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The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur

Department of Mechanical Engineering

NAME OF COURSE: - Thermal Engineering (TEG)

CODE OF COURSE: - 313310

SEMESTER: - SYME-3K

SUBJECT TEACHER: - Mr. Bhushan S. Patil

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QUESTION BANK

CHAPTER 1. FUNADAMENTAL OF THERMODYNAMICS

Program Name: Mechanical Engineering
Program Code: ME3k
Name of Subject & Code : Thermal Engineering (313310)
Semester : Third
Date & Time Slot: 20/05/2026 ;

Q. NO.	QUESTION	DETAIL	MAPPING
1	Define the following: – i) Intensive property ii) Extensive property.	W25 Q1A 2M	
2	Define the terms: i) Thermodynamic System ii) Thermodynamic Property.	S25 Q1A 2M	CO 1.1 R
3	Define Zeroth law of Thermodynamics.	W24 Q1A 2M	
4	Differentiate between heat engine and refrigerator. (Any four points)	W25 Q2A 4M	
5	Explain Zeroth law of thermodynamics with suitable examples.	W25 Q2B 4M	
6	State Kelvin-plank and clausius statement of second law of thermodynamics.	W24 Q2B 4M	
7	Explain the concept of Heat engine, Heat pump and Refrigerator with block diagram	S25 Q2A 4M	CO 1.2 U
8	Explain the concept of flow work with a neat sketch	S25 Q2B 4M	
9	Prove that $(COP)_{HP} = (COP)_{R} + 1$	W24 Q2A 4M	
10	Apply the steady flow energy equation to the boiler. Show that the heat supplied to the boiler increases the enthalpy of the system	S25 Q5A 6M	
11	Write a steady flow energy equation. State the meaning of each term in the equation and apply it to the boiler, and steam condenser	W25 Q5A 6M	CO 1.3 A
12	Write a steady flow energy equation and apply it to steam turbines and steam boilers.	W24 Q5A 6M	
13	A Cyclic Heat Engine Operates between source temperatures of 8000C And Sink temperature of 30 0C. What is the least rate of heat rejection per kw net output of the engine?	OTHER	CO 1.2 A
14	Differentiate between thermodynamic work and thermodynamic heat.	OTHER	CO 1.1 U
15	Explain the different types of thermodynamic systems.	OTHER	CO 1.1 R

20/05/2026

20/05/26

Unit - 1. Fundamentals of Thermodynamics

Total Hrs ⇒ 8Hrs , pattern of Questions
total marks ⇒ 16 Mark   Q1(A), Q2(A),(B), Q5(A)
(2M)   (8M)   6M

1.1] Thermodynamics system, types of system :→ [2M]

Thermodynamics :- Thermo means heat
Dynamics means force, work & power.

" It is a branch of science which deals with study of Inter-conversion of forms of Energy ie. heat & work."

Thermodynamic System:-

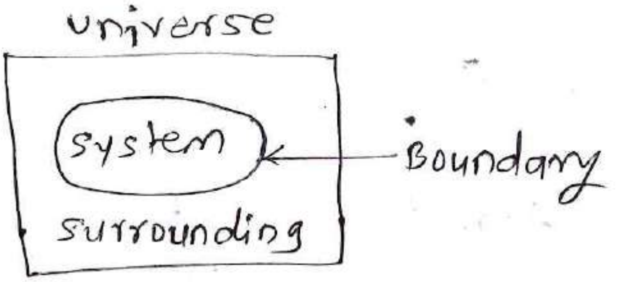
It is a quantity of matter or region in space considered for thermodynamic study.

eg. 1] Gas contained in a cylinder
2]. water circuit in a boiler.

Surrounding :-

" The mass or region outside the system." is known as surrounding.

Boundary :- Real or Imaginary surface that seperates the system from its surrounding.



so, System + surrounding = universe.

Classification of Thermodynamic System:-

1] open system 2] closed system 3] Isolated system.

1] open system:-

mass & Energy [heat & work] transfers between system & surrounding. It is a control volume system.

eg. 1] Steam turbine 2] Boiled water in cup.

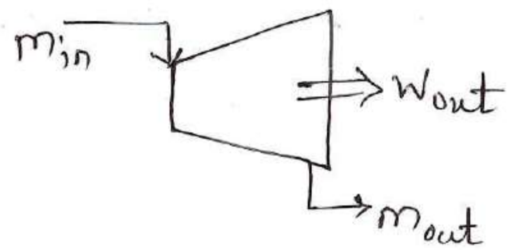


fig. steam turbine as open system

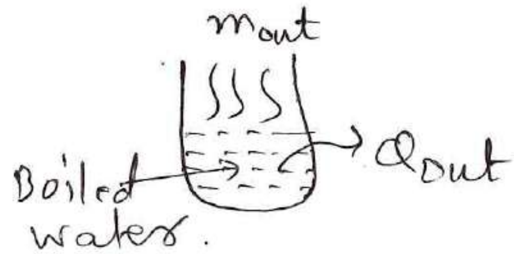


fig. open system

2] closed system:-

only Energy Interchange between system & surrounding & No mass Interchanges.

