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Thermodynamic Processes and Concept of Reversibility

Promita Ghosh,
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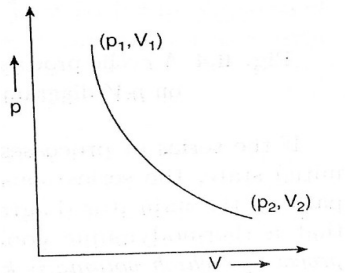
Abstract:

This article is about the concept of reversibility in thermodynamics process.

Definition:

A system is said to undergo a thermodynamic process when the values of its thermodynamic variables or coordinates change from one equilibrium state to another.



An indicator diagram

To analyse a thermodynamic process, the variation of one thermodynamic variable is plotted with respect to another and the plot is known as an indicator diagram. On such a diagram, the state of a system is determined uniquely by a point. And a process means a line connecting a series of such points. In the diagram the initial state of the system is represented by the point (p_1,V_1), the system undergoes an expansion and the final state of the system is defined by the point (p_2,V_2).

It is worth noting that joining the initial and final points by line has a important implication in that the intermediate states are also equilibrium states. And this at once imposes some restrictions as regards the evolution of the thermodynamics process. Since the intermediate states are uniquely defined they being all equilibrium states, a thermodynamics process can be made to retrace its original path to reach back the initial state. If retracing is possible, the process is said to be reversible; if not it is said to be irreversible. All natural processes are irreversible. In irreversible process, the change in thermodynamics variable occurs so fast that thermodynamics variables like p, V, T cannot be defined during the process.

The concept of reversibility facilitates mathematical formulation of thermodynamics. When a process is carried out extremely slowly such that every state through which the system passes departs only infinitesimally from equilibrium the process is said to be quasistatic. A quasistatic process is thus essentially a succession of thermodynamics equilibrium states. For finite departures from equilibrium

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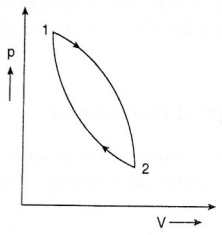
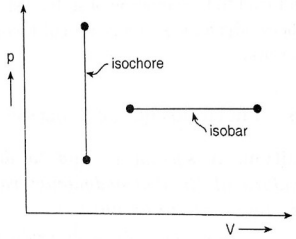
the process becomes non-static where the system variables do not define the states through which the system passes. They cannot also describe the processes the system undergoes. Consequently, a non quasistatic process cannot be represented by a line on the indicator diagram.



A cyclic process represented on p-V diagram



An isochoric and an isobaric process on p-V diagram

If the series of processes undergone by a system leads to its reversal back to the initial state, the series constitutes a cyclic process and is represented by a closed path on the indicated diagram. Some processes, again, are so characterized that a thermodynamic co-ordinate of the system remains constant throughout. A process in which volume is kept constant is called isochoric, represented on the p-V indicator diagram by a straight line parallel to the p-axis. A process where the pressure remains constant is called isobaric, represented by a line parallel to the V-axis on the p-V indicator diagram. Similarly a process in which the temperature remains constant is called isothermal and one in which there is no thermal interaction taking place between the system and its surroundings is called adiabatic.

Reference:

Thermal physics —A.B. Gupta , H.P. Roy.