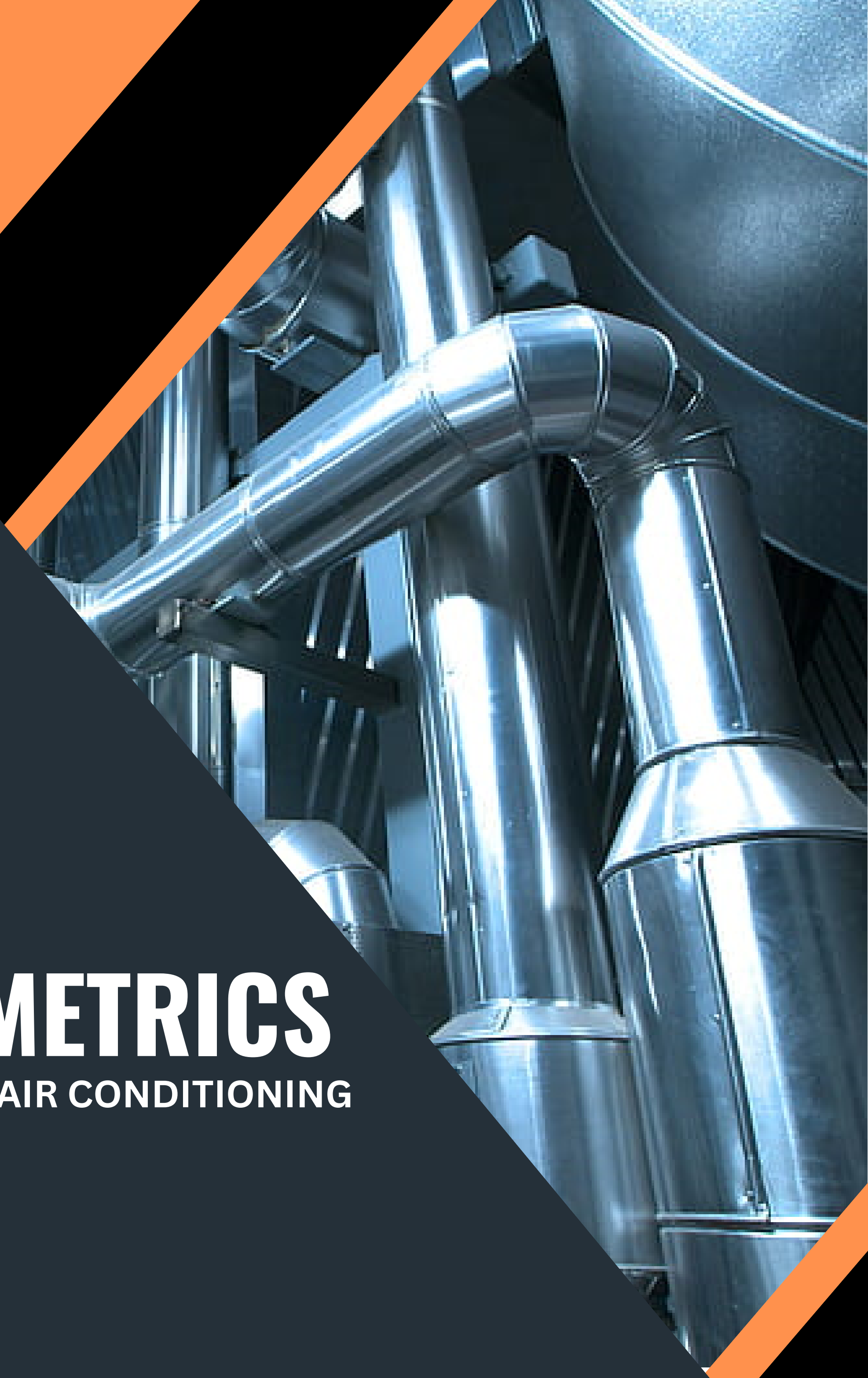

PSYCHROMETRICS

PROPERTIES OF AIR IN AIR CONDITIONING

2023 EDITION

written by:

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PSYCHROMETRICS

Properties of air in air conditioning

WRITER

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PREFACE

This eBook presents the topic of fundamental of properties of air in air conditioning. It also provides application principles, theoretical knowledge, and problem-solving involving plotting on Psychrometrics chart. It is with sincere gratitude to the Publishers that the author acknowledges the results achieved to have been due wholly to their kindly interest and indefatigable efforts. Hope that this new edition will be found to measure fully up to the expectations of readers.

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ACKNOWLEDGMENTS

First of all, alhamdulillah we give our deep gratitude and thanks to The Almighty Allah SWT for His mercy and guidance to complete this eBook entitled "Psychrometrics Properties of Air in Air Conditioning". Tonnes of thanks also to team members who have contributed greatly to this eBook. The purpose of establishing this eBook is as a guide for students for better understanding the fundamental of properties of air specifically for air conditioning. During preparing this eBook, we have faced lots of challenges and obstructions but with help of individual in our team members, those obstruction managed to be passed.

Finally, thank you to all individual members who helps in process of writing this eBook. Hopefully this eBook helps the reader to gain more knowledge about the topic.

e-BOOK AUTHORS

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CHAPTER 1

Fundamental Aspects of Psychrometry

1

1.1 Introduction

Psychrometrics is the thermodynamic study of atmospheric air contains gas mixtures in which one or more water vapour may condense while the other components remain gaseous. It is also investigated how dry air and water vapour behave in different situations. Notwithstanding the fact that the planet's atmosphere is composed of many other gases, including nitrogen (78% by volume), oxygen (21%), and carbon dioxide (CO2), the only gases that are thought to be present in it are dry air and water vapour for psychrometric reasons. When the air's moisture or heat content varies, psychometry can be utilised to forecast changes in the surrounding environment.

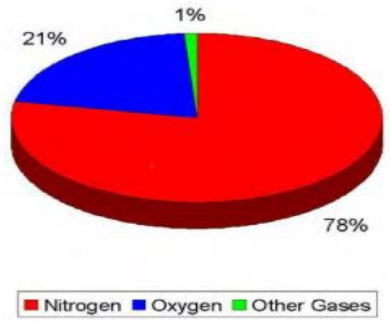
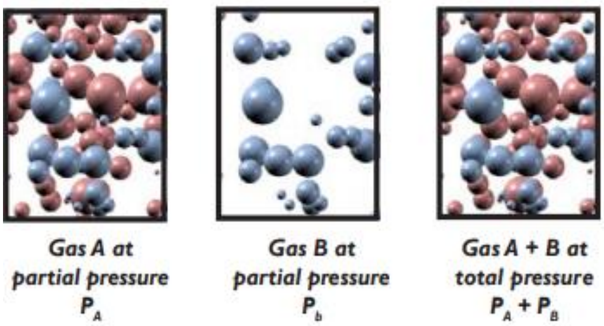


Figure 1.1 Properties of air

Dalton's Law states that in any mechanical mixture of gases and vapours that is not chemically mixed, the total pressure of a gaseous mixture is equal to the sum of the partial pressures exerted by each individual gas or vapour. Additionally, each gas or vapour in the combination exerts a unique partial pressure, which is the same pressure that the gas would have if it were the only element filling the area. The following equation illustrates this:

$$P_{tot} = P_A + P_B + P_C \text{....at constant V and T}$$

Where P_A, P_B, P_C .... refer to pressure of each individual gas would have if it was alone.

