Diploma Mechanical Study Material - Thermal Engineering - 1

Thermal Engineering-1 Study Material

BASICS OF THERMODYNAMICS AND THERMODYNAMIC PROCESSES OF PERFECT GASES

Introduction – definitions and units of mass, weight, volume, density, work –power- energy – types- specific weight, specific gravity and specific volume – pressure – units of pressure – temperature - absolute temperature – S.T.P and N.T.P conditions – heat -specific heat capacity at constant volume and at constant pressure

UNIT – I BASICS OF THERMODYNAMICS AND THERMODYNAMIC PROCESSES OF PERFECT GASES

Introduction

- Thermodynamics is a branch of science that deals with the relations between heat, and work.
- Thermodynamics deals with the study of energy transformations within systems and transfer of energy across the boundaries of the system.

Definition and Units

Mass

- Mass is the amount of matter contained in an object, and does not depends on gravity.
- Mass is measured in grams or kilograms. Therefore it is denoted by letter ‘W’ and its unit is Kg.

Weight

Weight is the amount of mass of an object, and it’s dependent upon gravity. It is denoted by letter ‘W’ and Its unit is Newton. Mathematically,

W = m g .

Where, ‘g’ is the acceleration due to gravity in m/s2.

Force

According to Newton’s second law of motion, the applied force or impressed force is directly proportional to the rate of change of momentum. It is denoted by letter ‘F’. Its unit is Newton (N). Mathematically,

F = Mass x Acceleration

F = m a

Note:

1N = 1kg-m/s2

Volume

Volume is defined as the ratio of mass to density. It is also defined as the space occupied by the mass. Its unit is m3. It is denoted by ‘V’. Mathematically,

Note:

1000 c.c = 1 litre = 0.001m3

Density

The amount of matter (mass) in a given amount of space (volume) Density is defined as mass per unit volume. Its unit is kg/m3. It is denoted by 'ρ'. It is also known as mass density or specific mass.

Specific Weight
Specific weight is defined as the weight per unit volume. Its unit is N/m3. It is denoted by 'w'. It is also known as weight density. Mathematically,

Specific Gravity
Specific gravity is defined as the ratio of density of given liquid to the density of a standard fluid (water). It has no unit. It is denoted by 's'. It is also known as relative density.

Note:
Density of water (ρw) = 1000 kg/m3.

Specific Volume
The volume occupied by unit mass is known as specific volume. Its unit is m3/kg. It is denoted by 'vs'.
Therefore, it is the reciprocal of density, i.e. v = 1/ρ.

Pressure
Pressure is defined as the normal force per unit area of the surface. The unit of pressure depends upon the units of force and area. Its unit is N/m2, Pascal (Pa) and bar. It is denoted by 'p'. Mathematically,

Note:
1 bar = 1x105 N/m2 = 100 kN/m2 = 0.1 MN/ m2.
1Pa = 1 N/m2
1kPa= 1 kN/m2

Gauge pressure and Absolute pressure
The reading of the pressure gage is known as gauge pressure, while the actual pressure is called absolute pressure. Mathematically,
For pressures above atmospheric,
Absolute pressure = Atmospheric pressure + Gauge pressure
For pressures below atmospheric, the gauge pressure will be negative. This negativepressure is known as vacuum pressure. Mathematically,
Absolute pressure = Atmospheric pressure – Vacuum pressure
Note:
pabs = patm + pg
pabs = patm – pv
Patm= 760 mm of Hg = 1.01325 bar = 1.01325 x 105 N/m2 = 101.325 kN/m2
Temperature
Temperature is the amount of heat in a system.
Temperature is defined as the degree of hotness or coldness of a body. The unit of temperature measurement is degree. It is denoted by 'T'. When the heat is added to a body and it becomes

hotter, its temperature is said to rise.
When a body cools down, its temperature is said to fall.

Absolute Temperature

Absolute zero temperature is taken as -273°C. The temperatures measured from this zero are called absolute temperatures. The absolute temperature in Celsius scale is called degree Kelvin (K). Mathematically,
Absolute Temperature in K = Temperature in °C + 273

Standard Temperature and Pressure (S.T.P)

The temperature and pressure of any gas, under standard atmospheric conditions, is taken as 15°C (288 K) and 760 mm of Hg respectively.

Normal Temperature and Pressure (N.T.P)

The conditions of temperature and pressure at 0°C (273 K) temperature and 760 mm of Hg pressure are termed as normal temperature and pressure

Heat

Heat is a form of energy. It can be transferred from one body to another due to the difference of temperature.
Heat is defined as the energy transferred, without transfer of mass, across the boundary of a system because of a temperature difference between the system and the surroundings. It is expressed in Joule (J). It is usually represented by 'Q'.

Specific Heat Capacity

It is defined as the amount of heat required to raise or lower the temperature of a unit mass of any substance through one degree. Its unit is kJ/kgK. It is denoted by 'C'.

Specific Heat at Capacity at Constant Volume

It is defined as the amount of heat required to raise or lower the temperature of a unit mass of any substance through one degree when the volume remains constant. Its unit is kJ/kgK. It is denoted by 'Cv'.

$Q = m \cdot C_v \cdot dT$

Where Q = Heat transferred (kJ)
m = Mass of the gas (kg)
C_v= Specific heat capacity at constant volume (kJ/kgK)
$dT = (T_2 - T_1)$ = Temperature difference (K)