It is control mass system.

eg. 1] Hot water enclosed in a container
2] Refrigerator or AC in closed room

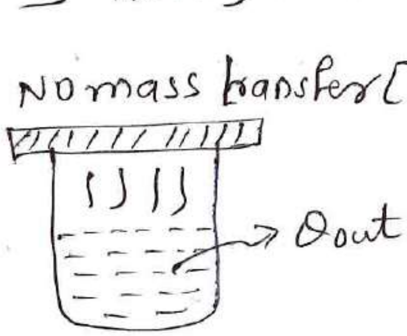


fig. closed system.

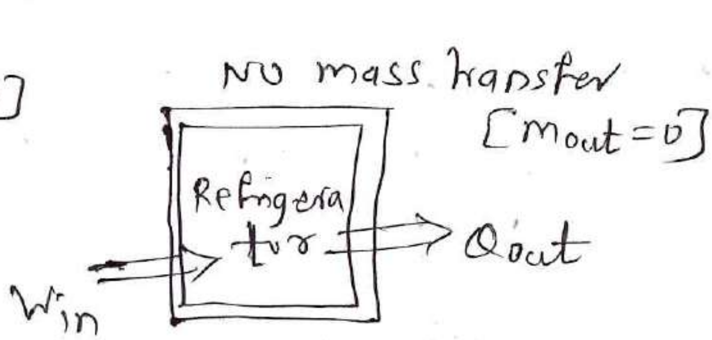


fig. Refrigerator as closed system.

3] Isolated system:-

NO Interchange of mass & Energy between system & surrounding.

It is control volume & control mass system.

eg. Thermoflask - Hot water enclosed in well insulated container

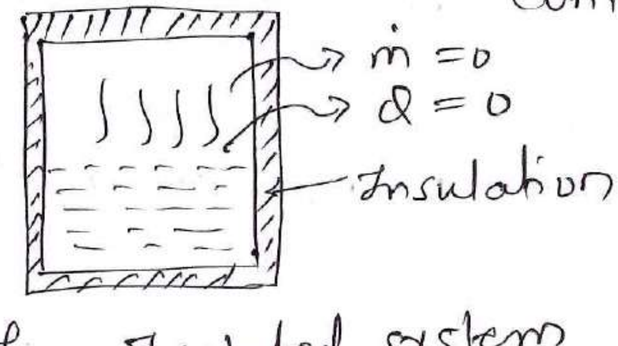


fig. Isolated system.

2] Thermodynamic properties of System:-

Property → eg. volume, Pressure, temperature, Entropy etc

A] Intensive properties

B] Extensive properties

A] Intensive properties:-

Properties of system which are independent on mass of system eg. Pressure, temperature, density etc.

All specific quantities are intensive property. eg. sp. vol^m.

B] Extensive properties:-

Properties of system which are dependent on mass of system eg. mass, enthalpy, volume, Energy etc.

3] Process & cycle:-

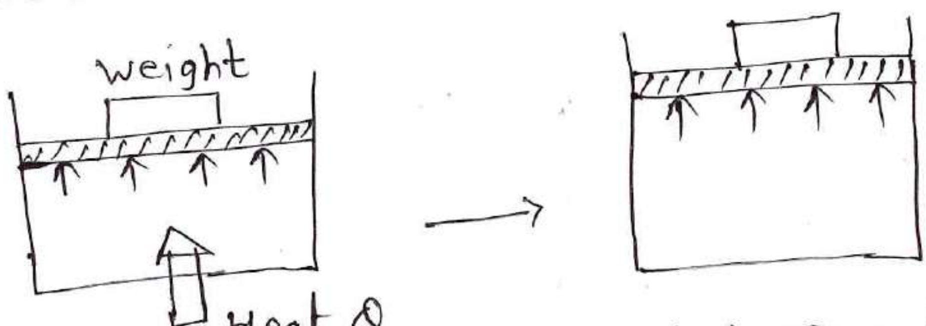
state:- it is a condition of a system described by its thermodynamic properties such as pressure, temperature, volume etc.

Path:- If all the changes of the system states are ploted, then the line joining the change of states of the system is known as path.

Process:- change of state of system through a specified path, is known as process.

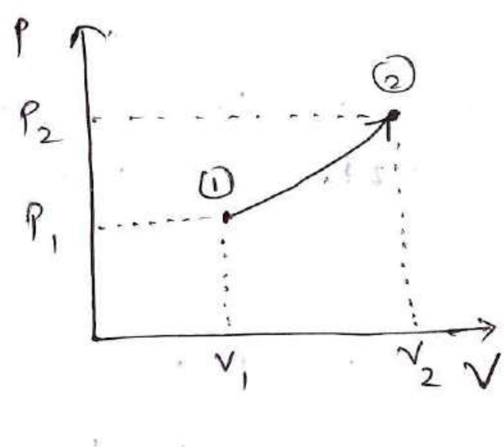
cycle:- It is defined as the series of state of changes such that the initial state is identical with the final state.