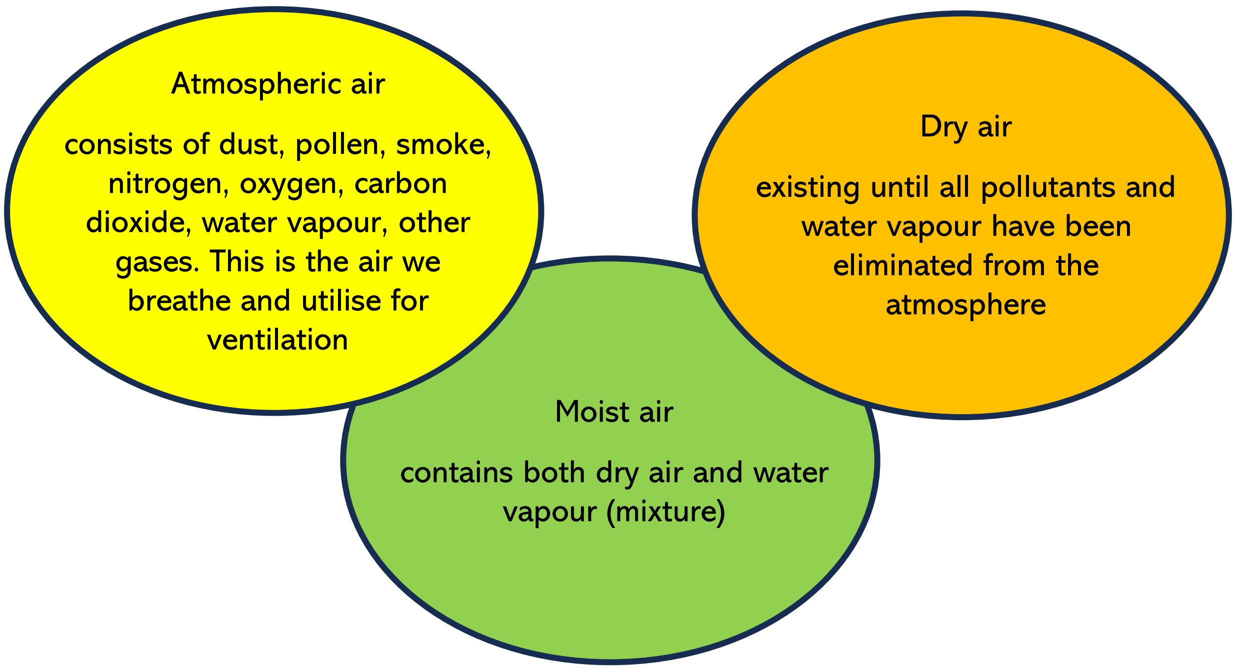


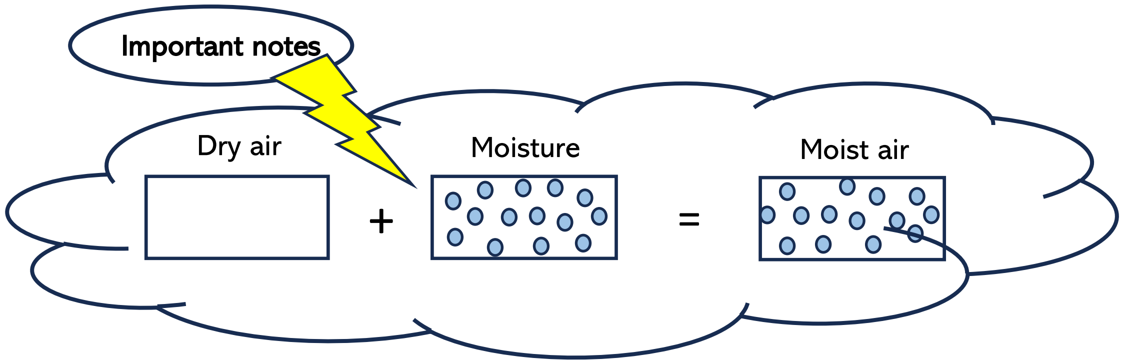
Dalton's Law, illustrates that if two gases are combined into the same volume, the total pressure is the sum of the individual partial gas pressures.

Figure 1.2 Dalton's law of Partial Pressures

1.2 Definitions of Air

Under various circumstances, air is described using three fundamental definitions:





1.1 Objectives

The objectives of the study are to:

1. Take values from the psychrometric chart for the attributes.
2. Quantify sensible and latent heat changes in air conditioning apparatus.
3. Establish the mixed air conditions.
4. Establish the necessary supply air conditions
5. Establish the cooling coil performance requirements
6. Ascertain the need for reheating
7. Use the psychrometric chart to identify the characteristics of the atmosphere's air.

CHAPTER 2

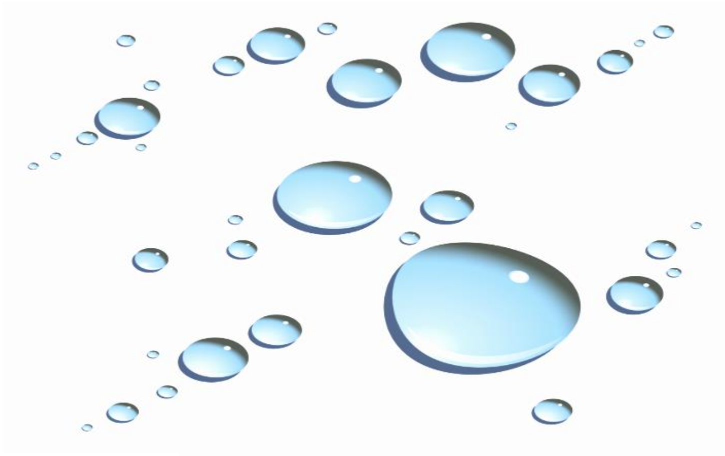
Properties of Air

2

2.1 Properties of Air

The psychrometric chart initially seems to be an intimidating network of lines. However, when utilised correctly, it offers useful knowledge about the characteristics of air. This class will discuss the psychrometric chart and how to utilise it to address a variety of air conditioning issues.

There are five physical qualities on the psychrometric chart that define the characteristics of air:



- Dry-bulb temperature
- Wet-bulb temperature
- Dew-point temperature
- Relative humidity
- Humidity ratio
- Specific enthalpy
- Specific volume

2.2 Dry-bulb temperature (DBT) is the temperature of the air determined by a standard thermometer reads when there is no water on its surface. Generally, the temperature of the air is measured by a dry bulb. It is standard practise to measure temperature using a various kind of scales.

Figure 2.1 Dry-bulb thermometer

Figure 2.2 Wet-bulb thermometer

2.3 The temperature that is associated with the air's moisture content is known as the **wet-bulb temperature (WBT).** When measuring the temperature of a wet bulb, a wet wick is placed around the thermometer, and the measurement is obtained as the water evaporates. Wet bulb temperatures are always lower than dry bulb always lower than dry bulb temperatures due to the evaporative cooling effect, and the only time they will be equal is at saturation (i.e., 100% relative humidity). In relation to the dry bulb temperature, the wet bulb temperature measures relative humidity. When the temperature is high and the relative humidity is low, moisture will evaporate fast, which, because of the much lower evaporation rate, will have a stronger cooling effect than if the relative humidity were already high. The drier the air, the greater the difference between the dry-bulb and wet-bulb readings.

2.4 Dew point temperature (DPT) is the temperature at which moisture in the air leaves and condenses on objects, much as how dew develops on grass and plant leaves. Relative humidity increases as air is cooled until saturation is reached and condensation begin to occur. Surfaces that are at or below the dew point temperature experience condensation.

Figure 2.3 Condensation occurs at dew point

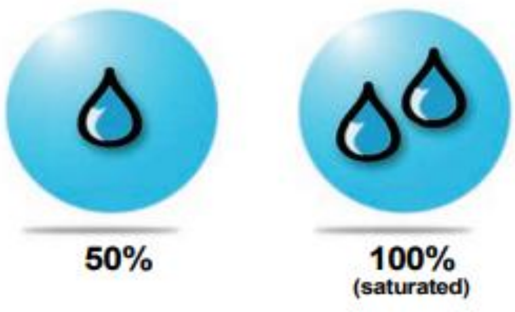


Figure 2.4 Relative humidity

2.5 Relative humidity (RH) is a measurement of the amount of water air can contain at a specific temperature. Warmer air may contain more moisture than colder air, hence air temperature (dry-bulb) is significant. For instance, with 50% relative humidity, the air has half the moisture that may be present at the current dry-bulb temperature.

2.6 Humidity ratio/absolute humidity is which the air contains vapour. It also explains how much water is present in a combination of air and water vapour. To put it another way, the humidity ratio would be determined if one pound of air was totally wrung dry and the weight of the water added to it was calculated.

