

Chapter no.02

The working fluids

In this chapter we will discuss these topics:

2.1 Liquid, vapour, and gas

2.2 The use of vapour tables

2.3 The perfect gas

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In previous chapter we study that the matter contained within the boundaries of a system is defined as the working fluid, and it is stated that when two independent properties of the fluid are known then the thermodynamics state of the fluid is defined. In thermodynamic systems the working fluid can be in the liquid, vapour, or gaseous phase.

2.1 Liquid, vapour, and gas

2.1.1 Liquid:

- A liquid is nearly incompressible fluid that conforms to the shape of its container but retains a (nearly) constant volume independent of pressure.
- Important difference exists between them; liquid describes a state of matter—as do “solid” and “gaseous”—whereas a fluid is any substance that flows.
Example, Nitrogen gas, for example, is a fluid, whereas orange juice is both a liquid and a fluid.

2.1.2 Vapour:

- Vapour refers to a gas phase at a temperature where the same substance can also exist in the liquid or solid-state, below the critical temperature of the substance.
- Fixed gases are gases for which no liquid or solid can form at the temperature of the gas, such as air at typical ambient temperatures.

2.1.3 Gases:

- An ideal gas is a theoretical gas composed of many randomly moving point particles whose only interactions are perfectly elastic collisions.

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2.2 The use of vapour/steam tables:

Steam tables are generally used when you deal with steam engines/turbines or other steam involving applications. We use these tables because hand-calculating all properties may not be possible at times. For example, specific heats for a fluid are a weak non-linear function of temperature.

2.2.1 Saturation state properties:

1. Specific enthalpy of vaporization:

The heat required to change a saturated liquid to a dry saturated vapour is called the specific enthalpy of vaporization, h_{fg} .

2.2 The use of vapour tables

2.2.1 Saturation state properties

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2.2.2 Properties of wet vapour

Definition of the wet vapour:

Wet steam is a mixture of **steam** and liquid water. It exists at a saturation temperature containing more than 5% water. It is said to be a two-phase mix: **steam** contains droplets of water that have not changed phase. ... **Wet steam** is also known as supersaturated **steam**.

2.2.3 Properties of superheated vapour:

When the vapour is at a **temperature** greater than the saturation **temperature**, it is said to exist as superheated vapor. The pressure and **temperature** of superheated vapor are independent properties, since the **temperature** may increase while the pressure remains constant.

2.3 The perfect gas

2.3.1 The characteristic equation of state

Equation of state. ... In physics and **thermodynamics**, an **equation of state** is a **thermodynamic equation** relating **state** variables which describe the **state** of matter under a given set of physical conditions, such as pressure, volume, temperature (PVT), or internal energy.

2.3.2 Specific Heat capacity:

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Specific heat capacity. ... Informally, it is the amount of energy that must be added, in the form of **heat**, to one unit of mass of the substance in order to cause an increase of one unit in its temperature. The SI unit of **specific heat** is joule per kelvin and kilogram, J/(K kg).

2.3.3 Joule's law:

Joule conducted a series of **experiments** which showed the relationship between heat and work in a **thermodynamic** cycle for a system. He used a paddle to stir an insulated vessel filled with fluid. The amount of work done on the paddle was noted (the work was done by lowering a weight, so that work done = mgz).

2.3.4 Relationship between the specific heat capacities:

Molar **heat capacity** is a measure of the amount of **heat** necessary to raise the temperature of one mole of a pure **substance** by one degree K. **Specific heat capacity** is a measure of the amount of **heat** necessary to raise the temperature of one gram of a pure **substance** by one degree K.

2.3.5 Specific enthalpy of a perfect gas:

Perfect gas is one in which intermolecular forces are not considered. Most of the **gases** behave as **perfect gases** at low pressures and at very high temperatures. **Perfect gas** obeys **ideal gas** law and it has constant specific heats. C_p , C_v has constant values.

2.3.6 Ratio of specific heat capacities:

The **ratio** of the **specific heats** $\gamma = C_p/C_v$ is a factor in adiabatic engine processes and in determining the speed of sound in a gas. This **ratio** $\gamma = 1.66$ for an ideal monoatomic gas and $\gamma = 1.4$ for air, which is predominantly a diatomic gas.