eg:-



state ② → P_2, V_2, T_2

state ① - P_1, V_1, T_1



① → ② is a process

1] Thermodynamic definition of heat & work :→

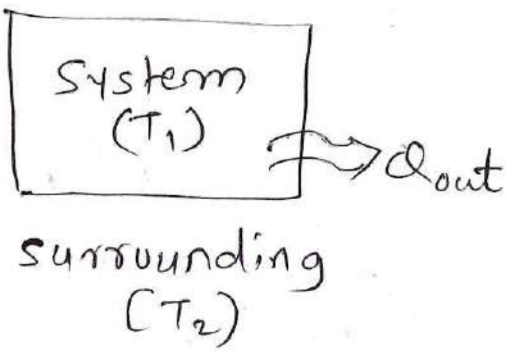
Energy :- capacity to do work
unit ⇒ Joule (J) or calories [cal]

Types or forms :- 1] Heat & 2] work

Heat :-

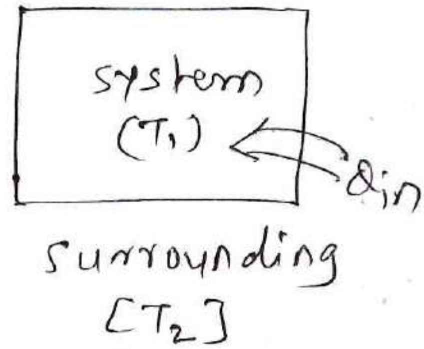
It is a form of energy that is transfered by virtue of a temperature difference.

eg.



if, $T_1 > T_2$

Heat transfer from system to surrounding is taken as "Negative."
eg. condenser

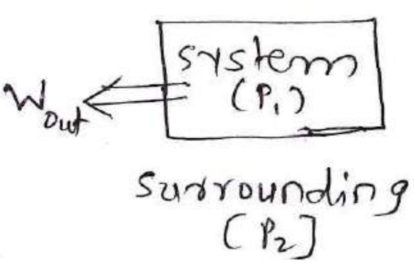


if $T_1 < T_2$

Heat transfer from surrounding to system & it is taken as "Positive."
eg. Boiler.

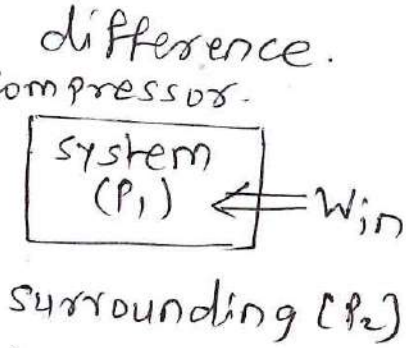
Work :- It is a form of Energy that is transfered by virtue of a pressure difference.

eg. turbine



if, $P_1 > P_2$, then work is done by system & it is positive

eg. Compressor.



if $P_2 > P_1$, then work is done by system & it is Negative.

5] Difference between Heat & Work:-

Heat	Work
1] Heat transfer by virtue of temperature difference	1] Work transfer by virtue of pressure difference
2] Heat added to system is positive & heat rejected by ~~st~~ system is taken as negative	2] Work done on system is taken as negative & work done by system is taken as positive.
3] It is low grade energy	3] It is high grade energy.
4] Application:- Boiling ~~of~~ water	4) Application:- Expansion of gas.

6] Flow work

The work required to cause a flow of ~~work~~ fluid. & which is a product of pressure & volume.

$\therefore$ flow work = PV

7] Enthalpy:- Heat content of system or total heat of system.

It is a combination of flow work & Internal Energy.

$\therefore$ $H = U + PV$ --- [total Enthalpy in KJ] change in Enthalpy is calculated as,

$$\Delta H = H_2 - H_1 = [U_2 - V_1] + [P_2 V_2 - P_1 V_1]$$

specific Enthalpy :-

Enthalpy of system per mass is known as sp. Enthalpy. denoted by 'h' in "KJ/Kg".

eg.

$$h = \frac{H}{m} \quad [KJ/kg]$$

It

8] Entropy [S] :-

It is a measure of randomness of system & increases with addition of heat & decreases with removal of heat.

It is a property of system & point function.

It is denoted by ΔS

$$\therefore \quad \Delta S = \frac{dQ}{T}$$

$$S_2 - S_1 = \frac{dQ}{T} \quad \text{--- in } [KJ/^\circ C] \text{ or } [KJ/^\circ K]$$

sp. Entropy [s] ⇒

Entropy of system per unit mass is known sp. Entropy

$$\therefore \quad s = \frac{S}{m} \quad \text{— [unit is } KJ/kg K]$$

9] Internal Energy [U] :-

It is a total Energy ~~content~~ contained within a system due to the motion & kinetic Energy & potential energy. It is a point function & Extensive property.

unit ⇒ KJ

sp. internal Energy [u] :- Internal Energy per unit mass

$$\boxed{u = \frac{U}{m}} \Rightarrow \text{unit } [KJ/kg]$$

1.2 Laws of Thermodynamics [8M]

1] Zeroth Law:-

IF Body A is in thermal equilibrium with body B & Body C seperately, then Body B & C are also in thermal equilibrium with each other
eg. Thermometer.

