Thermodynamics Definitions

1 Introduction to Thermodynamics

Thermodynamics is the science of energy. There are two kinds of thermodynamics. When applying **classical thermodynamics**, we do not consider individual atoms. We only look at a so-called **continuum**. In **statistical thermodynamics** we do deal with large groups of particles. In this summary we will generally discuss classical thermodynamics though.

2 Systems and their Properties

A **system** is defined as a quantity of matter or a region in space chosen for study. The mass/region outside the system is called the **surroundings**. The surface in between is the **boundary**. The boundary can be fixed or movable. A system can also be closed or open. In a **closed system** no mass can cross the boundary, while in an **open system** (also called a **control volume**) mass exchange with the surroundings is possible.

A characteristic of a system is called a **property**. There are multiple types of properties. **Intensive properties** do not directly depend on the amount of matter in the system (like temperature and pressure). **Extensive properties** like mass and volume do directly depend on the number of particles. When extensive properties are calculated per unit mass, then they are **specific properties**. These specific properties are usually denoted by small letters. Examples are the **specific volume** $v = \rho^{-1}$ (where ρ is the density) and the **specific weight** $\gamma = \rho g$.

3 Equilibrium States

In thermodynamics, we consider the **state** or condition of a system. We usually deal with **equilibrium states**. A system in equilibrium experiences no changes when it is isolated from its surroundings. A system is in **thermal equilibrium** if the temperature is the same throughout the system. It is in **mechanical equilibrium** if the pressure stays constant. There are also more complicated types of equilibrium. Only if all the above equilibrium states are present, a system is in so-called **thermodynamic equilibrium**.

But how do we express the state of a system? We do this by using properties. The **state postulate** says that the state of a simple compressible system is specified by two independent intensive properties. This postulate requires some clarification. A system is **compressible** if the density isn't constant throughout the system. A system is a **simple system** if electrical effects, magnetic effects, gravitational effects, and so on, are not present. (Otherwise an additional property is needed for every effect that is present.) Also two properties are **independent** if one property can be varied while the other is held constant.

4 Processes

A **process** is the change of a system from one state to another. The **path** is the series of states through which the system passes. A system has undergone a **cycle** if the initial and final states of the process are the same.

There are multiple types of processes. When the system remains very close to an equilibrium state at all times, we have a **quasi-static process**. In a **steady-state flow process** a fluid flows through a control volume steadily. The term **steady** indicates nothing changes in time.

Also the prefix "iso" can be used to indicate certain properties stay constant. In an **isothermal process** the temperature T stays constant. In an **isobaric process** the pressure P remains the same. Finally in **adiabatic processes** there is no heat exchange with the surroundings.

5 Pressure

Pressure is a normal force exerted per unit area. It is the same in all directions, and is therefore a scalar quantity. The **absolute pressure** is the pressure measured relative to a vacuum. Pressure is often measured with respect to atmospheric pressure. We then speak of **gage pressure**. In thermodynamics, the absolute pressure (denoted by P) is almost always used though.

The pressure varies with the height z, due to gravity. How this occurs can be derived by looking at a small piece of fluid/gas. Doing this will result in

$$\frac{dP}{dz} = -\rho g = -\gamma. \tag{5.1}$$

This principle is used in a **manometer**. This is a device that measures pressure differences. It consists of a U-tube with a fluid, connecting two parts A and B. When a pressure difference is present between A and B, then the fluid levels h_A and h_B will not be equal. The relation between the pressures in A and B is then given by

$$P_A - P_B = \rho g \left(h_B - h_A\right) = \gamma \left(h_B - h_A\right). \tag{5.2}$$