rate depends on the total area of the cracks, the type of crack and the pressure difference across the crack.
- The volume flow rate of infiltration is calculated by:

$$\dot{Q} = AC\Delta P^n \qquad (6\text{-}5)$$

where:

A = effective leakage area of the cracks

C = flow coefficient, which depends on the type of crack and the nature of the flow in the crack

ΔP = outside – inside pressure difference, $P_o - P_i$

n = exponent that depends on the nature of the flow in the crack, $0.4 < n < 1.0$.

Heat Losses From Air Ducts

- This kind of losses is considerable when the ducts are not in the conditioned space.
- Insulation will reduce the problem but will not eliminate it.
- The losses are estimated from the equation $q = UA_s \Delta t_m$, where A_s is the surface area of the duct and the Δt_m is the mean temperature difference between the duct air and the environment.
- All ducts systems should be insulated to provide thermal resistance.
- Table 6-4 shows the design temperature difference between the air in the duct and the surrounding air.
- Heat losses from the supply ducts become part of the space heating load and should be summed with the transmission and infiltration heat losses.
- Heat losses from the return air ducts are not part of the space heat loss but should be added to the heating equipment load.