Figure 2.4 Relative humidity

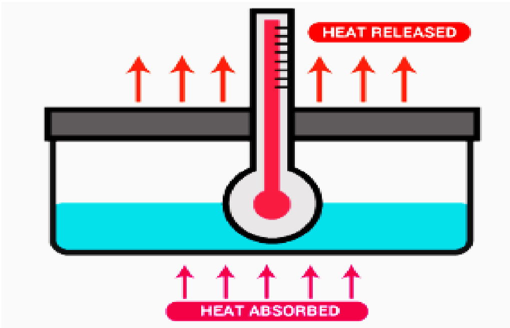


Figure 2.5 Enthalpy

2.7 Enthalpy (h) reflects the amount of sensible or latent heat energy present in the atmosphere. Latent heat is the energy (heat) in the air that originates from the moisture in the air, as opposed to sensible heat, which is the energy (heat) in the air that derives from the temperature in the air. The term "air enthalpy is kilojoules per kilogramme (kJ/kg) or BTU per pound of dry air (Btu/lb of dry air). Applications involving the cooling and heating of air benefit from enthalpy. Both chilly wet air and dry hot air with the same amount of energy are possible states of air.

2.8 Specific volume (V) is the amount of space a certain weight of air takes up under a given set of circumstances is known as the specific volume. Air density is essentially the reciprocal of the specific volume of air. Consequently, as temperature rises, the specific volume will as well. The reason why warmed air rises because warm air is less dense than chilly air. The term thermal buoyancy is used to describe this phenomenon. The specific volume of the air will increase with the amount of moisture vapour. The denser the air is, the lower its specific volume becomes as atmospheric pressure rises.

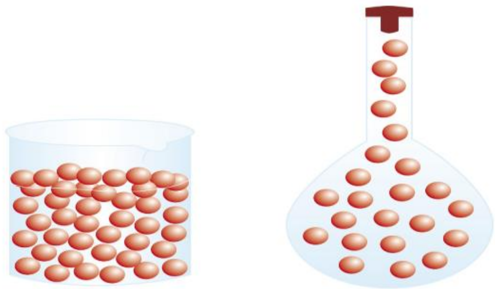


Figure 2.5 Relative humidity

CHAPTER 3

The Psychrometry Chart

3

3.1 Psychrometer

Psychrometer are commonly used in air conditioning as an instrument used to measure how much moisture is in the air to assist engineers in making buildings comfortable. The psychrometer has constructed with two thermometers; the dry bulb thermometer, which gauges air temperature, is one of them. The temperature displayed is known as the wet bulb temperature; it is encircled by a wick that is air-flown across and dips into a small water reservoir.

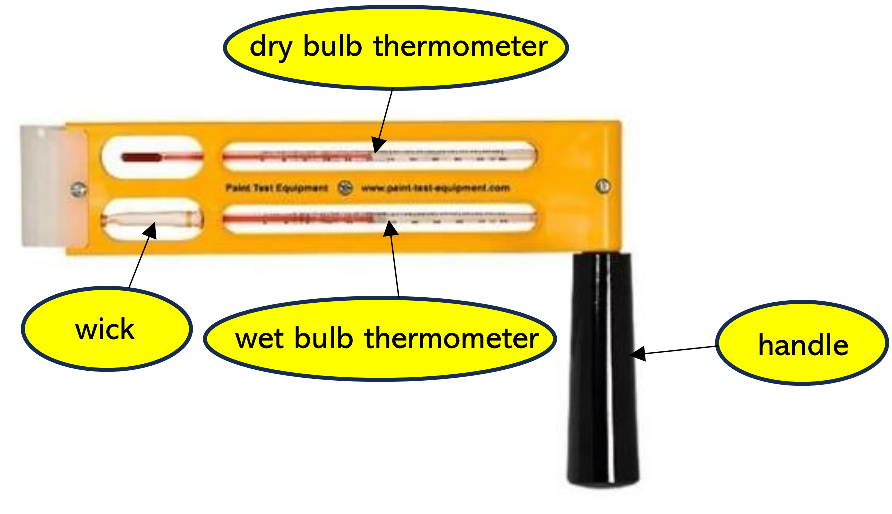


Figure 3.1 Labelled Sling psychrometer

3.2 Psychrometric chart

The psychrometric chart as referred to Figure 3.2 is a visual tool and graphical illustration of the many thermodynamic characteristics of wet air. The psychrometric chart may save a lot of time and effort by helping to determine the properties of air that are needed for air conditioning. It is also helping designers find solutions to many common HVAC problems by plotting conditions on the chart.

The psychrometric chart conveys an astounding quantity of information about air. It is a powerful tool for demonstrating and diagnosing environmental issues, such as why warm air may contain more moisture and, on the other hand, how enabling wet air to condensation will happen in cool.

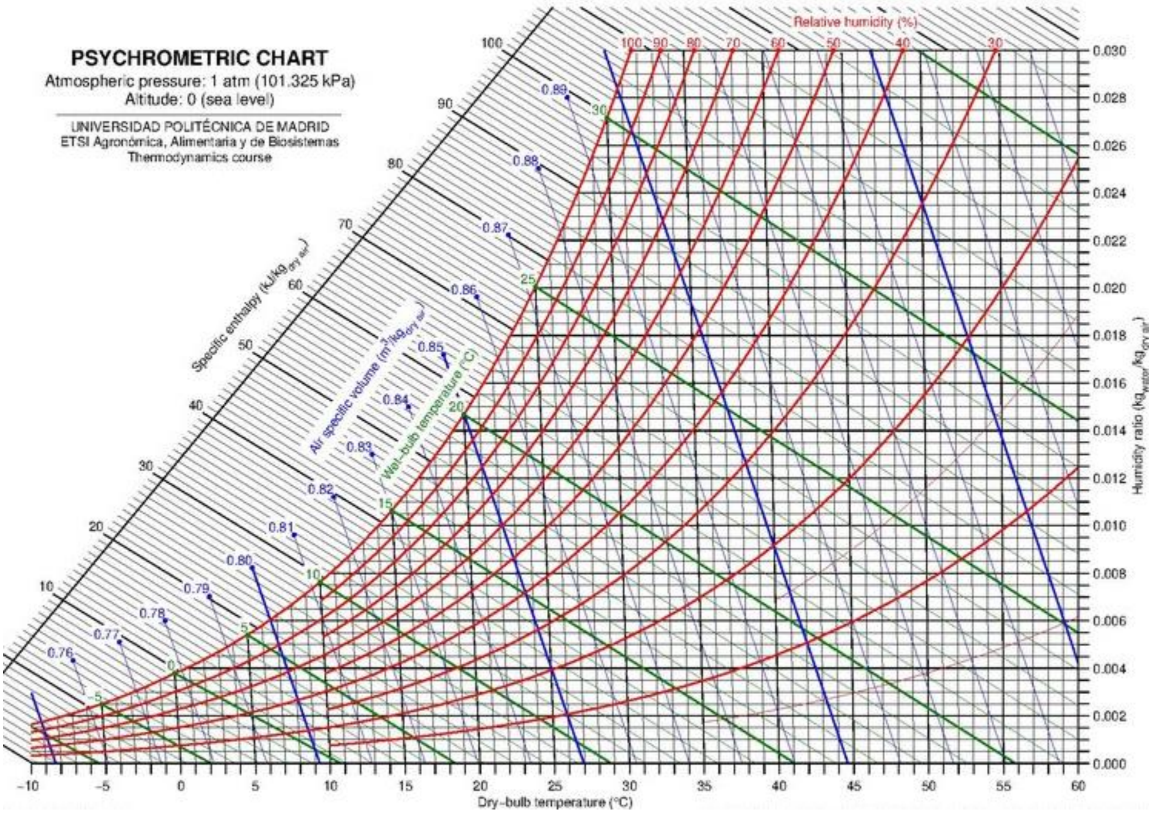


Figure 3.2 Psychrometric chart

Every air condition is represented by a point on the psychrometric chart. When two independent attributes are known, the condition may be found. The point that represents the state of the air is established at the intersection of the two lines because each characteristic is represented by a line. The chart may be used to read any further attributes after the condition has been identified.

