Thermodynamic Systems and Processes

A thermodynamic system is a collection of particular atoms, molecules or other fundamental particles that is large enough to allow definition of the average energies associated with the motions of those individual components. In fluid mechanical terms it is a Lagrangian control volume that follows the coherent global motion of those atoms, molecules, etc. Conceptually it is convenient to envisage a surface that surrounds the collection, particularly since we will want to consider the work done on or by that collection on or by the surroundings (for example, other collections) or the transfer of heat into or out of the collection. Herein we will refer to that containing surface as defining the thermodynamic system or *control volume*. In these sections all the thermodynamic variables used to define the state of a system will be given per unit mass of the contents of the control volume.

The **heat added** to a thermodynamic system through the control volume surface per unit mass will be denoted by q and an increment of that heat by dq. Correspondingly the rate of heat addition and an increment in that quantity will be denoted by $\dot{q}$ and $d\dot{q}$.

The **work done** on a thermodynamic system through the control volume surface per unit mass will be denoted by w and an increment of that work by dw. Since the incremental work done on a system is the force (or pressure) times the displacement (or $-d(1/\rho)$) it follows that

$$dw \;=\; -pd\left(\frac{1}{\rho}\right) \tag{Acb1}$$

Correspondingly the rate of work done and an increment in that quantity will be denoted by $\dot{w}$ and $d\dot{w}$.

It is also useful to define particular kinds of processes that the system is subjected to:

- An **adiabatic** process is defined as a change to the system that involves zero heat exchange with the surroundings or $dq = 0$.
- An **isentropic** process is defined as a change to the system that involves no change is the entropy of the system or $ds = 0$.
- A **reversible** process is defined as a change to the system that can be reversed so that the final state of the system and the surroundings is identical to the state prior to the initiation of the first change. A reversible, adiabatic process is isentropic.
- An **irreversible** process is defined as a change to the system that can not be reversed so that the final state of the system and the surroundings is identical to the state prior to the initiation of the first change.

Common irreversible processes in the context of mechanics are those that involve diffusion. Thus frictional effects lead to an irreversible process because the conversion of mechanical energy into heat by the action of friction cannot be reversed. Other processes involving the diffusion of heat by conduction or radiation are also irreversible.