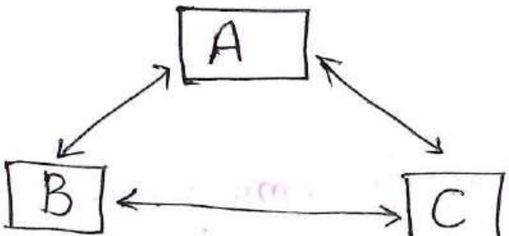


fig. zeroth of thermodynamic.

2] First law of thermodynamics:-

- When a closed system undergoes through the cyclic change then the heat transfer to system is converted to mechanical work.
- ie. Energy is conserve.

$\therefore \; dQ \propto dW$

for closed system, $dQ - dW = dU$

- ie. heat supplied to closed system, is utilized to do work & to increase the internal Energy of system.

- First law of thermodynamics is also known as law of conservation of Energy, which states that Energy can not be created, destroyed but it can be converted to other forms of Energy.

Limitations of I^{st} law of Thermodynamics:-

1] First law does not help to predict whether the certain process is possible or not.

2] The first law does not give info about direction & specify sufficient condition to process take place.

3] Second law of thermodynamics:-

Two statements.

a] Kelvin plank statements

b) Clausius statements.

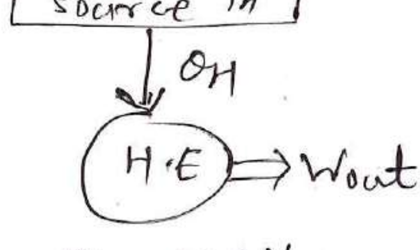
a] Kelvin-plank statement:-

"It is impossible to construct an engine working in a cyclic process whose sole effect is to convert all the heat supplied to it into an equivalent amount of work."

"OR"

~~[illegible]~~

No actual heat Engine, working on a cyclic process, can convert whole of the heat supplied to it into mechanical work



$\eta_{HE} = 100\%$.
Impossible Heat Engine.

Heat Engine:-

It converts the heat Energy supplied from high Energy source into mechanical work by rejecting part of heat Energy to low temperature sink. $[T_L]$.

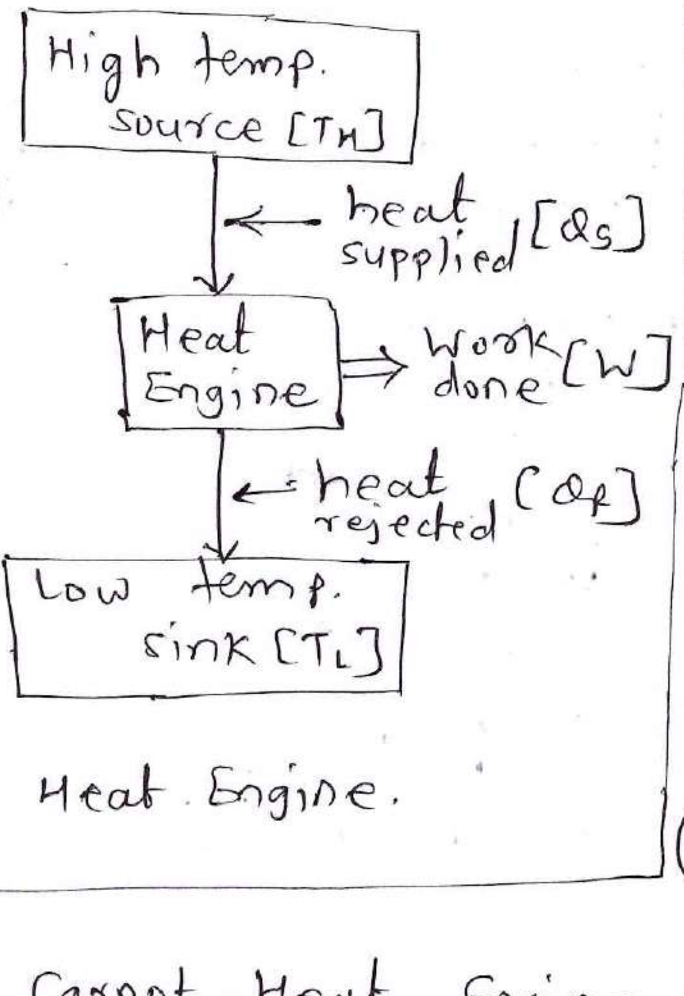


fig. Heat Engine.

