University of Diyala
College of Engineering
Mechanical Department

Air Conditioning

5-Applications of Psychrometric Processes

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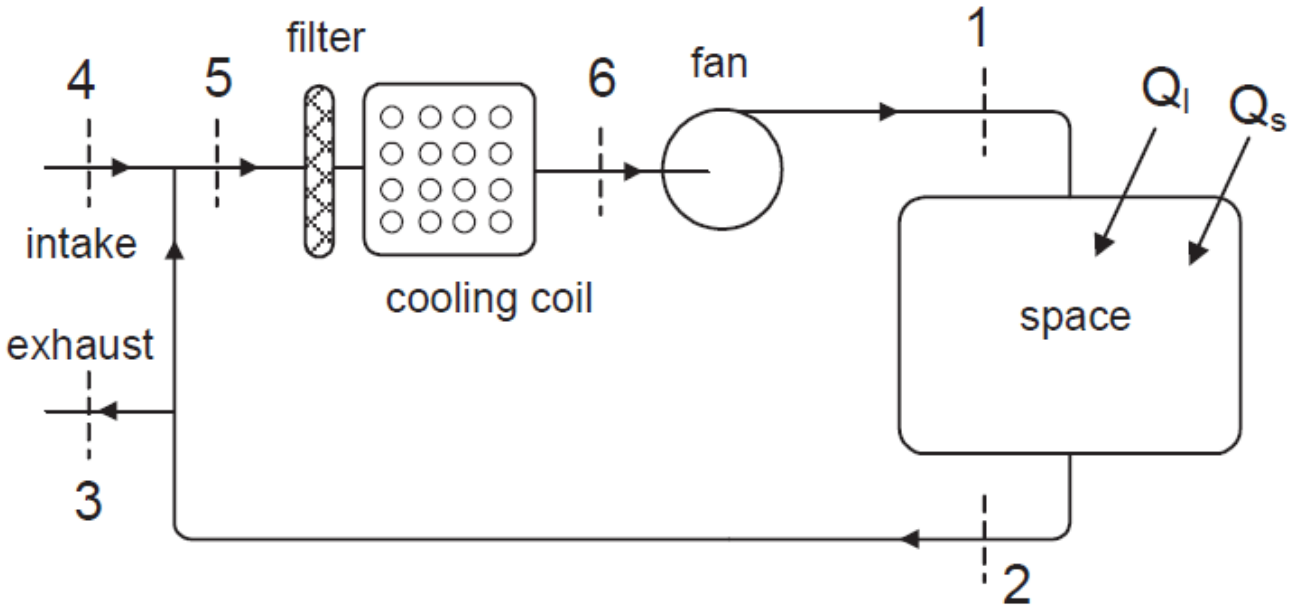
Air conditioning systems are designed to maintain the temperature and humidity ratio of a space at desired values when the space is subjected heating loads or cooling loads.

This is usually achieved by supplying conditioned air with the appropriate temperature and humidity ratio to the space. The desired conditions of the space, its heating/cooling loads, and the required supply air conditions are related by the condition line of the space.

In real air conditioning systems these basic processes are combined appropriately in the air processing units to achieve the required conditions in the air being supplied to a space.

