MECHANICAL ENGINEERING SCIENCE (UE25ME141A/B)

Dr. Mantesh B Khot

Department of Mechanical Engineering

Thermodynamic Equilibrium

Equilibrium refers to a state of balance within the system and between the system and its surroundings.

A system is said to be thermodynamic equilibrium when no change in macroscopic property is observed after it is isolated from its surroundings.

Such a system has to possess the following types of equilibria: -

1. Mechanical Equilibrium
2. Chemical Equilibrium
3. Thermal Equilibrium
4. Other Equilibria such as Electrical Equilibrium, Phase Equilibrium etc.

Process

When a system undergoes a change of state, it is said to have undergone a process. During a process, it is implicit that the system is not in a state of thermodynamic equilibrium.

When a process takes place, the values of the properties change.

However, during a process, one or more properties of the system may remain constant. This makes the process distinct and gives it a name: -

- ✓ isothermal process – temperature remains constant
- ✓ Isobaric process– pressure remains constant
- ✓ Isochoric process – volume remains constant
- ✓ Isentropic process – entropy remains constant.

Quasi static or Quasi Equilibrium Process

Quasi-static Process

A **quasi-static process** (or **quasi-equilibrium process**) is a thermodynamic process that happens **infinitely slowly**, so the system remains nearly in **thermodynamic equilibrium** at every instant during the process.

Key Features

- The process proceeds so slowly that the system passes through a continuous sequence of **equilibrium states**.
- Because the system is always nearly at equilibrium, its properties (like pressure, volume, temperature) are well-defined at every moment.
- This makes quasi-static processes idealized models — real processes can never be perfectly quasi-static because they always involve some finite rate and irreversibility.
- It allows us to apply the laws of thermodynamics easily because the system is always close to equilibrium.

Temperature

Temperature is a measure of the hotness or coldness of a system

Since hotness or coldness is a highly relative term, temperature cannot be measured in an absolute sense.

To overcome this, we define equality of temperature or thermal equilibrium.

Equality of Temperature

Two systems or a system and its surrounding are said to have equality of temperature if there is no change in any observable property when they are brought into thermal contact.

- When two objects are in contact, heat flows from the hotter object to the cooler one.
- This heat flow continues until both objects reach the **same temperature**.
- At that point, **no net heat transfer** occurs between them.
- This state is called **thermal equilibrium**.

Example

- If you put a hot cup of tea and a cold room-temperature spoon together, heat will flow from the tea to the spoon.
- Eventually, the spoon warms up, and the tea cools down.
- They both reach the **same temperature** (equality of temperature), and then heat flow stops.

Zeroth Law of Thermodynamics

"When two systems, say A and B are independently in thermal equilibrium with a third system, say C, then they are in thermal equilibrium with each other. "

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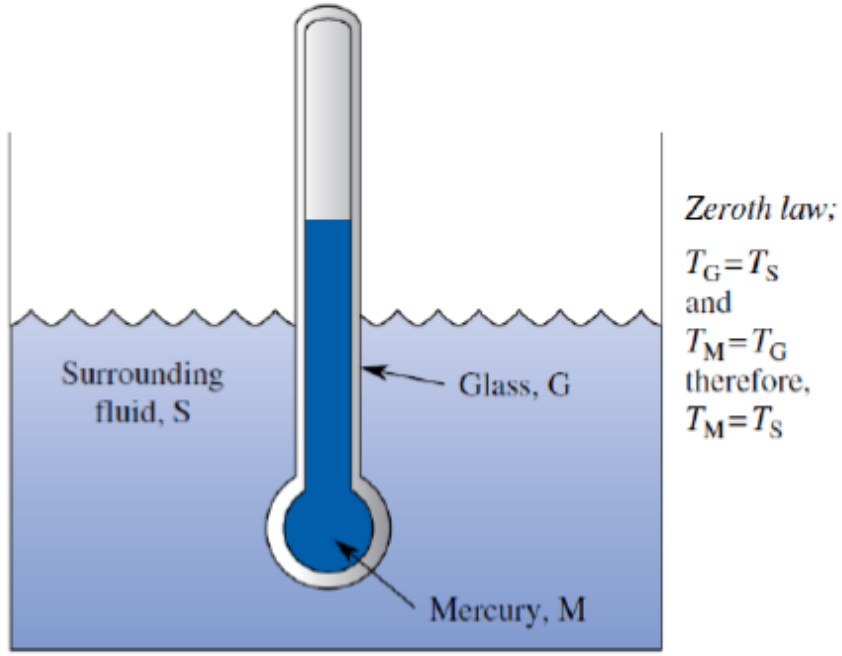
Illustration of Zeroth Law of Thermodynamics as basis for Temperature Measurement

Consider the mercury in glass thermometer shown.

The Zeroth Law tell us that if the glass is at the same temperature (thermal equilibrium) as the surrounding fluid, and if the mercury is at the same temperature as the glass, then the mercury is at the same temperature as the surrounding fluid.

Thus, the thermometer can be calibrated to show the temperature of mercury, and this temperature, by the Zeroth Law, is equal to the temperature of the surrounding fluid.



THANK YOU

Dr. Mantesh B Khot
Department of Mechanical Engineering
mahanteshbk@pes.edu
+91 87 2202 4584