* Efficiency of H.E:- (η_{HE})

$$\eta_{HE} = \frac{\text{desire o/p}}{\text{Required i/p}}$$

$$= \frac{W_{out}}{Q_S} \times 100\%$$

but

$$Q_S = W + Q_R$$

$$\therefore W = Q_S - Q_R$$

$$\therefore \eta_{HE} = \frac{Q_S - Q_R}{Q_S} \times 100\%$$

$$(\eta_{HE})_{actual} = \left(1 - \frac{Q_R}{Q_S}\right) \times 100\%$$

for Carnot Heat Engine (Reversible) $Q_S = mC_pT_H$, $Q_R = mC_pT_L$

$$\therefore (\eta_{HE})_{Rev} = \left(1 - \frac{mC_pT_L}{mC_pT_H}\right) \times 100\% \Rightarrow \left[1 - \frac{T_L}{T_H}\right) \times 100\%$$

$$\therefore \left[1 - \frac{T_L}{T_H}\right] = \left[1 - \frac{Q_L}{Q_H}\right]$$

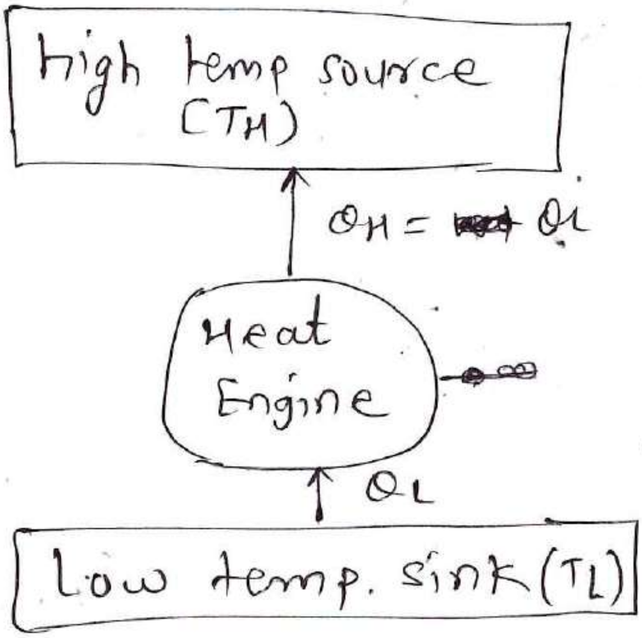
$$\therefore \boxed{\frac{T_L}{T_H} = \frac{Q_L}{Q_H}}$$ ← only for Carnot Heat Engine.

B] Clausius statement :-

- It is impossible to construct a machine working in a cyclic process whose sole effect is to transfer heat from a low temperature sink to high temperature source without help of external mechanical work.

"OR"

No macchine will transfer heat from low temperature sink to high temperature source itself.



Impossible machine.

a) Refrigerator :-

- It is a device works on cyclic process, Extracts heat from low temperature sink & transfer it to the high temperature source by the aid of External mechanical work.
- It maintains the temperature of low temp. sink [TL].

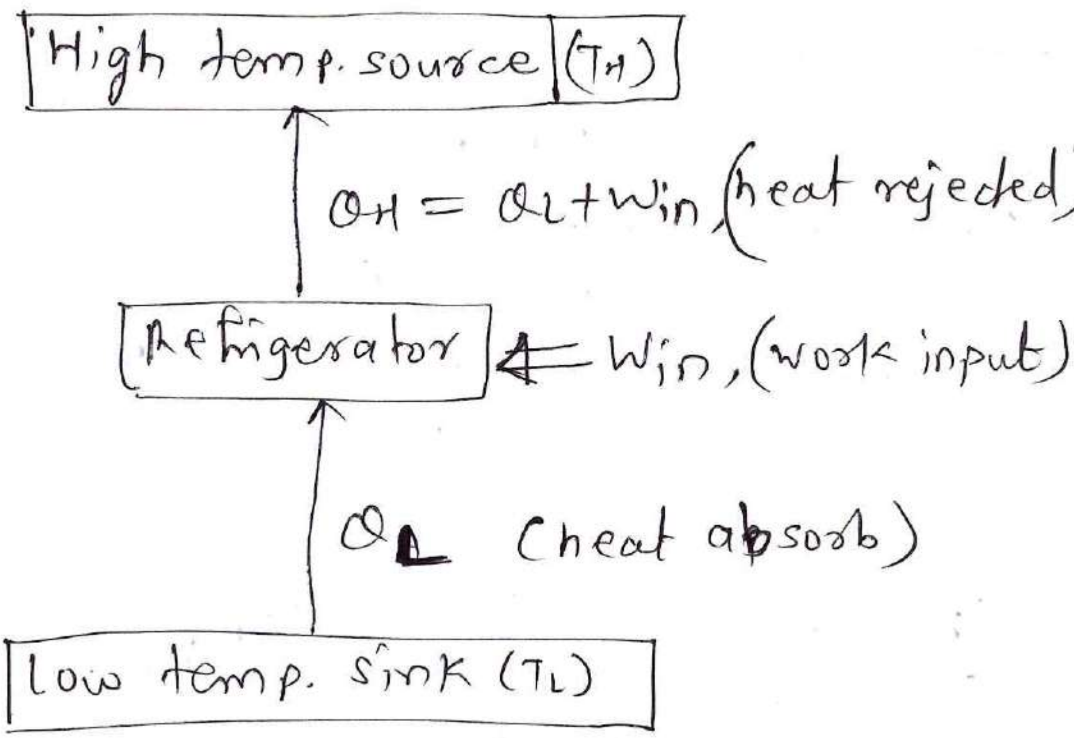


fig. Refrigerator.