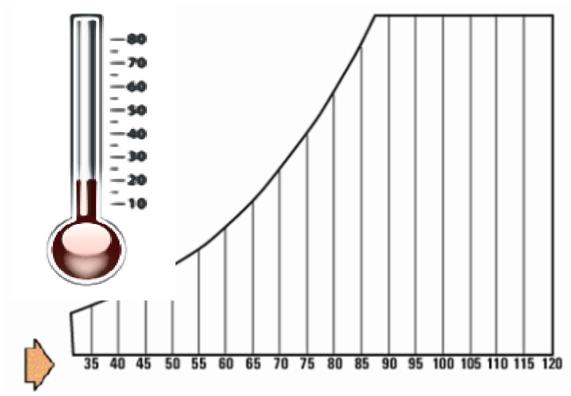


Figure 3.3 Dry bulb temperature lines

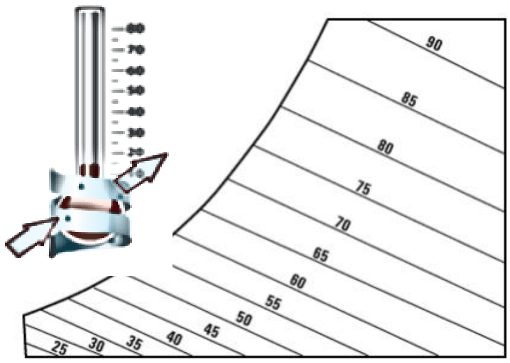


Figure 3.4 Wet bulb temperature lines

3.3 Dry bulb temperature lines, as shown in Fig. 3.3, are vertical, that is, parallel to the ordinate, and evenly spaced. It is located on the X-axis.

3.4 Lines that diagonally slope from the upper right corner of the chart (along the saturation line) to the lower left corner of the chart represent the **wet bulb temperature** line.

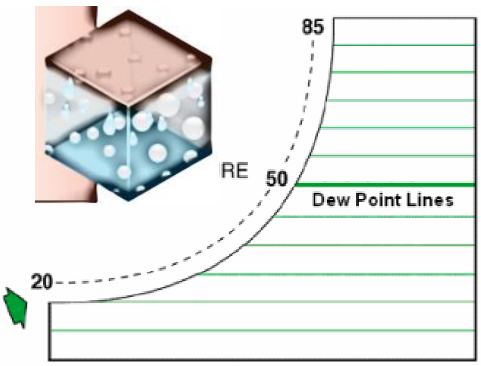


Figure 3.5 Dew point temperature lines

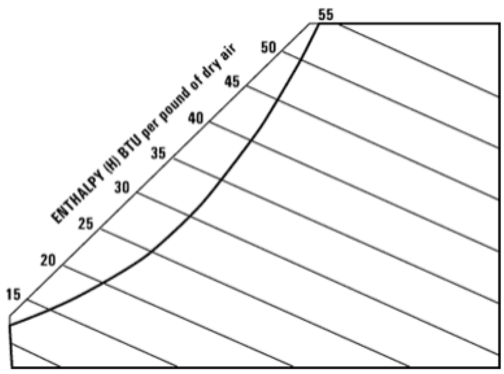


Figure 3.6 Specific enthalpy lines

3.5 Dew point temperature is where the line representing 100% relative humidity. From a state point, the dew point temperature is found by moving horizontally along lines with a constant humidity ratio until the upper, curved saturation temperature limit is reached.

3.6 Specific enthalpy line is situated over the chart's upper limit, which represents saturation. On the diagram, lines with constant enthalpy run downhill in a diagonal direction. Aligned almost precisely parallel to the line of constant wet bulb temperature

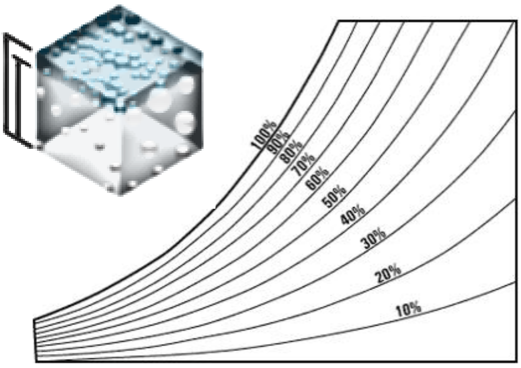


Figure 3.7 Relative humidity lines

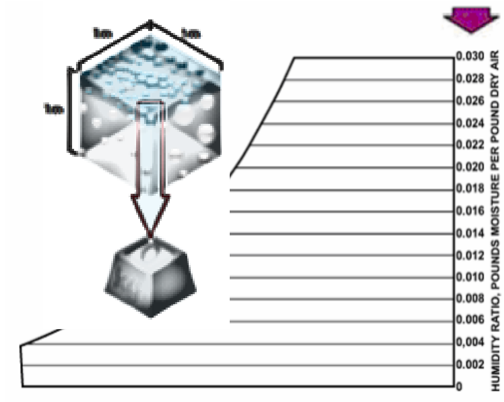


Figure 3.8 Humidity ratio lines

3.7 The curved lines that ascend from the bottom left corner of the chart to the upper right corner represent the **relative humidity lines.** The upper, left edge of the figure is the line representing saturation, or 100 percent relative humidity.

3.8 Humidity ratio line is shown on the graph as horizontal lines and the Y-axis on the right side of the graph, which represents the humidity ratio line, has values that rise from bottom to top.

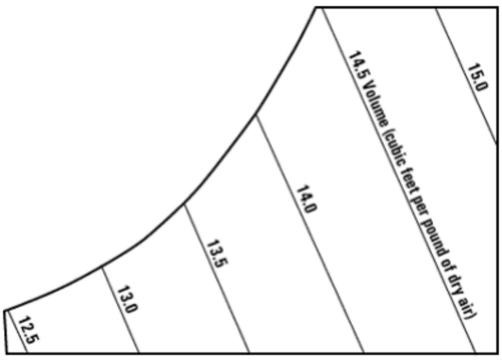


Figure 3.9 Specific volume lines

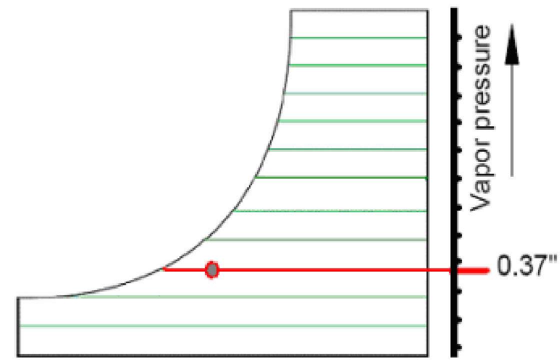


Figure 3.10 Vapour pressure lines

3.9 Specific volume line is shown on the psychrometric chart as lines that slant from the lower right corner to the upper left corner at an angle that is steeper than the lines for wet bulb temperature and enthalpy.

3.10 Vapour pressure line happens where the saturation point and saturation pressure are the same thing. At this point, there will not be any more evaporation because the air is now