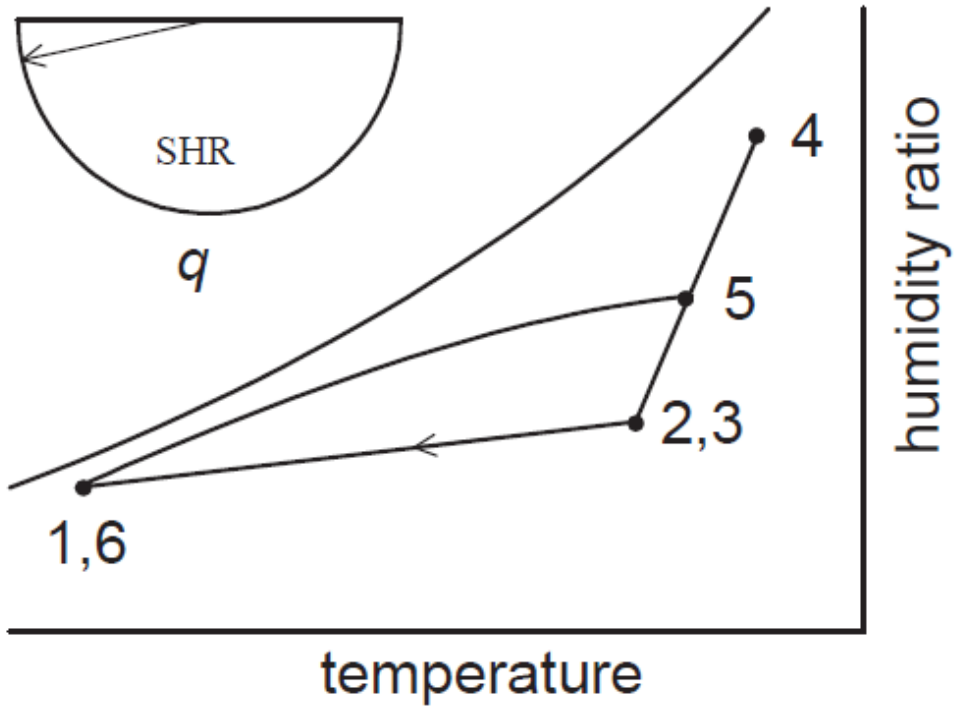
Summer air conditioning systems

The essential air processing components consisting of a filter, a cooling and dehumidifying coil, and a fan are arranged in series. These are connected using metal ducts through which air flows. For ventilation purposes, a portion of the air withdrawn from the conditioned space at 2 is discharged to the ambient at 3, and replaced with an equal mass of fresh air at 4.

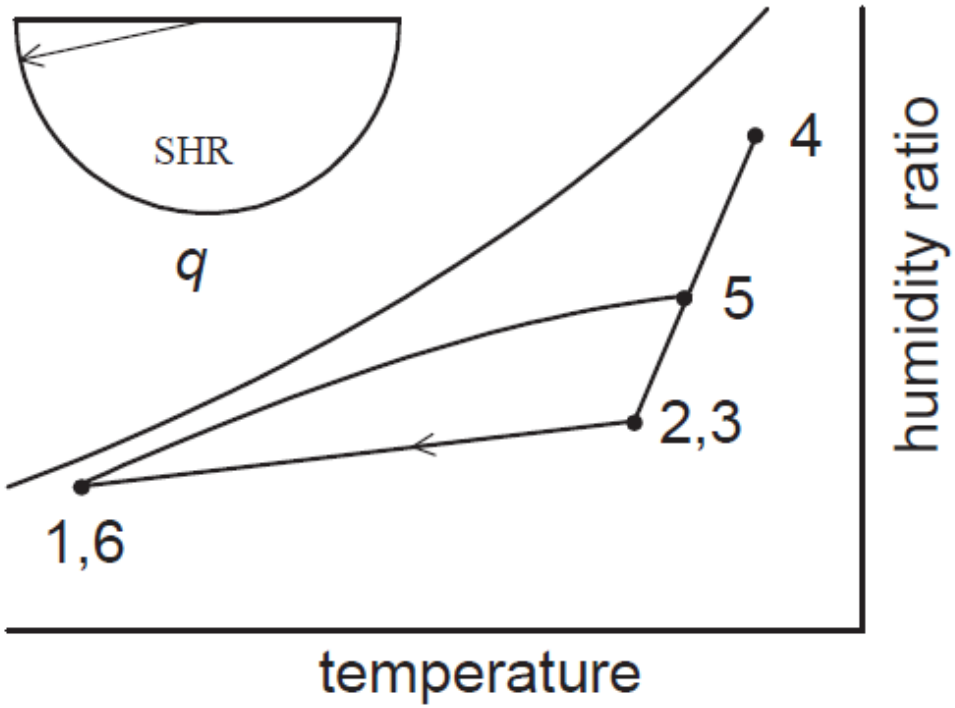


For ventilation purposes, fresh ambient air is admitted to the system at 4. The state of fresh air is easily located on the psychrometric chart by knowing two of its properties like the temperature and the relative humidity. The dry air mass fraction of fresh air to be admitted to compensate for the return air discharged at 3 is usually specified.

The air entering the cooling coil through the filter at 5 is a mixture of the fresh air admitted at state 4 and the return air at state 2. We obtain the state of air at 5, by dividing the straight line 2-4 in the inverse ratio of the dry air mass flow rates of the above two air streams.



The curved line 5-1, commonly called the coil condition line, gives the state of the air as it flows through the cooling and dehumidifying coil.



In a summer air conditioning system, 25% of the return air from a space at 30°C dry-bulb (db) temperature, and 22°C wet-bulb (wb) temperature is exhausted and an equal quantity of fresh air at 34°C db-temperature, and 28°C wb-temperature is mixed with the remaining return air. The mixture passes over a cooling coil whose coil-surface temperature (apparatus dew-point) is 8°C and the bypass factor is 0.25. The mass flow rate of dry air to the space is 0.8 kg /s. The pressure is constant at 101.3 kPa.