Efficiency of Refrigerator :→

efficiency of Refrigerator is terms as $(COP)_R$

$$\therefore (COP)_R = \frac{\text{desired o/p}}{\text{Required i/p}}$$

$$= \frac{Q_L}{W_{in}} \Rightarrow \frac{Q_L}{Q_H - Q_L}$$

$$(COP)_{\text{carnot Refrigerator}} \Rightarrow \frac{T_L}{T_H - T_L}$$

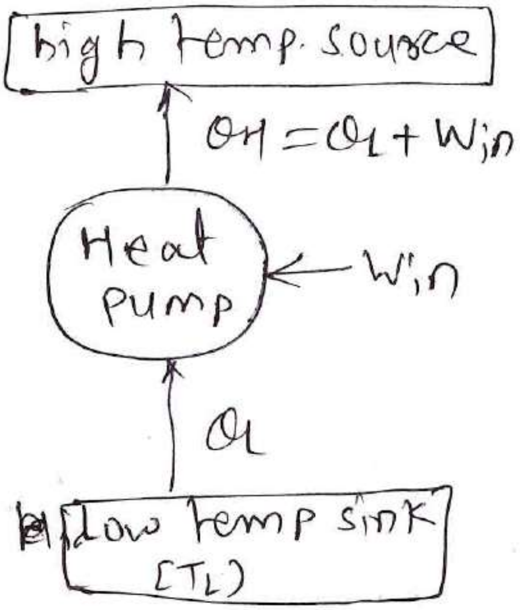
$$\therefore \left[\frac{Q_L}{Q_H - Q_L} = \frac{T_L}{T_H - T_L} \right]$$

COP = Coefficient of performance

* $(COP)_R$ is always greater than 1.

Heat pump:-

- It is a device, which works on cyclic process, Extract heat from low temperature sink & transfer it to the high temperature source with the help of external mechanical work.
- It maintain the temperature of high temp. source



$$(COP)_{HP} = \frac{\text{desired o/p}}{\text{required i/p}}$$

$$= \frac{Q_H}{W_{in}}$$

$$= \frac{Q_H}{W_{in}}$$

$$(COP)_{HP\ carnot} = \frac{Q_H}{Q_H - Q_L}$$

$$= \frac{T_H}{T_H - T_L}$$

$$\therefore \boxed{\frac{Q_H}{Q_H - Q_L} = \frac{T_H}{T_H - T_L}}$$

Proove $[COP]_{HP} = 1 + [COP]_R$.

→ we know, $(COP)_{HP} = \frac{T_H}{T_H - T_L}$

$$= \frac{T_H - T_L + T_L}{T_H - T_L}$$

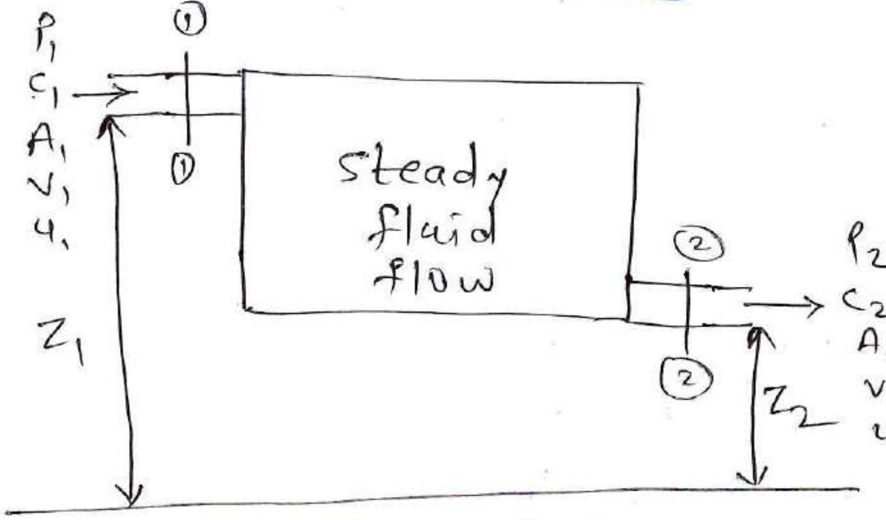
$$= 1 + \frac{T_L}{T_H - T_L}$$

$$\boxed{(COP)_{HP} = 1 + (COP)_R}$$

So, $(COP)_{HP}$ is always greater than $(COP)_R$ by one.

1.3 Application of Laws of Thermodynamics [6m]

steady flow Energy equation:- [SFEE]



fluid enters control volume at section ①-① & exits at section ②-② with steady state. with following Assumptions.

P = Pressure in N/m^2
V = Volume in m^3
A = area in m^2
C = velocity in m/s
U = internal energy in KJ.

1] mass flow rate of fluid is remains constant
2] state of fluid is remains constant within control vol^m.
3] Heat & work transfer rates are constant.