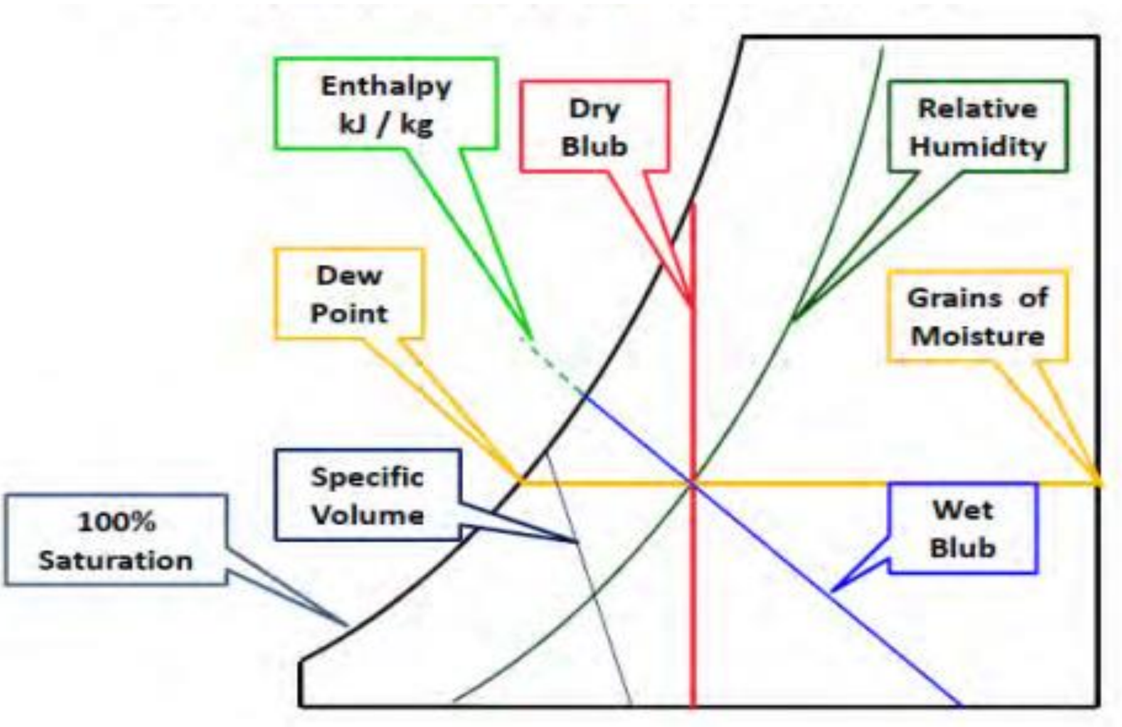


Figure 3.11 Breakdown of the lines

CHAPTER 4

Psychrometric Processes

4

4.1 Psychrometric processes

A thermodynamic system is considered to be in a process when it changes from one state-point to another. This state shift in psychrometric analysis can be induced by adding or removing mass (usually made up of water vapour), forcing the fluid to work on or by itself, merging two fluids in different states, or adding or removing heat. These processes include sensible heating, sensible cooling, humidifying, and dehumidifying.

4.2 Relationship between temperature and humidity approaches

Psychrometrics can be used to predict how the environment will change when there is a variation in the amount of heat and/or moisture in the air. The volume flow rates of air that must be driven into the ducting system and the sizes of the major system components must be determined via the application of psychrometric analysis.

Cooling
Heating
} Temperature control

Humidification
Dehumidification
Heating
} Humidity control

The following processes must occur in the air during air conditioning in air conditioning system:

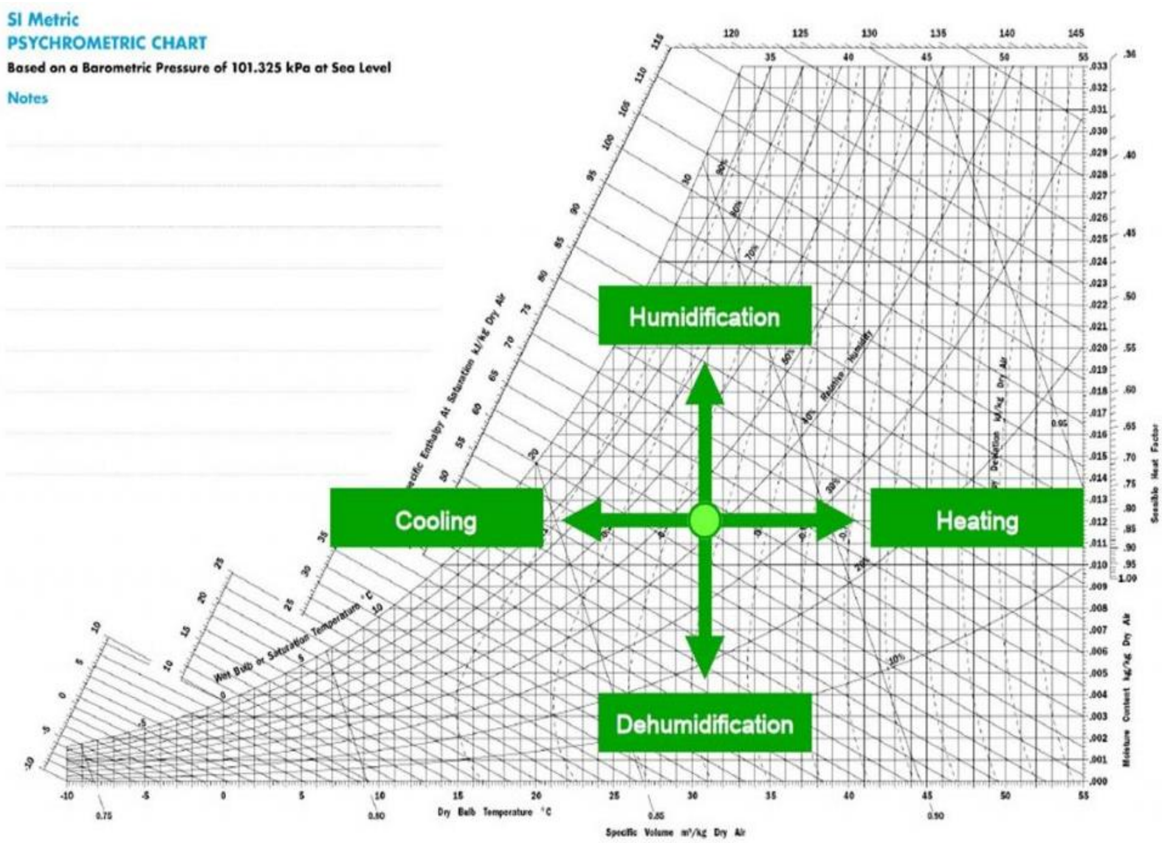


Figure 4.1 Process of air in psychrometrics

4.3 Temperature control approaches

Air is passed through a cooling or heating coil in an air conditioning system to manage temperature. This coil may use one of the following methods:

1. Change the temperature of the air being transported into the space while keeping the same airflow. The most basic approach is variable temperature, constant volume.
2. Modify the velocity of airflow while keeping the air provided to the area at a consistent temperature. In this case, the variable volume, constant temperature approach is applied.
3. Change the air temperature and airflow rate being delivered to the area space. This method uses a changeable volume and temperature.
4. Modify the temperature and flow rate of the supply air by first reducing the airflow rate to a minimum and then regulating the energy needed to reheat the coil in order

to adjust the temperature of the air. The technique of variable volume reheating is employed.

4.4 Humidity control approaches

Humidity can be managed by adjusting the amount of water vapour in the air in the space. When the relative humidity at the intended temperature set-point is too high, dehumidification is required to lower the amount of water vapour in the air for humidity control. Similar to this, when the relative humidity at the desired temperature set point is too low, humidification is required to raise the amount of water vapour in the air for humidity control. In an HVAC system, humidification is not always necessary, but when it is, a humidifier provides it.

Dehumidification techniques that are frequently employed include:

1. Sensible cooling and simultaneous surface dehumidification on cooling coils.
2. Directly removing moisture with dehumidifiers that use desiccant.

A humidifier provides the necessary humidity when it is needed in an HVAC system, which is not always the case. There are several popular humidification techniques:

1. Water spray humidifier
2. Steam pan humidifier

CHAPTER 5

Air Conditoning System Design

5

5.1 Air Conditioning System

The first obstacle to overcome in developing an air conditioning system is understanding the variables that affect a building's heat gain or loss; this process is known as heating or cooling load calculation. The reactive issue is to "design" controlled operations to maintain the intended condition or state-point inside the inhabited area; these activities are sometimes referred to as system processes that employ psychrometrics.

For designers of air conditioners, psychrometry is essential. A set of procedures known as air conditioning procedures is needed to keep a living space or industrial at the preferred temperature and humidity. It takes certain procedures known as air conditioning operations to keep a living space or an industrial facility at the desired temperature and humidity. These processes include:

1. Simple heating which raising the temperature
2. Simple cooling which lowering the temperature
3. Humidifying that adding moisture
4. Dehumidifying that removing moiture

A desired temperature and humidity level in the air can occasionally only be reached by combining two or more of these processes that are:

1. The air is commonly heated and humidified in winter
2. The air is also cooled and dehumidified in the summer time

Most air conditioning processes can be modeled as steady-flow processes with the following general mass and energy balances:

Mass balance: $\dot{m_{in}} = \dot{m_{out}}$

Mass balance for dry air: $\sum_{in} \dot{m_w} = \sum_{out} \dot{m_w}$

Mass balance for water: $\sum_{in} \dot{m_w} = \sum_{out} \dot{m_w}$ or $\sum_{in} \dot{m_a}\omega = \sum_{out} \dot{m_a}\omega$

Energy balance: $\dot{E_{in}} = \dot{E_{out}}$

$$\dot{Q_{in}} + \dot{W}_{in} + \sum_{in} \dot{m}h = \dot{Q_{out}} + \dot{W}_{out} + \sum_{out} \dot{m}h$$

Typically, the work component in energy balance relations is made up of the fan work input, which is negligible in comparison to the other factors.

