# THERMODYNAMIC SYSTEMS

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**ABSTRACT:** A thermodynamic system is any three-dimensional region of space that is bounded by one or more surfaces. The bounding surfaces may be real or imaginary and may be at rest or in motion. The boundary may change its size or shape. The region of physical space that lies outside the selected boundaries of the system is called the surroundings or the environment.

**KEY WORDS**: system, thermodynamic, process.

## 1. INTRODUCTION

Thermodynamics involves the study of various systems. A system in thermodynamics is nothing more than the collection of matter that is being studied. A system could be the water within one side of a heat exchanger, the fluid inside a length of pipe, or the entire lubricating oil system for a diesel engine. Determining the boundary to solve a thermodynamic problem for a system will depend on what information is known about the system and what question is asked about the system.

Thermodynamic system is composed of several bodies properties different, which are in mechanical and thermal interaction. Ensemble is the external environment surrounding bodies. If thermodynamic system is considered extensive, covering it and the external environment, results in a broadened thermodynamic system.

Everything external to the system is called the thermodynamic surroundings, and the system is separated from the surroundings by the system boundaries. These boundaries may either be fixed or movable. In many cases, a thermodynamic analysis must be made of a device, such as a heat exchanger, that involves a flow of mass into and/or out of the device. The procedure that is followed in such an analysis is to specify a control surface, such as the heat exchanger tube walls. Mass, as well as heat and work (and momentum), may flow across the control surface.

### Types of Thermodynamic Systems

Systems in thermodynamics are classified as isolated, closed, or open based on the possible transfer of mass and energy across the system boundaries. An isolated system is one that is not influenced in any way by the surroundings. This means that no energy in the form of heat or work may cross the boundary of the system. In addition, no mass may cross the boundary of the system.

A thermodynamic system that do not change with the outside or heat or mechanical work is called isolated thermodynamic system.

A thermodynamic system is defined as a quantity of matter of fixed mass and identity upon which attention is focused for study. A closed system has no transfer of mass with its surroundings, but may have a transfer of energy (either heat or work) with its surroundings.

An open system is one that may have a transfer of both mass and energy with its surroundings (figure 1).

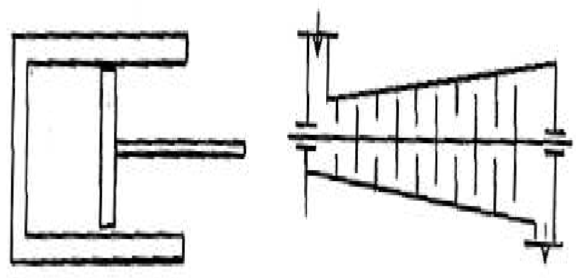

Figure 1. a)closed system; b)open system

**Thermodynamic Equilibrium**

When a system is in equilibrium with regard to all possible changes in state, the system is in thermodynamic equilibrium.

For example, if the gas that comprises a system is in thermal equilibrium, the temperature will be the same throughout the entire system.

**Control Volume**

A control volume is a fixed region in space chosen for the thermodynamic study of mass and energy balances for flowing systems. The boundary of the control volume may be a real or imaginary envelope. The control surface is the boundary of the control volume.

**Steady State**

Steady state is that circumstance in which there is no accumulation of mass or energy within the control volume, and the properties at any point within the system are independent of time.

**Thermodynamic Process**

Whenever one or more of the properties of a system change, a change in the state of the system occurs. The path of the succession of states through which the system passes is called the thermodynamic process.

One example of a thermodynamic process is increasing the temperature of a fluid while maintaining a constant pressure. Another example is increasing the pressure of a confined gas while maintaining a constant temperature.

**Cyclic Process**

When a system in a given initial state goes through a number of different changes in state (going through various processes) and finally returns to its initial values, the system has undergone a cyclic process or cycle. Therefore, at the conclusion of a cycle, all the properties have the same value they had at the beginning. Steam (water) that circulates through a closed cooling loop undergoes a cycle.

**Reversible Process**

A reversible process for a system is defined as a process that, once having taken place, can be reversed, and in so doing leaves no change in either the system or surroundings.

In other words the system and surroundings are returned to their original condition before the process took place. In reality, there are no truly reversible processes; however, for analysis purposes, one uses reversible to make the analysis simpler, and to determine maximum theoretical efficiencies. Therefore, the reversible process is an appropriate starting point on which to base engineering study and calculation. Although the reversible process can be approximated, it can never be matched by real processes. One way to make real processes approximate reversible process is to carry out the process in a series of small or infinitesimal steps.

For example, heat transfer may be considered reversible if it occurs due to a small temperature difference between the system and its surroundings.

For example, transferring heat across a temperature difference of 0.00001 °F to be more reversible than for transferring heat across a temperature difference of 100 °F.