Now by Laws of Conservation of Energy

$$\begin{bmatrix}\text{Total Energy of fluid} \\ \text{at inlet}\end{bmatrix} = \begin{bmatrix}\text{Total Energy of fluid} \\ \text{at outlet}\end{bmatrix}$$

$$P_1V_1 + K.E_1 + P.E_1 + I.E_1 + \frac{dQ}{dt} = K.E_2 + P.E_2 + I.E_2 + \frac{dW}{dt} + P_2V_2$$

$$\therefore P_1V_1 + \frac{1}{2}\dot{m}C_1^2 + \dot{m}gz_1 + U_1 + \dot{Q} = \frac{1}{2}\dot{m}C_2^2 + \dot{m}gz_2 + U_2 + P_2V_2 + \dot{W}$$

$$P_1V_1 + \frac{1}{2}\dot{m}C_1^2 + \dot{m}gz_1 + \dot{m}u_1 + \dot{m}\dot{q} = \frac{1}{2}\dot{m}C_2^2 + \dot{m}gz_2 + \dot{m}u_2 + P_2V_2 + \dot{m}\dot{w}$$

$$\therefore \dot{m}\left[\frac{P_1V_1}{m} + \frac{1}{2}C_1^2 + gz_1 + u_1 + \dot{q}\right] = \dot{m}\left[\frac{1}{2}C_2^2 + gz_2 + u_2 + \frac{P_2V_2}{m} + \dot{w}\right]$$

Now, $\frac{V_1}{m} = \nu_1$ = sp. vol^m & u_1 = sp. Internal Energy

$$\therefore P_1\nu_1 + u_1 + \frac{1}{2}C_1^2 + gz_1 + \dot{q} = P_2\nu_2 + u_2 + \frac{1}{2}C_2^2 + gz_2 + \dot{w}$$

Now $P_1\nu_1 + u_1 = h_1$ & $P_2\nu_2 + u_2 = h_2$

$$\therefore \boxed{h_1 + \frac{1}{2}C_1^2 + gz_1 + \dot{q} = h_2 + \frac{1}{2}C_2^2 + gz_2 + \dot{w}}$$

$$q - w = \Delta KE + \Delta PE + \Delta h$$

IMP

Steady flow Energy equation :→ [SFEE]

$$\dot{Q} + \dot{m}\left(h_1 + \frac{c_1^2}{2} + gz_1\right) = \dot{W} + \dot{m}\left[h_2 + \frac{c_2^2}{2} + gz_2\right]$$

where, $\dot{Q}$ = heat transfer in KJ/sec
$\dot{W}$ = Work transfer in KJ/sec
$\dot{m}$ = mass flow in Kg/sec
h = sp. Enthalpy [KJ/Kg]
c = fluid velocity [m/sec]
g = acc. due to gravity [m/sec²]
z = elevation in [m]

OR $$\dot{Q} - \dot{W} = \dot{m}\left[(h_2 - h_1) + \left[\frac{c_2^2}{2} - \frac{c_1^2}{2}\right] + (gz_2 - gz_1)\right] \quad \text{[KJ]}$$

$$\boxed{\dot{q} - \dot{w} = \Delta h + \Delta KE + \Delta P.E.} \quad \text{[KJ/kg]}$$

1] Application of SFEE to boiler :-

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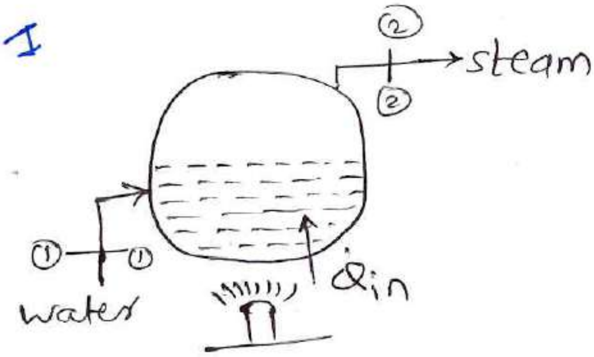

fig. Boiler

Boiler :- A closed vessel in which water is converted into pressurized steam by supplying heat (Q) due to burning of fossils fuels.

We know, SFEE as.

$$\dot{Q} + \dot{m}\left[h_1 + \frac{c_1^2}{2} + gz_1\right] = \dot{W} + \dot{m}\left[h_2 + \frac{c_2^2}{2} + gz_2\right]$$

Here, $z_1 = z_2$ ⇒ elevation of inlet & outlet of boiler is at same level, $\boxed{\Delta PE = 0}$

$c_1 = c_2$ ⇒ velocity of fluid flow is constant $\boxed{\Delta KE = 0}$

$\dot{W} = 0$ ⇒ No work transfer

therefore, $\dot{Q} + \dot{m}\left[h_1 + \cancel{\frac{c_1^2}{2}} + \cancel{gz_1}\right] = \cancel{\dot{W}} + \dot{m}\left[h_2 + \cancel{\frac{c_2^2}{2}} + \cancel{gz_2}\right]$

$\therefore \quad \dot{Q} + \dot{m}[h_1] = \dot{m}[h_2]$

$\therefore \quad \dot{Q} = \dot{m}[h_2 - h_1]$ ------- [KJ] also, $\frac{\dot{Q}}{m} = h_2 - h_1$

$\therefore$ $\boxed{\dot{q} = h_2 - h_1}$ ...... [In KJ/kg]

Heat supplied is used to increase the Enthalpy of ~~steam~~. fluid.

