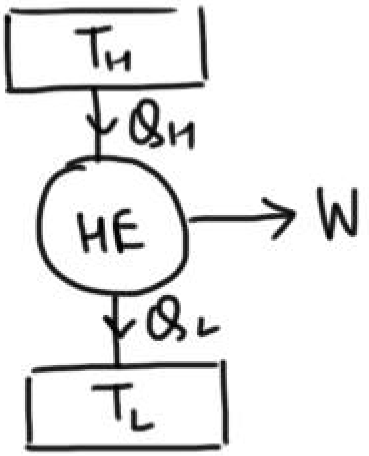
ENTROPY BASICS

If cyclic integral of any parameter is zero. What does it signifies??????

Birth of entropy :



For rev HE,

$$\frac{Q_H}{Q_L} = \frac{T_H}{T_L}$$

$$\frac{Q_H}{T_H} = \frac{Q_L}{T_L}$$

$$\left(\frac{Q_H}{T_H}\right) + \left(-\frac{Q_L}{T_L}\right) = 0$$

$$\sum_{cycle}\left(\frac{Q}{T}\right) = 0$$

$$\oint \frac{\delta Q}{T} = 0$$

It is a property. What to do with this?

Lets give it a name.

Is it entropy or change in entropy?

The property is entropy. The expression is change in entropy.

Let's call is entropy which is given by:

$$dS = \left(\frac{\delta Q}{T}\right)_{rev}$$

$$S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T}\right)_{rev}$$

S is enropy and dS is change in entropy

summation (Q/T) = 0 and cyclic integral (delQ/t)=0 are both mathematically same expression?

Summation from point A to another point B is integration. When A and B are same, it is a cyclic integration

QUES. what does " cyclic integral of any parameter is zero" signify ? does it signifies that net change in entropy (ie parameter) is zero ?

ANS. It implies that net change in entropy over a cycle is zero. Which is possible only if entropy was a property.

Lets see an irrev engine and see what happens.

For irrev heat engines:

$$\frac{Q_L}{Q_H} > \frac{T_L}{T_H}$$

$$\frac{Q_H}{T_H} < \frac{Q_L}{T_L}$$

$$\frac{Q_H}{T_H} - \frac{Q_L}{T_L} < 0$$

$$\left(\frac{Q_H}{T_H}\right) + \left(-\frac{Q_L}{T_L}\right) < 0$$

$$\oint\left(\frac{\delta Q}{T}\right) < 0$$

$$\eta_{irrev} < \eta_{rev}$$

$$1 - \frac{Q_L}{Q_H} < 1 - \frac{T_L}{T_H}$$

$$-\frac{Q_L}{Q_H} < -\frac{T_L}{T_H} \Rightarrow \frac{Q_L}{Q_H} > \frac{T_L}{T_H}$$

Combining the result of #1 and #2, we get:

The Claussius Inequality:

$$\oint \frac{\delta Q}{T} \leq 0$$

$\rightarrow$ '$<$' : for irrev

$\rightarrow$ '$=$' : for rev

#4

With Correction

$$dS = \left(\frac{\delta Q}{T}\right)_{rev}$$

$$S_2 - S_1 = \int_1^2 \left(\frac{\delta Q}{T}\right)_{rev}$$

For irrev processes,

$$S_2 - S_1 > \int_1^2 \left(\frac{\delta Q}{T}\right)$$

(del Q / T) is NOT the entropy. It is a tool to measure entropy.

Look, you need to measure entropy, it is measured by calculating (del Q/T). Now, if the process is rev, (del Q/T) will directly give the value of change in entropy.

If the process is irrev, the value given by (del Q / T) will be somewhat less than actual change in entropy.

But how is this possible????
delta S is supposed to be a property and property does not depends upon the type of process.
Delta S should be same irrespective of the process. Right?

See #4

Change is entropy is less than integral (del Q/T).

Think of it like this:

Suppose that (del Q/T) represents students of a class.

There are all types of students. Some good at studies while some are not.

each (del Q/T) is assigned a task: Calculate the change in entropy!!

But only good (del Q/T) [good here means reversible] will be able to calculate is on its own

bad (del Q/T) [for irrev], will try as much as it can, but the value calculated will always be less than the actual value.

But since change is entropy should be same, irrespective of the type of process whether rev or irrev.
Since for irrev, (del Q/T) does not becomes equal to the change in entropy, SOME ADDITIONAL ENTROPY IS GENERATED SO THAT NET CHANGE IS EQUAL TO DELTA S.

Entropy cannot be defined....only change in entropy can be defined.

Absorb it!

$S_2 - S_1$ is const. whether process is rev or irrev

$$S_2 - S_1 = \int \left(\frac{\delta Q}{T}\right)_{rev}$$

but for irrev $S_2 - S_1 > \int \left(\frac{\delta Q}{T}\right)_{irrev}$

$\because (S_2 - S_1)_{irrev} = (S_2 - S_1)_{rev}$

$\therefore$ In irrev process, some entropy is generated so that $S_2 - S_1 = \int \left(\frac{\delta Q}{T}\right)_{irrev} + S_{gen}$

Conclusion

Change in S(rev) = S(irrev) for any process from 1 to 2.
Now deltaS(rev) = int deltaQ/T (let this value be X)

For irrev, since entropy is derived from rev process only,with the same formula of rev process of entropy we get the Y which is smaller than X.. BUT since entropy is a property,the difference S2-S1 should be same for both processes.

For this to happen,some irreversibilities are generated which gives rise to another entropy whose value is equal to X-Y so that finally we get,
X=Y+Z where Z is the entropy generated.