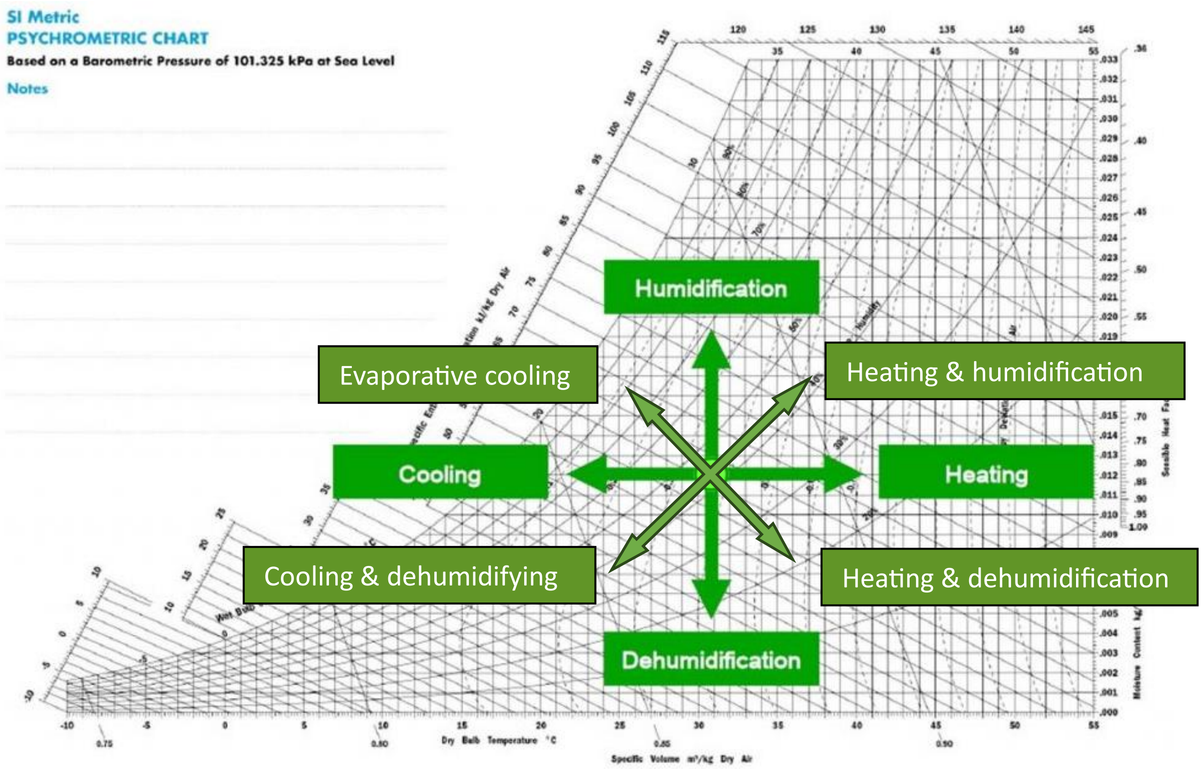


Figure 5.1 Air conditioning processes of air in psychrometric

5.2 Cooling and Heating Load Estimation

Heat transfer components that enter (gain) or exit (lose) a building's spaces are added together to provide load estimations. Each heat transfer component, also known as a load component, can be constructed into one of three different types of loads: external space loads, internal space loads, or system loads. It is necessary to acquire the following information from a set of blueprints, an assessment of the current building, or inhabitant interviews to fully comprehend how the different exterior, internal, and system load component's function:

1. Building area and volume
2. Building orientation (sun effects on surface)
3. Annual weather information (design conditions, heat transfer)
4. Use of the interior spaces of the building (the offices, conference rooms, laboratories, and data centres)
5. Operating hours (occupied and unoccupied)
6. Thermostat set points (main comfort parameter)
7. Dimensions of walls, roofs, windows, and doors
8. Materials used in construction (collect densities, exterior colour, and U-factors, or explain each type of material layer by layer (R-values)
9. Stairways and elevators (floor-to-floor openings)
10. People occupancy and activity
11. Lighting intensity and hours used
12. Electrical appliance sizes or kW and times they are used
13. Ventilation needs (IAQ and exhaust makeup)

Following that, the total heat gains calculated are added together to get the overall cooling load in kW or tonnes*. The basis for HVAC system design and operation is established by load estimation in conjunction with psychrometrics.

Note:
1 tonne = 12000 BTU//hr
1 kW = 3414 BTU's/hr

5.3 Determine Design Supply Airflow Rate

HVAC engineers use psychrometrics to translate their understanding of heating and cooling loads, which are represented in kW or tonnes, into volume flow rates, which are expressed in m^3/s or CFM, for the air that is cycled through the duct system. The volume flow rate is used to calculate the dimensions of packaged units, air-handling units, grills, outlets, and fans. This has an impact on the physical dimensions (footprint) of air handling units and package units and is the single most significant element for determining the amount of space needed for mechanical rooms and air distribution ducts.

Determining the volume flow rates of air to be forced into the ducting system and the size of the main system components are the two primary purposes of a psychrometric study of an air-conditioning system. Before doing so, let's review some fundamental psychrometrics before we analyse this in further depth.

CHAPTER 6

Psychrometric Processes in Air Conditioning System

6

6.1 Psychrometric Processes in Air Conditioning System

A process is said to be in motion whenever a thermodynamic system changes from one state-point to another. In psychrometric analysis, this change in state can be brought about by the addition or removal of heat, the application or removal of work to the fluid, the addition or removal of mass (often composed of water vapour), or the mixing of two fluids that are in different states.

The air quality at any given condition can be expressed as a single point on the chart. The point will move around the graph if conditions alter. Depending on whatever aspects of the air are changing, the point will travel in a specific direction.

6.2 Processes Involve in Psychrometrics

Most of the air conditioning practises involve one, a combination of, or a series of the following processes:

Cooling and heating

Circulating air over a cooling coil is a common way to cool air in HVAC systems. Use of finned-tube heat exchangers is widespread in cooling coils., in which cool water or refrigerant is forced through tubes with exterior fins to maximise the area of heat transfer if the air has been chilled. Water will condense and need to be drained from the cooling coil's bottom if the air is cooled below the dewpoint temperature.

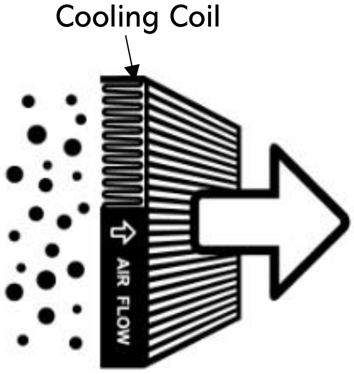


Figure 6.2. Cooled air stream flow

6.2.1 Sensible Cooling

The temperature starts to drop when warm, moist air flows over a cooling coil and is subsequently cooled. Condensation does not happen if the air exits the coil at a temperature higher than its dew point temperature. The humidity ratio stays constant since no moisture is condensed from the air, even when the temperature difference between the arriving and outgoing air is shown on a psychrometric chart. Sensible cooling refers to lowering air temperatures without affecting the amount of water in the atmosphere. We illustrate this process on the psychrometric chart with a horizontal line since the humidity ratio stays constant. The relative humidity cannot be controlled in this way, which might lead to unpleasant situations. When cooling is sensible, the relative humidity rises.