2] Application of SFEE to steam Condenser:-

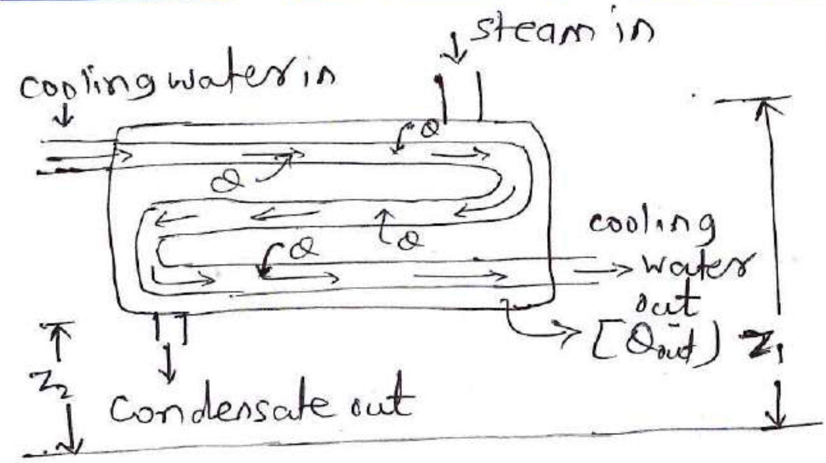

fig. Condenser

steam condenser:- It is a device where steam is condensed into condensate by circulating over cooling coil surface

considering a steam side for analysis.

We know, SFEE as,

$$\dot{Q} + \dot{m}\left[h_1 + \frac{c_1^2}{2} + gz_1\right] = \dot{W} + \dot{m}\left[h_2 + \frac{c_2^2}{2} + gz_2\right]$$

Here, $z_1 = z_2$ ⇒ elevation of inlet & outlet of steam to condenser is approximately at same level. [$\Delta PE \approx 0$]

$c_1 = c_2$ ⇒ velocity of fluid flow is approximately constant [$\Delta KE \approx 0$]

$\dot{W} = 0$ ⇒ No work transfer

Q = Heat is transfer from steam to cooling water

Therefore,

$$\therefore \quad \dot{Q} + \dot{m}\left[h_1 + \cancel{\frac{c_1^2}{2}} + \cancel{gz_1}\right] = 0 + \dot{m}\left[h_2 + \cancel{\frac{c_2^2}{2}} + \cancel{gz_2}\right]$$

$$\therefore \quad \dot{Q} = m[h_2 - h_1] \ldots [KJ]$$

$$\dot{q} = h_2 - h_1 \ldots [KJ/kg]$$

Amount of heat Rejection is equal to decrease in Enthalpy of steam.

3] Application of SFEE over steam turbine :-

Turbine :→ It is a device in which, mechanical work is produced by expansion of steam from high pressure [boiler pressure] to low pressure [Condenser Pressure]

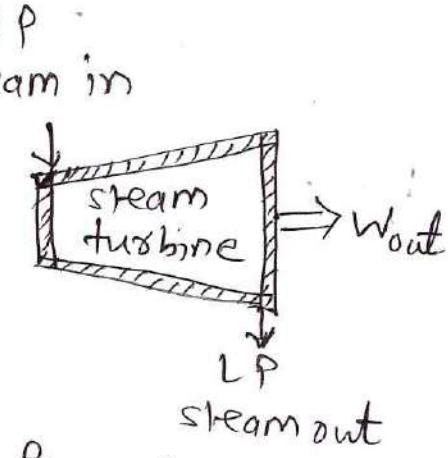

fig. steam turbine

We know, SFEE,

$$\dot{Q} + \dot{m}\left[\frac{c_1^2}{2} + gz_1 + h_1\right] = \dot{W} + \dot{m}\left[\frac{c_2^2}{2} + gz_2 + h_2\right]$$

Here, $\dot{Q} = 0$ ⇒ No heat transfer, turbine is well insulated.

$c_1 = c_2$ ⇒ velocity of fluid flow is approximately same or change in Kinetic Energy is negligible [ΔPE=0]

$z_1 = z_2$ ⇒ Inlet & outlet point of turbine is approximately at same level OR change in Potential Energy is negligible.

Therefore, $0 + \dot{m}\left[\cancel{\frac{c_1^2}{2}} + \cancel{gz_1} + h_1\right] = \dot{W} + \dot{m}\left[\cancel{\frac{c_2^2}{2}} + \cancel{gz_2} + h_2\right]$

$$\therefore \quad \dot{W} = \dot{m}\left[h_1 - h_2\right]$$

i] Decrease in Enthalpy of steam is converted into work done. [OR]

i] Work is obtained due to decrease in Enthalpy.