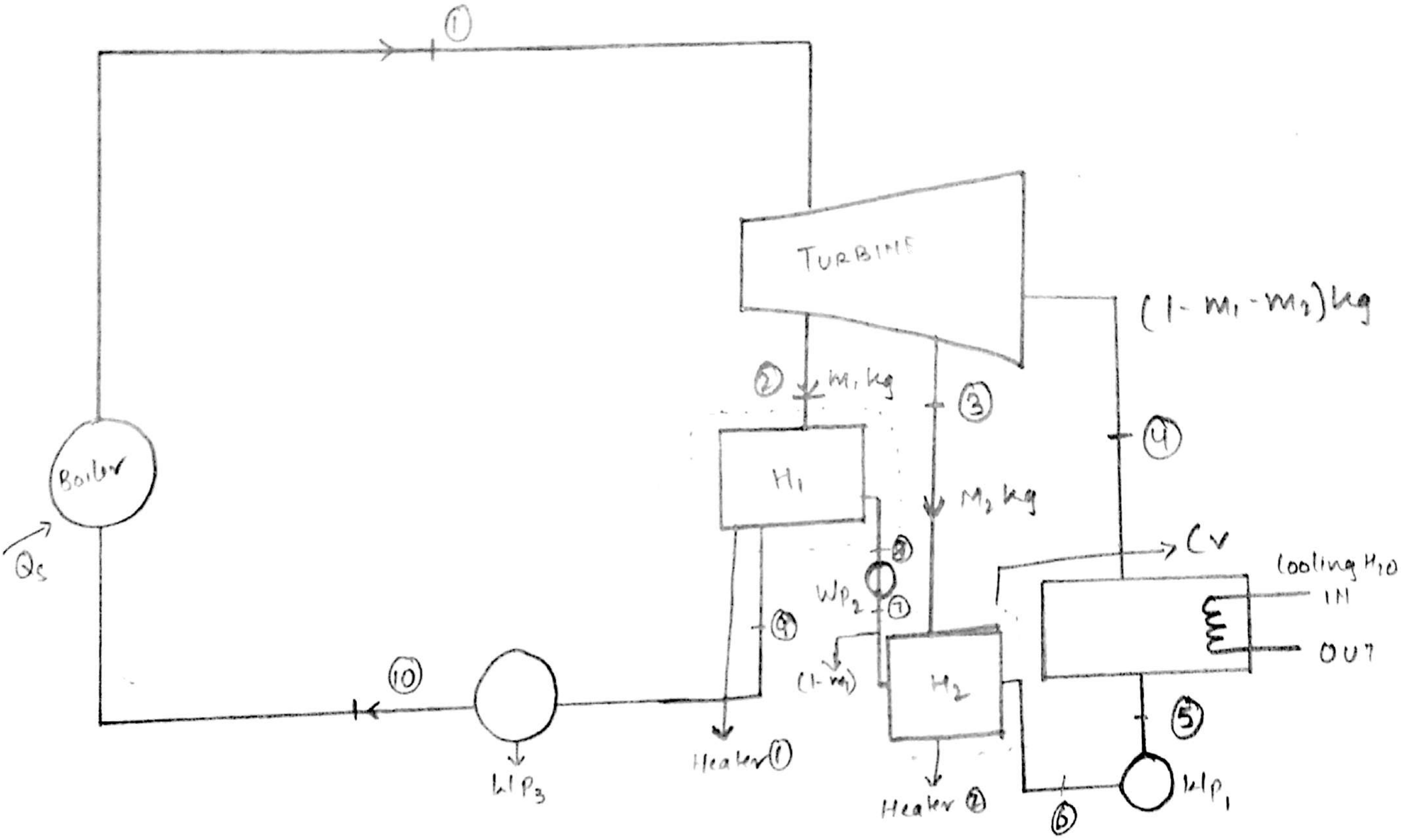
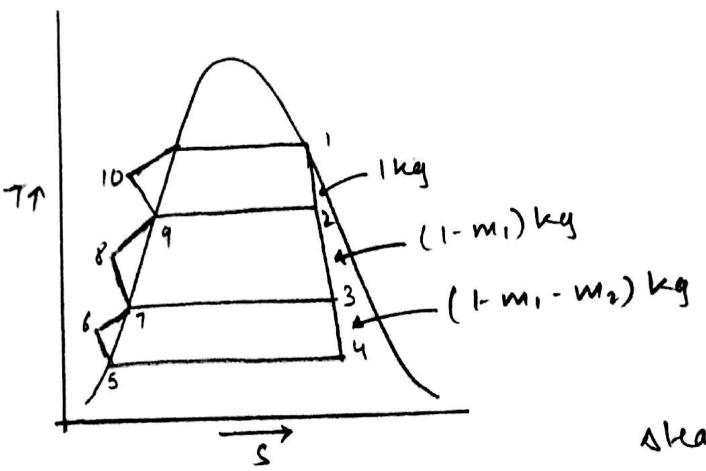
OPEN FEED WATER HEATER





