



ENERGY SAVINGS PERFORMANCE AND MEASUREMENT & VERIFICATION ONLINE TRAINING COURSE

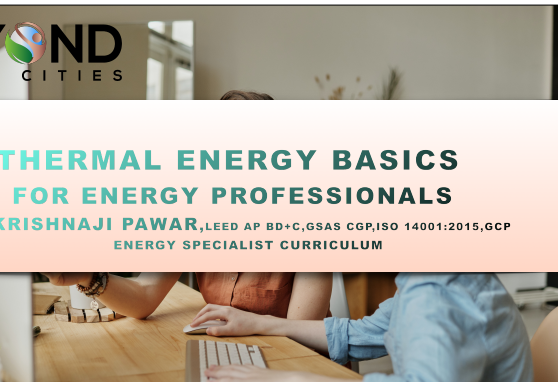
KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP
ENERGY SPECIALIST CURRICULUM





THERMAL ENERGY BASICS FOR ENERGY PROFESSIONALS

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP
ENERGY SPECIALIST CURRICULUM



WHAT SHOULD YOU LEARN



- Thermal energy contents of fuel,
- Temperature & Pressure
- Heat capacity,
- Sensible and Latent heat, Evaporation, Condensation,
- Steam, Moist air and Humidity & Heat transfer
- Units and conversion.



WHAT IS THERMAL ENERGY?

Thermal energy refers to the energy contained within a system that is responsible for its temperature. Heat is the flow of thermal energy. A whole branch of physics, thermodynamics, deals with how heat is transferred between different systems and how work is done in the process.

In the context of mechanics problems, we are usually interested in the role thermal energy plays in ensuring conservation of energy. Almost every transfer of energy that takes place in real world physical systems does so with efficiency less than 100% and results in some thermal energy.

Temperature and Pressure Temperature and pressure are measures of the physical state of a substance. They are closely related to the energy contained in the substance. As a result, measurements of temperature and pressure provide a means of determining energy content.



TEMPERATURE

It is the degree of hotness or coldness measured on a definite scale. Heat is a form of energy; temperature is a measure of its thermal effects. In other words, temperature is a means of determining sensible heat content of the substance.

In the Celsius scale the freezing point of water is 0°C and the boiling point of water is 100°C at atmospheric pressure.

To change temperature given in Fahrenheit (°F) to Celsius (°C) Start with (°F); subtract 32; multiply by 5; divide by 9; the answer is (°C)

To change temperature given in Celsius (°C) to Fahrenheit (°F) Start with (°C); multiply by 9; divide by 5; add on 32; the answer is (°F)

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5/9$$



PRESSURE

It is the force per unit area applied to outside of a body. When we heat a gas in a confined space, we create more force; a pressure increase. For example, heating the air inside a balloon will cause the balloon to stretch as the pressure increases.

Pressure, therefore, is also indicative of stored energy. Steam at high pressures contains much more energy than at low pressures.



SPECIFIC HEAT

If the same amount of heat energy is supplied to equal quantities of water and milk, their temperature goes up by different amounts. This property is called the specific heat of a substance and is defined as the quantity of heat required to raise the temperature of 1kg of a substance through 1°C.

Substance	Specific Heat (Joules / kg °C)
Lead	130
Mercury	140
Brass	380
Copper	390
Iron	470
Glass	670
Aluminium	910
Rubber	1890
Ice	2100
Alcohol	2400
Water	4200

The specific heat of water is very high as compared to other common substances; it takes a lot of heat to raise the temperature of water. Also, when water is cooled, it gives out a large quantity of heat.

Sensible heat It is that heat which when added or subtracted results in a change of temperature.

QUANTITY OF HEAT

The quantity of heat, Q, supplied to a substance to increase its temperature by t°C depends on

- ✓ mass of the substance (m)
- ✓ increase in temperature (Δt)
- ✓ specific heat of the substance (C_p)

The quantity of heat is given by:

$Q = \text{mass} \times \text{specific heat} \times \text{increase in temperature}$

$Q = m \times C_p \times \Delta t$

Phase Change:

The change of state from the solid state to a liquid state is called fusion. The fixed temperature at which a solid changes into a liquid is called its melting point. The change of a state from a liquid state to a gas is called vaporization.

LATENT HEAT OF FUSION

The latent heat of fusion of a substance is the quantity of heat required to convert 1kg solid to liquid state without change of temperature. It is represented by the symbol L. Its unit is Joule per kilogram (J/Kg) Thus,
 $L(\text{ice}) = 336000 \text{ J/kg}$,

Latent Heat of Vaporization :

The latent heat of vaporization of a substance is the quantity of heat required to change 1kg of the substance from liquid to vapour state without change of temperature. It is also denoted by the symbol L and its unit is also J/kg. The latent heat of vaporization of water is 22,60,000 J/kg. When 1 kg of steam at 100°C condenses to form water at 100°C, it gives out 2260 kJ (540 kCals) of heat. Steam gives out more heat than an equal amount of boiling water because of its latent heat.

LATENT HEAT OF FUSION +

Latent heat : It is the change in heat content of a substance, when its physical state is changed without a change in temperature

Super Heat : The heating of vapour, particularly saturated steam to a temperature much higher than the boiling point at the existing pressure. This is done in power plants to improve efficiency and to avoid condensation in the turbine.

Humidity : The moisture content of air is referred to as humidity and may be expressed in two ways: specific humidity and relative humidity.

Specific Humidity : It is the actual weight of water vapour mixed in a kg of dry air.

Humidity Factor :
Humidity factor = kg of water per kg of dry air (kg/kg).

RELATIVE HUMIDITY (RH)

It is the measure of degree of saturation of the air at any dry-bulb (DB) temperature. Relative humidity given as a percentage is the actual water content of the air divided by the moisture content of fully saturated air at the existing temperature.

Dew Point : It is the temperature at which condensation of water vapour from the air begins as the temperature of the air-water vapour mixture falls.

Dry bulb Temperature : It is an indication of the sensible heat content of air water vapour mixtures.

Wet bulb Temperature: It is a measure of total heat content or enthalpy. It is the temperature approached by the dry bulb and the dew point as saturation occurs.

Dew Point Temperature It is a measure of the latent heat content of air-water vapour mixtures and since latent heat is a function of moisture content, the dew point temperature is determined by the moisture content.

FUEL DENSITY +

Density is the ratio of the mass of the fuel to the volume of the fuel at a stated temperature.

Specific gravity of fuel : The density of fuel, relative to water, is called specific gravity. The specific gravity of water is defined as 1. As it is a ratio there are no units. Higher the specific gravity, higher will be the heating values.

Viscosity : The viscosity of a fluid is a measure of its internal resistance to flow. All liquid fuels decrease in viscosity with increasing temperature

Calorific Value Energy content in an organic matter (Calorific Value) can be measured by burning it and measuring the heat released. This is done by placing a sample of known mass in a bomb calorimeter, a device that is completely sealed and insulated to prevent heat loss. A thermometer is placed inside (but it can be read from the outside) and the increase in temperature after the sample is burnt completely is measured. From this data, energy content in the organic matter can be found out.