SET Problem session

Nuclear Units Informatics Design Engineering Architect

Problem statement

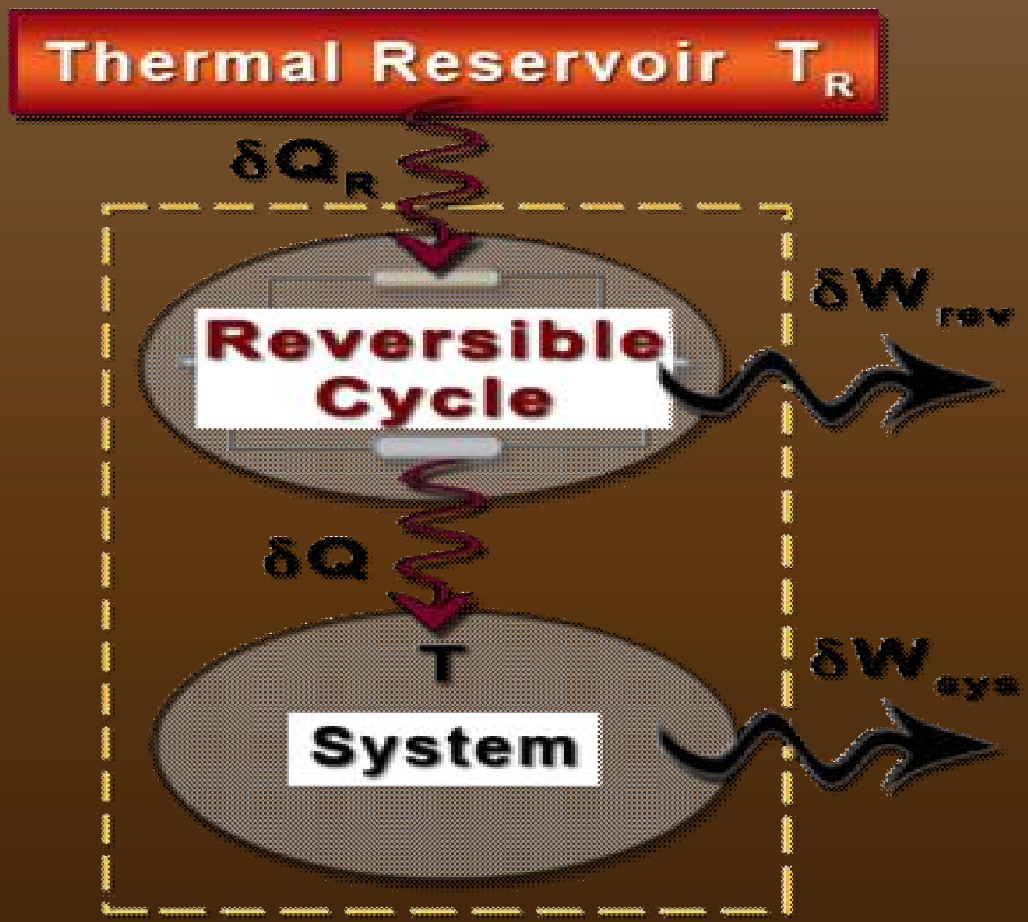
State and Prove Clausius inequality:

The clausius inequality is: $\oint \frac{q}{T} \leq 0$ *(For any thermodynamic process)*

(For reversible process equality holds)

To prove this first consider the Kelvin Plancks statement of the second law: It is impossible for any system to operate in a thermodynamic cycle and deliver a net amount of energy by work to its surroundings while receiving energy by heat transfer from a single thermal reservoir. i.e ***Wcycle<=0*** *(Single reservoir)*

Solution


Thermal Reservoir T_R
δQ_R
Reversible Cycle
δW_{rev}
δQ
T
System
δW_{sys}

Since no irreversibilities are present owing to the selection of reversible cycle thus $\frac{\delta Q_R}{\delta Q} = T_R/T$ (Definition of Kelvin temperature scale)

From the first law of thermodynamics for a system undergoing a process: $\delta E = \delta Q_R - \delta W_{sys} - \delta W_{rev}$

or, $\delta E = \delta Q \frac{T_R}{T} - \delta W_{sys} - \delta W_{rev}$

Suppose the system under dotted line undergoes one full cycle while the intermediary reversible cycle may undergo many cycles.

For the whole cycle $\oint E = 0$,Thus the last equation becomes

$$(\oint \delta Q \frac{T_R}{T}) - W_{Cycle} = 0$$

Since from Kelvin Plancks statement $W_{Cycle} \leq 0$

Using this in the above equation yields the Clausius inequality.