Clausius inequality.

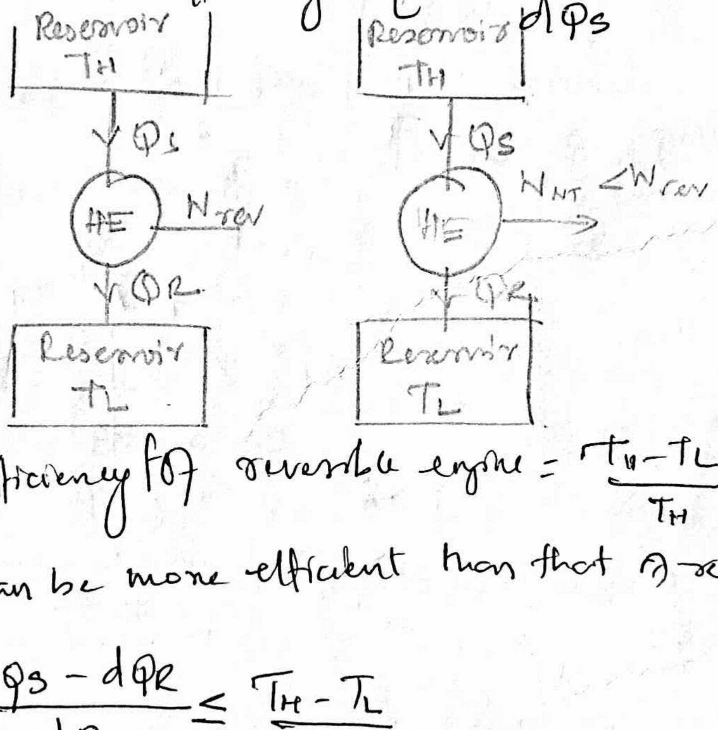
The Clausius theorem states that $\oint \frac{dQ}{T} = 0$. The cyclic integral of $\frac{dQ}{T}$ for a reversible cycle is equal to zero.

Let us consider a cycle ABCD in which AB is a irreversible process and all other process are reversible. when it is divided into number of cycles, then η is

$$\eta_{irr} = 1 - \frac{dQ_2}{(dQ_1)_{irr}}$$

An engine operating between two fixed temperature reservoirs T_H and T_L. Let dQ_S units of heat be supplied at temperature T_H and dQ_R units of heat be rejected at temp T_L.

$$\therefore \text{Thermal efficiency} = \eta = \frac{dQ_S - dQ_R}{dQ_S}$$



Thermal efficiency of reversible engine $= \frac{T_H - T_L}{T_H}$

No engine can be more efficient than that of reversible engine

$$\frac{dQ_S - dQ_R}{dQ_S} \leq \frac{T_H - T_L}{T_H}$$

$$\frac{dQ_R}{dQ_S} \leq \frac{T_L}{T_H}$$

$$\frac{dQ_R}{T_L} \leq \frac{dQ_S}{T_H}$$

$$\frac{dQ_R}{\delta T_L} - \frac{dQ_S}{T_H} \le 0$$

For entire cycle $\oint \frac{dQ}{T} \le 0$

This is Clasious inequality equation. If

$\oint \frac{dQ}{T} = 0$, the cycle is reversible,

$\oint \frac{dQ}{T} < 0$, irreversible and possible

$\oint \frac{dQ}{T} > 0$, the cycle is impossible.

Since the cyclic integral $\oint \frac{dQ}{T}$ is less than zero in a cycle, the cycle violates the second law of thermodynamics.

We can apply the equality to the Carnot cycle since it is reversible cycle. Then equation becomes

$$\oint \frac{dQ}{T} = 0 //.$$

Concept of entropy T-s diagram.

The molecules of the gas are in random motion and they move in different directions with different velocities during colliding with each other and with the irregular behaviour of molecules. Let us heat the gas, the random motion further increases which leads to more irregularities or more disorderness. This degree of disorderness existing in a system is known as entropy.

S 8 1 4 7 0 3

We can't measure entropy we can only measure the increase in disorderness or decrease in disorderness of a system.

Heat always flows from hot body to cold body and thus becomes lesser value available. This unavailable energy is measured by entropy.

Change in entropy, $ds = \frac{\text{Change of heat transfer}}{\text{Absolute temperature}} = \frac{dQ}{T}$

Unit – KJ/K

Reversible adiabatic process entropy is zero.

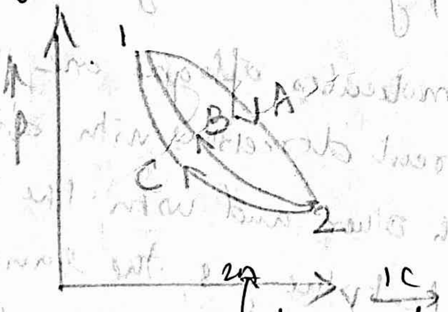
Entropy a property of system

Thermodynamics system undergoes a change of state from 1 to 2 by a reversible process 1-A-2 and returns to its original state by another process 2-B-1 and a cycle 1-2-1

Cyclic reversible process, Entropy equation is

$$\int_{rev} \frac{dQ}{T} = \int_{1A}^{2A} \frac{dQ}{T} + \int_{2B}^{1B} \frac{dQ}{T} \quad (1)$$

Completed by another cycle 1-2-1 by another reversible process 2-C-1



then $$\oint_{rev} \frac{dQ}{T} = 0 = \int_{1A}^{2A} \frac{dQ}{T} + \int_{2C}^{1C} \frac{dQ}{T} \quad (2)$$

Subtracting (2) from (1)

$$\int_{2B}^{1B} \frac{dQ}{T} = \int_{2C}^{1C} \frac{dQ}{T}$$

∴ $\frac{dQ}{T}$ is the same for all reversible paths b/w 1 & 2

It is independent of the path and a function of end states. Hence entropy is a property.