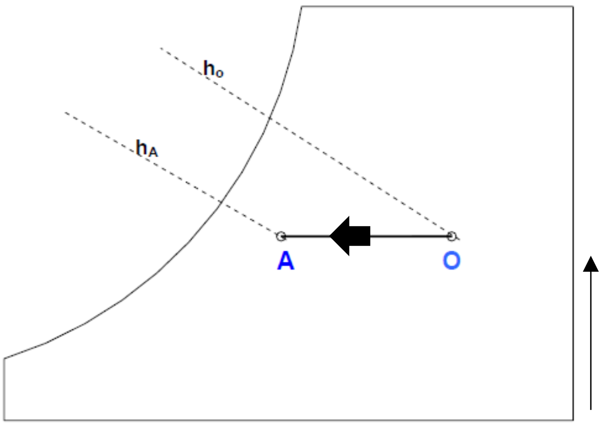


Figure 6.2.1 Sensible cooling process

6.2.2 Sensible Heating

In air conditioning systems, air is often heated via electric strip heaters or by passing it over a heating coil.

Straight horizontal lines parallel to the abscissa on the psychrometric chart reflect the sensible heating process. We illustrate this process on the psychrometric chart with a horizontal line since the humidity ratio stays constant. The relative humidity will decrease as it warms.

Common sensible cooling or heating methods include the use of space heating loads, sensible cooling loads, heating coils, space heating appliances, air-moving fans, sensible cooling coils, and radiant cooling or heating devices.

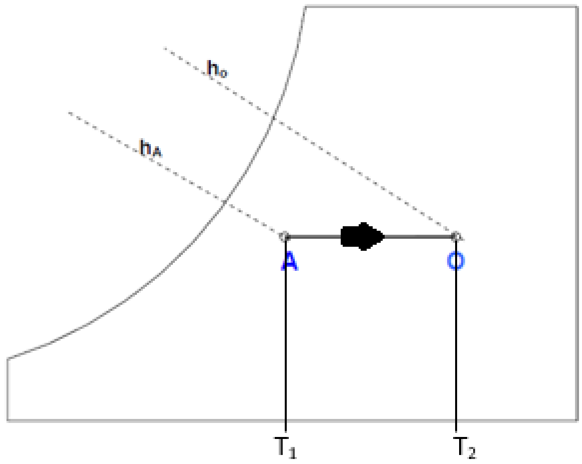


Figure 6.2.2 Sensible heating process

6.2.3 Humidification (Cooling or Heating)

This is how moisture is added to the airstream. In the winter, humidification is frequently necessary because the dry outside air that enters heated spaces unintentionally or purposefully to meet ventilation requirements is too chilly. In the summer, humidification is typically done in conjunction with an evaporative cooling system. The air is passed over a pool of water, steam is injected, or spray washers are all methods of humidification.

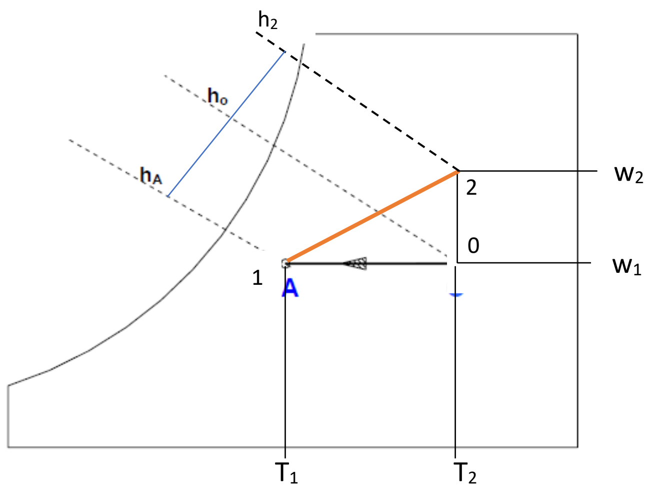


Figure 6.2.3 Humidification process

The process of heating and humidifying involves raising the air's dry-bulb temperature and relative humidity at the same time. Sensible and latent heat parts of the total heat

acquired (Q or q) during the transition from the starting to the final condition can be distinguished. The total enthalpy can be divided into sensible and latent heat by viewing a horizontal movement on the chart as representing sensible heat and a vertical movement as latent heat. When moving horizontally (sensible), the humidity ratio is constant, and when moving vertically (latent), the dry-bulb temperature is constant.

This process is represented on a psychrometric chart as an upward and right-sloping line. It is preferable to think of air heating and humidification as two separate processes. First, as the air passes through the heat exchanger, it sensible heats up and changes from state 1 to state 0. The humidification process is the second step, which takes us from state 0 to state 2.

6.2.4 Cooling and dehumidifying

Moisture is pulled out of the air stream and condensation occurs when air is cooled below the dew point temperature, Tdewpoint. The temperature and humidity ratio of the outgoing air stream are lower than those of the incoming air stream. Latent cooling or dehumidification is the cooling process used to condense water vapour from the air. Thus, both sensible and latent cooling are involved in this process. Latent and sensible cooling together make for total cooling. This process is depicted on a psychrometric chart as a line sloping downward and to the left. It is believed that this process will simply start with cooling and end with condensation. The assumption is that the air is still saturated as the moisture condenses.

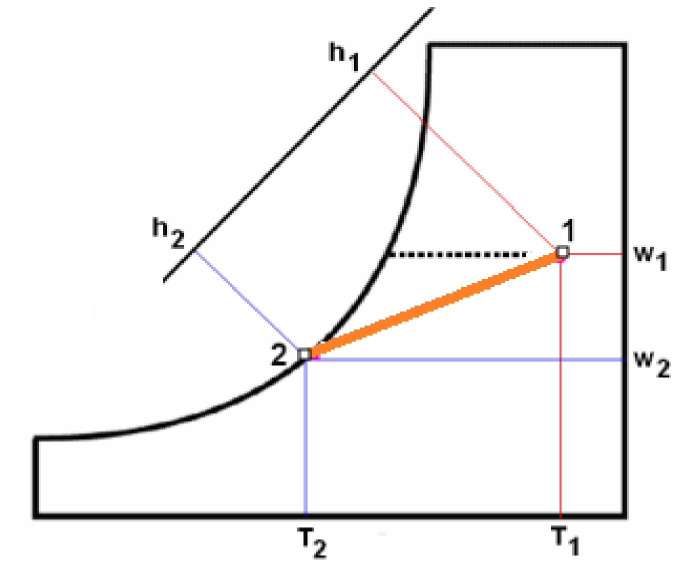


Figure 6.2.4 Cooling and dehumidifying process

Systems that operate in hot, humid areas adopt this procedure. This can only be accomplished by using a cooling coil whose surface temperature is below the dew point of water vapour in the air. The normal dew-point temperature of interior air operates at a temperature between 40° and 50°F, below the operating range of cooling coils in air conditioning systems. With the exception of the beginning condition (state 1), which is the warmer, more humid state, the computations are exactly the same for heating and humidifying. As previously, a sensible and latent heat part may be separated out of the total heat change (Q or q) that occurs when a condition changes from its initial state to its final state.

Chilled water and refrigerant cooling coils that condition recirculated room air or combinations of recirculated air and outside air that is supplied for ventilation are typical methods of cooling and dehumidifying. In order to effectively condense, the cooling coil's surface temperature must be lower than the dew point of the surrounding air.

6.2.5 Heating and dehumidification (Chemical Dehydration)

Modern air conditioning systems increasingly incorporate heating and dehumidification, which also known as "chemical dehydration," particularly in industrial settings. The molecules of water vapour in the air will be adsorbent when it comes into touch with a desiccant or sorption substance, making the air "dryer." Condensation heat will then enter the air stream, raising the temperature of the air stream as it happens. Fundamentally, the process is adiabatic or isenthalpic.

On the psychrometric chart, dehumidification by solid desiccants is depicted as an increase in dry-bulb temperature and a decrease in the humidity ratio. A line that is similar to this one shows the process of dehumidification using liquid desiccants; however, when the apparatus is internally cooled, the process air line on the graph can vary from being warm and moist to being cold and dry.

The desiccant dehumidification technique in this case is either adsorption (when no physical or chemical changes occur) or absorption (when physical or chemical changes occur). Desiccant heat wheels, which are commonly used for heating and dehumidification, can be set up for regulated dehumidification (typically dew point management) or in ventilation air streams used for latent heat recovery in warm, humid environments.

6.2.6 Evaporative Cooling (Chemical Dehydration)

As an adiabatic process, evaporative cooling results in no net heat gain or loss. The sensible heat of air vaporises the water when hot air is forced through wet spray, causing the air's dry bulb temperature to drop. No heat is supplied or withdrawn since the sensible heat needed to vaporise the water enters the air as latent heat in the additional vapour. The temperature of the wet bulb doesn't change.

