Thermal – Fluids Lecture 1. Fundamental Concepts and Definitions

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Thermodynamics

The science of the conversion of energy from one form to another.

We study the relationships between:

HEAT
WORK
ENERGY (internal, mechanical, enelctrical, etc..)
PHYSICAL PROPERTIES OF SUBSTANCES (properties of the working medium)

System

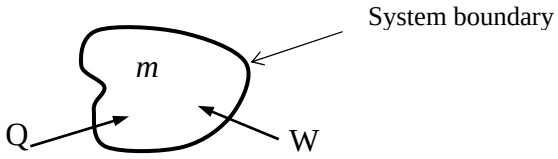
A system is any quantity of matter, or any region of space of interest for the purposes of analysis. (Note that systems have boundaries: fixed, deformable, or imaginary)

We consider the following systems:

CLOSED
OPEN
ISOLATED

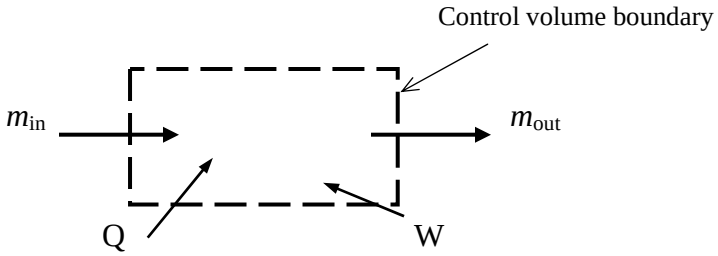
CLOSED system, also known as a control mass system.

A closed system represents a fixed amount of mass, *m*, confined by a boundary.
Only heat, Q, and work, W, can cross the boundary and interact with its surroundings.
There can be no mass, *m*, transfer across the boundary



OPEN system, also known as <u>control volume</u> system

An open, or control volume, system is an imaginary boundary enveloping a particular region or device of interest through which mass flows between it and its surroundings. The control volume is generally a fixed volume with mass, heat and work interaction across its boundaries.



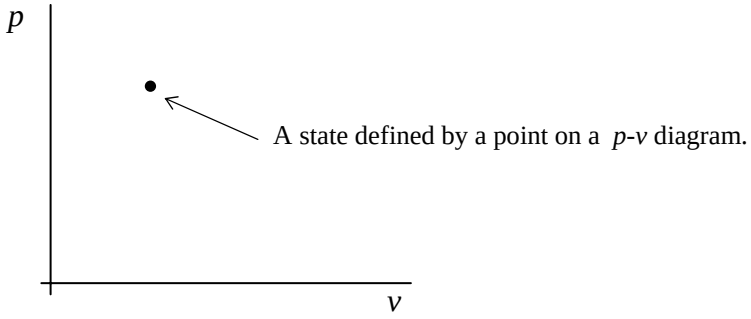
An **ISOLATED** system is a special case of a closed system where no interaction occurs across its boundaries. No mass, heat or work transfer occurs between it and its surroundings.

PROPERTIES

To describe a system we must know its properties and how these properties are related. A Property is a macroscopic characteristic such as pressure, volume, temperature, mass and energy. There are two classes of properties: **extensive** and **intensive**. Extensive properties depend on the size of mass of the system; for example extensive properties are mass, volume, energy. Intensive variables do not depend on the size or mass of the system; examples are temperature, pressure, and specific variables. Specific variables are formed by dividing and extensive variables by the mass. Specific volume is equal to the volume of the system divided by its mass, similarly, specific energy is the total energy divided by its mass.

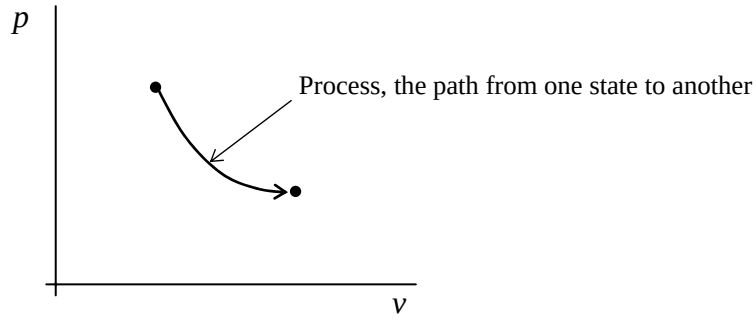
STATE

State is the condition of a system defined by its properties. The relation between its properties is called and equation of state. For example the relationship between the pressure, temperature and specific volume is called an equation of state.



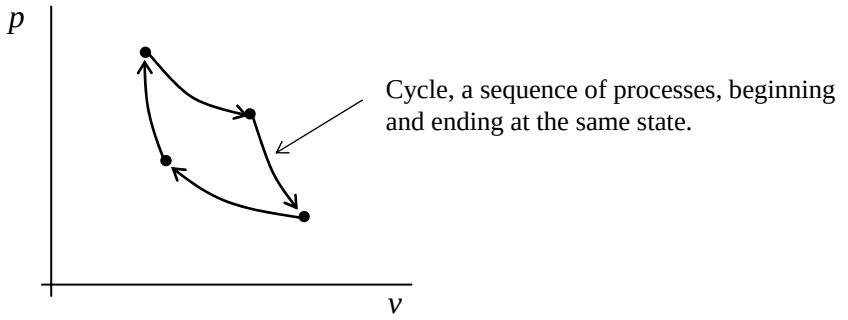
PROCESS

We are generally interested in changes from one state to another. The process of changing from one state to another is called a process.



CYCLE

A sequence of processes that begin and ends at the same state is called a cycle.



PURE SUBSTANCE

A pure substance is one of uniform chemical composition. We shall be dealing only with pure substances. Note that although air is a mixture of gases, we shall treat it as a pure substance.

EQUILIBRIUM

A state of a system with properties that do not vary in time is said to be in a state of equilibrium. A process that takes us from one state to another is modeled as a sequence of equilibrium states. The change is state is relatively slow compared to any changes that occur in the system. For example, the pressure and temperature change nearly instantaneously on a microscopic level compared with the macroscopic effort to change

the pressure and temperature. The changes of state in a process are thus said to occur quasistatically.

Units

We deal with the following units:

Force (F)
Mass (m)
Length (L)
Time (t)

The fundamental relationship between these units is given by Newton's Second Law:

$$F = ma = mL/t^2$$

In the System International (SI) system the primary units are:

Mass (kilogram, *kg*), length (meter, *m*) and time (second, *s*), the unit force (Newton, *N*) is a derived quantity from Newton's 2nd law as above.

In the customary US engineering system the primary units are:

Force (pound force, lb_f), length (*ft*), and time (second, *s*)