Calculate:

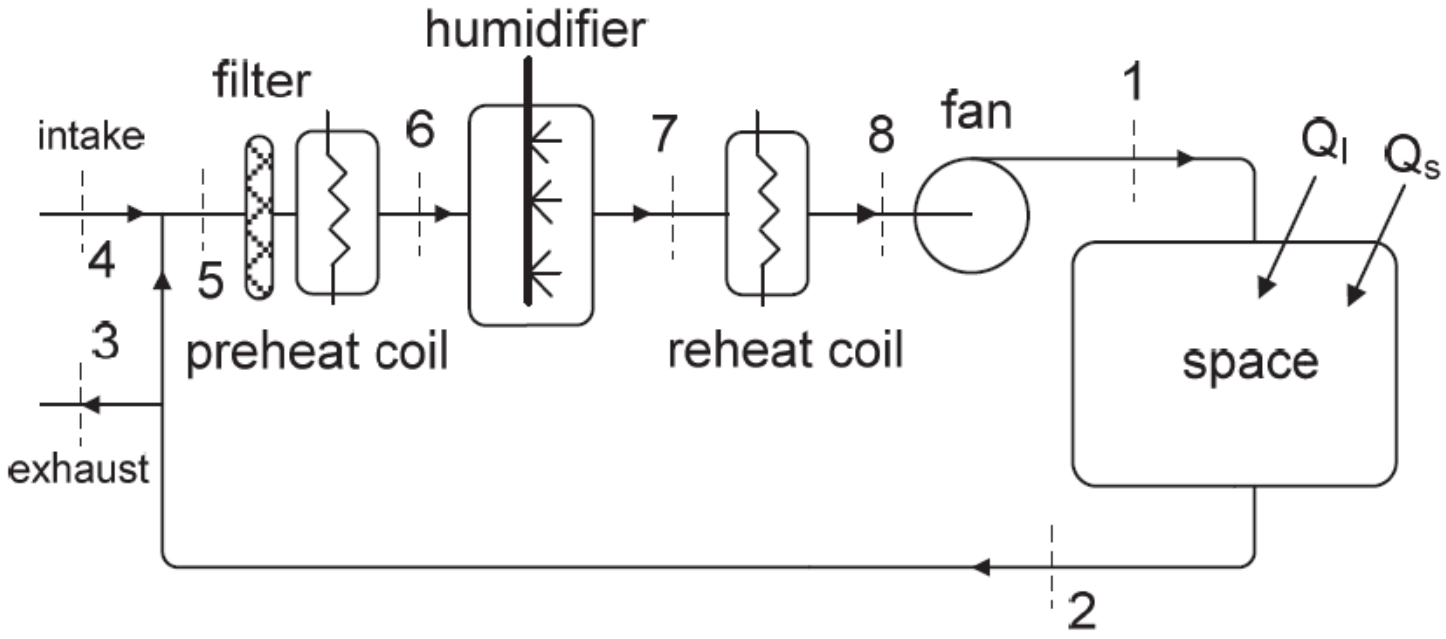
(i) db-temperature and the relative humidity of the air leaving the cooling coil,

(ii) enthalpy-humidity ratio of the cooling process

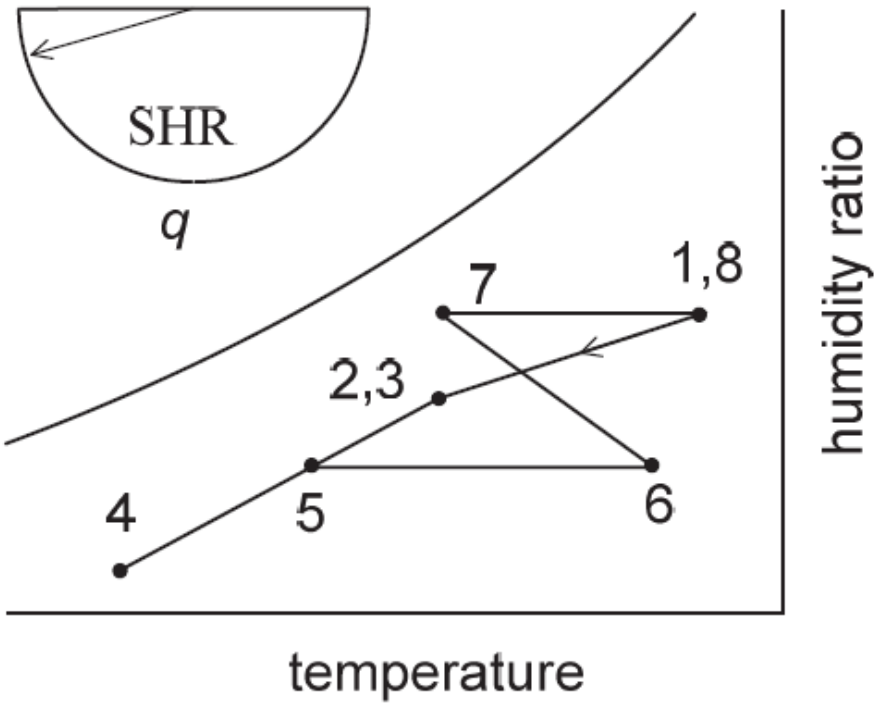
(iii) the refrigeration capacity of the cooling coil.