To lower the air's dry bulb temperature without refrigeration, the evaporative cooling technique is frequently used. Reduced dry bulb temperature is achieved by a continuous wet bulb procedure. The essential components of an adiabatic saturation chamber plus a mechanism (wetted wick, matting, plates, spray, etc.) to enhance the surface area of the water reservoir's contact with the air make up the equipment needed to perform this technique.

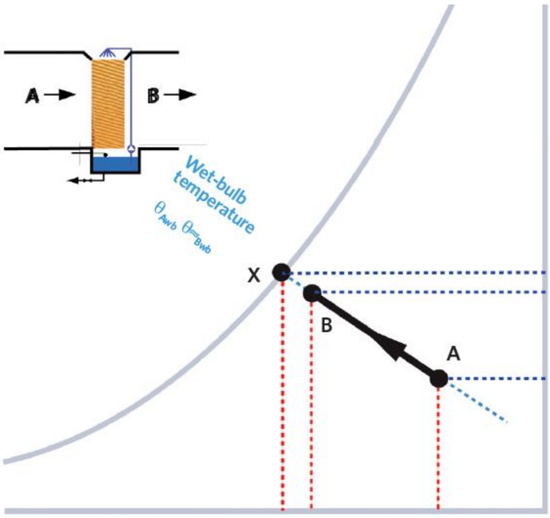


Figure 6.2.5 Evaporative cooling process

6.2.7 Adiabatic Processes

'Adiabatic' is a phrase that simply indicates that there is no energy gain or loss. This usually applies to the evaporative cooling and desiccant dehumidification procedures. Warm air passing close to water causes evaporative cooling. Even in temperatures much below their boiling point, surface-bound water molecules will gather sufficient energy from the flowing air to transition from one phase to another and produce moisture vapour. Eventually, the moisture vapour mixes with the air, changing the energy from sensible heat to latent heat of vaporisation. As a result, even while the air temperature decreases, the absolute humidity increases, keeping the total energy content, or enthalpy, constant.

When the air comes into contact with a material like silica gel or Condi's Crystals, desiccant dehumidification takes place. These chemicals just take moisture directly from the atmosphere. Through the process, the latent heat of the vaporisation is released back into the atmosphere, raising its temperature and reducing its absolute humidity. The net total enthalpy remains constant once more.

6.2.8 Mixing Process (Steady flow)

The parameters of the resultant mixture (enthalpy, dry bulb temperature, and saturation ratio) can be computed using basic proportional mass and energy balances when two streams of air with different properties and flow rates are mixed together.

The system may often be modelled as adiabatic since the heat loss from the system is minimal. The outgoing air stream's state has to be on the line joining the entering air streams on a psychrometric chart. The ratio of the mass flow rates of the entering streams determines how far down that line the distance will be.

In dual stream systems (double duct or multi-zone), the supply air-recirculated air mixing in fan-powered terminals, the outside air-return air mixing chamber of an air handling unit, and warm stream-cold stream mixing are examples of steady flow mixing processes.

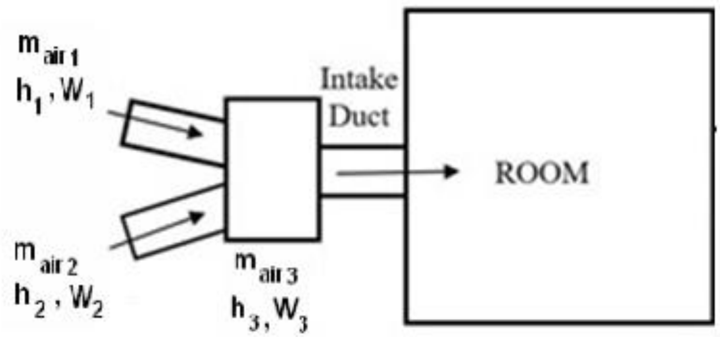


Figure 6.2.7 Mix air process

6.3 Bypass Factor

The air departing the cooling coil is not totally saturated because, in most cooling applications, some air does not come into contact with the coil. The fraction of air that does not reach the coil is known as the bypass factor (BF). The bypass factor can be determined using the temperature of the water delivered to the cooling coil as well as the characteristics of the air entering and exiting the system. The process is depicted on the psychrometric chart below.

The bypass factor (BF) of a cooling coil comes from the air that does not come into contact with it;

$$\mathrm{BF} = \frac{T_2 - T_3}{T_1 - T_3}$$

6.4 Sensible Heat vs Latent Heat Sensible

Sensible heat is the amount of heat that raises the dry-bulb temperature meanwhile the latent heat is the heat that is produced as a result of the atmosphere's water vapour concentration is known as latent heat. To cause the specified amount of moisture to evaporate, heat was necessary.

6.5 Sensible Heat Factor

Between the initial and final stages of conditioning, moist air undergoes a change in its thermodynamic properties. An air-conditioning process also describes the corresponding energy and mass transfers between the moist air and a medium, such as water, a refrigerant, an absorbent or adsorbent, or the moist air itself. The two guiding concepts for the study and computation of the moist air's thermodynamic characteristics are the energy balance and the conservation of mass.

Latent and sensible heat may be distinguished among the thermal characteristics of air. The ratio of the change in the absolute value of sensible heat to the change in the absolute value of total heat, both expressed in Btu/hr, is known as the sensible heat ratio (SHR) of an air-conditioning process:

$$\mathrm{SHF} = \frac{SH}{SH + LH}$$

where;

SHF = sensible heat factor

SH = sensible heat

LH = latent heat

The sensible heat change for any air-conditioning procedure

$$SH = 60 * Vs * \rho * c\,(T2 - T1) = 60 * m * c * (T2 - T1)$$

where;

Vs = volume flow rate of supply air

ρ = density of supply air

T2, T1 = moist air temperature at final and initial states of an air conditioning process

The mass flow rate of supply air is m = Vs * ρ

The latent heat change is

LH = 60 * Vs * ρ * (w2 – w1) * hfg = 1060 * 60 * Vs * ρ * (w2 – w1)

where;

w2, w1 = humidity ratio at final and initial states of an air-conditioning process

Questions

1. The sensible cooling process on a psychrometric chart is illustrated by
   (a) curved line
   (b) inclined line
   (c) vertical line
   (d) horizontal line

2. Lines of moist air with a constant dew point temperature are shown in psychrometric charts
   (a) curved
   (b) inclined
   (c) vertical
   (d) horizontal

3. Moist air's DBT and WBT differ in that
   (a) degree of saturation
   (b) wet bulb depression
   (c) dry bulb depression
   (d) dew point depression

4. Which of the subsequent statements about the saturated moist air is accurate?
   (a) DPT=WBT
   (b) DBT=WBT
   (c) DBT>WBT
   (d) DBT=WBT=DPT

5. The relative humidity of moist air during sensible heating
   (a) decreases
   (b) Increases
   (c) remain unchanged
   (d) may Increase or decrease

6. Saturated moist in the air denotes a relative humidity of
   (a) 50%
   (b) 100%
   (c) 80%
   (d) 90%

7. A moist air's sensible heat to total heat ratio is defined as
   (a) Relative humidity
   (b) humidity ratio
   (c) sensible heat factor
   (d) apparatus dew

8. Calculate the amount of heat needed to increase 14 m3 of air per minute, at 20°C and 80% relative humidity, to 35°C. What is the final relative humidity?

9. What amount of heat and moisture must be removed to bring 28 m3 of air down from a temperature of 35°C for a dry bulb and 26°C for a wet bulb to 21°C and 40% relative humidity?

10. Air enters the dehumidifier at a temperature of 24°C dry bulb and 15°C wet bulb, and it exits at a temperature of 41°C dry bulb and 19°C wet bulb. How many grammes of dry air have been produced after removing how much moisture?

11. Room air with a relative humidity of 50% and a dry bulb temperature of 26°C is to be mixed with outside air at 35° dry bulb and 24° wet bulb temperatures. The final combination should be made up of two thirds of return air from the room and one third outdoor air. The mixture's dry bulb and wet bulb temperatures should be determined.

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