Therefore, by cooling or heating the system in a number of infinitesamally small steps, we can approximate a reversible process. Although not practical for real processes, this method is beneficial for thermodynamic studies since the rate at which processes occur is not important.

**Irreversible Process**

An irreversible process is a process that cannot return both the system and the surroundings to their original conditions. That is, the system and the surroundings would not return to their original conditions if the process was reversed.

For example, an automobile engine does not give back the fuel it took to drive up a hill as it coasts back down the hill.

There are many factors that make a process irreversible. Four of the most common causes of irreversibility are friction, unrestrained expansion of a fluid, heat transfer through a finite temperature difference, and mixing of two different substances. These factors are present in real, irreversible processes and prevent these processes from being reversible.(figure 2)

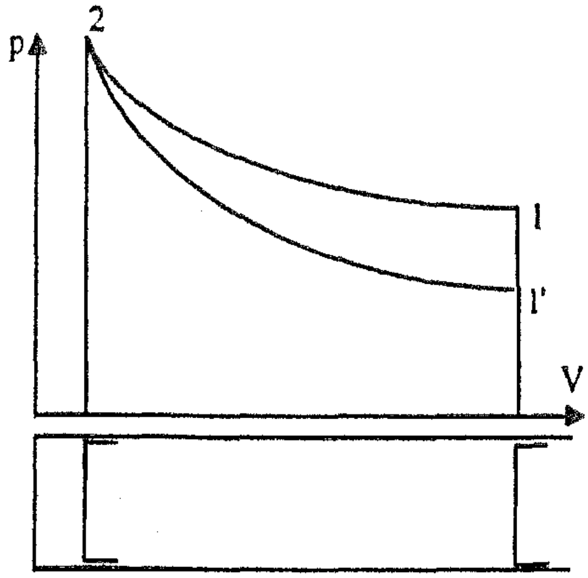


Figure 2 Reversible and irreversible process

**Adiabatic Process**

An adiabatic process is one in which there is no heat transfer into or out of the system. The system can be considered to be perfectly insulated.

**Isentropic Process**

An isentropic process is one in which the entropy of the fluid remains constant. This will be true if the process the system goes through is reversible and adiabatic. An isentropic process can also be called a constant entropy process.

**Polytropic Process**

When a gas undergoes a reversible process in which there is heat transfer, the process frequently takes place in such a manner that a plot of the Log P (pressure) vs. Log V (volume) is a straight line. Or stated in equation form $PV^n$ = a constant. This type of process is called a polytropic process. An example of a polytropic process is the expansion of the combustion gasses in the cylinder of a water-cooled reciprocating engine.

**Throttling Process**

A throttling process is defined as a process in which there is no change in enthalpy from state one to state two, $h_1 = h_2$; no work is done, W = 0; and the process is adiabatic, Q = 0. To better understand the theory of the ideal throttling process let's compare what we can observe with the above theoretical assumptions.

An example of a throttling process is an ideal gas flowing through a valve in midposition. From experience we can observe that: $P_{in} > P_{out}$, $vel_{in} < vel_{out}$ (where P = pressure and vel = velocity). These observations confirm the theory that $h_{in} = h_{out}$. Remember h = u + Pv (v = specific volume), so if pressure decreases then specific volume must increase if enthalpy is to remain constant (assuming u is constant).

Because mass flow is constant, the change in specific volume is observed as an increase in gas velocity.

The theory also states W = 0. Our observations again confirm this to be true as clearly no "work" has been done by the throttling process. Finally, the theory states that an ideal throttling process is adiabatic. This cannot clearly be proven by observation since a "real" throttling process is not ideal and will have some heat transfer.

## CONCLUSION

A thermodynamic system is a collection of matter and space with its boundaries defined in such a way that the energy transfer across the boundaries can be best understood.

Surroundings are everything not in the system being studied. Systems are classified into one of three groups:

- Isolated system-neither mass nor energy can cross the boundaries;
- Closed system-only energy can cross the boundaries;
- Open system-both mass and energy can cross the boundaries.

A control volume is a fixed region of space that is studied as a thermodynamic system.

Steady state refers to a condition where the properties at any given point within the system are constant over time. Neither mass nor energy are accumulating within the system.

A thermodynamic process is the succession of states that a system passes through. Processes can be described by any of the following terms:

Cyclic process - a series of processes that results in the system returning to its original state.

Reversible process - a process that can be reversed resulting in no change in the system or surroundings.

Irreversible process - a process that, if reversed, would result in a change to the system or surroundings.

Adiabatic process - a process in which there is no heat transfer across the system boundaries.

Isentropic process - a process in which the entropy of the system remains unchanged.

Polytropic process - the plot of Log P vs. Log V is a straight line, $PV^n$ =constant.

Throttling process - a process in which enthalpy is constant $h_1 = h_2$, work= 0, and which is adiabatic, Q=0.

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