Winter air conditioning systems

Most winter air conditioning systems involve processing equipment that humidify and heat the air supplied to the space. The basic form of such a system consisting of a preheat coil, a humidifier, and a reheat coil

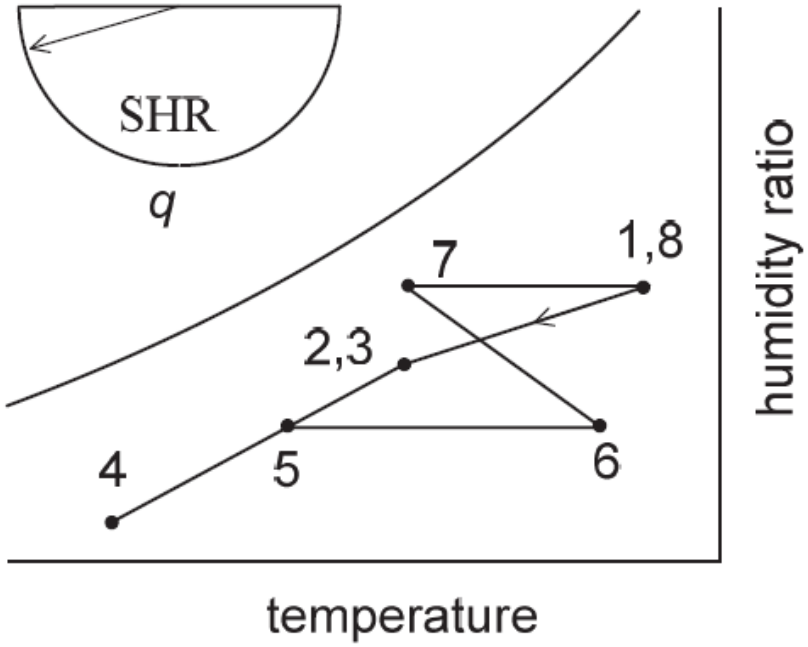


The preheat coil ensures that the air entering the humidifier is above 0°C and therefore there is no danger of water freezing in the humidifier. Moreover, by controlling the temperature of the air entering the humidifier it is possible to control the rate of evaporation of water. The reheat coil is used to control the dry bulb temperature of the air entering the space.



Fresh air at state 4 is mixed with a fraction of the return air to produce air at state 5. In the preheat coil the air is heated sensibly at constant humidity ratio to state 6. Ideally, the process line 6-7 in the humidifier follows a constant wet-bulb temperature line. The state 7 of the air leaving the humidifier depends on the saturation effectiveness of the humidifier.

In the reheat coil, the air is sensibly heated at constant humidity ratio and therefore the process is represented by a horizontal line through 7. The intersection of this line with the space condition line drawn through 2 locates the required supply air state 1 on the psychrometric chart.



The winter air conditioning system supplies air at 38°C db-temperature to a space maintained at 21°C db-temperature and 13°C wb-temperature. The sensible and latent heat loads on the space are 50 kW and 10 kW respectively.

Of the return air from the space, 40% by dry air mass is discharged to the ambient and replaced with fresh outdoor air at 2°C db-temperature and 95% relative humidity. In the preheater, the air is heated to a db temperature of 21°C. Assume that the water added in the air washer is at the wb-temperature of the air entering it. The pressure is constant at 101.3 kPa. **Determine**:

(i) mass flow rate of supply air,

(ii) the rates of heat input in the preheat coil and the reheat coil,

(iii) the mass flow rate of water in the air washer, and

(iv) the saturation effectiveness of the air washer.

Reference:

- Nihal E Wijeysundera; 2015. Principles of heating ventilating and air conditioning- with worked examples

Thank you very much