In a practical regenerative cycle the feed water enter the boiler. The temp between 10 and 40 and it is heading by steam excited by boiler. The flow diagram of the regenerative cycle with saturated steam at the inlet of the turbine and corresponding T-S diagram are shown in fig. Let M_1 kg of steam 1 kg of steam entering the turbine. Let M_1 kg of steam extracted from an intermediate stage of the turbine where the pressure is P_2 and it is used to heat up feed water $(1-m_1)$ at Point 8. by mixing in Heater 2. The remaining $(1-m_1)$ kg of steam expands isotropically. M_2 kg of steam is

extracted at Pt 3 centre into heater 2. So $(1-m_1-m_2)$ kg of steam expands remaining stages of the turbine Pressure P_4.
$(1-m_1-m_2)$ kg of steam gets condensed in the condenser and pump into the heater 2, where it is mixed with M_2 kg of steam extracted at P_3.
$(1-M_1)$ kg of water is pumped to heater ② where it is mixed 1kg of steam P_2. Now 1kg working fluid with half of pump③ pumping back to boiler & when it is heated from an external source

$$W_T = 1(H_1 - H_2) + (1-m_1)(H_2 - H_3) + (1-m_1-m_2)(H_3 - H_2)$$

$$Q_S = (H_1 - H_{11})$$

$$klp = klp_1 + klp_2 + klp_3$$

$$\eta_{cycle} = \frac{Q_S - Q_R}{Q_S} = \frac{kW_T - klp}{W_T}$$

1(b)

$H_1 = 3400$ kJ/kg

$H_2 = 2760$ kJ/kg

$H_3 = 3270$ kJ/kg

$H_4 = 2370$ kJ/kg

$$m_1 H_2 + (1-m_1) H_5 = H_7$$

$$m_1 \times 2760 + (1-m_1) 163.4 = 697.1$$

$$2760 m_1 + 163.4 - m_1 (163.4) = 697.1$$

$$m_1 (2760 - 163.4) = 697.1 - 163.4$$

$$m_1 = 0.2055 \text{ kg}.$$

$$W_T = (H_1 - H_2) + (1-m_1)(H_3 - H_4)$$

$$= (3400 - 2760) + (1 - 0.2055)(3270 - 2370)$$

$$= 1355.05 \text{ kJ/kg}.$$

$$Q_s = (H_1 - H_7) + (1 - m_1)(H_3 - H_2)$$

$$= (3400 - 697.1) + (1 - 0.2055)(3270 - 2760) =$$

$$= 3108 \text{ kJ/kg}$$

$$\eta_{th} = \frac{W_T}{Q_s} = \frac{1355.05}{3108} = 0.4399$$

$$= 44\%$$

$$P = m_s \times W_n$$

$$80 \times 10^3 = m_s \times 1355.05$$

$$m_s = 59.08 \text{ kg/s}$$

Steam flow rate $= m_1 \times m_s = 0.2055 \times 59.08$

$= 12.13$

1(c) Characteristics of an Ideal working fluid in Vapour Power cycles.

a) The fluid should have high critical temperature so that saturation pressure at the max. permissible temperature is relatively low.

b) The saturation pressure at the temperature of heat rejection should be above atmospheric pressure so as to avoid the necessity of maintaining vaccum in the condenser.

c) The specific heat of liquid should be small so that little heat transfer is required to rise the liquid to the boiling point.

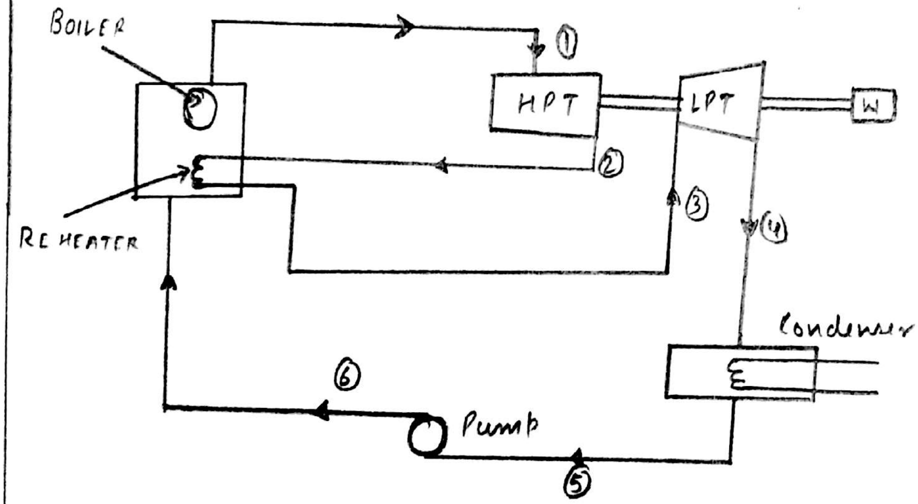
d) The ~~standard~~ saturated line of the T-S diagram should be steep, very close for the turbine expansion process so that excessive moisture does not appear during expansion.

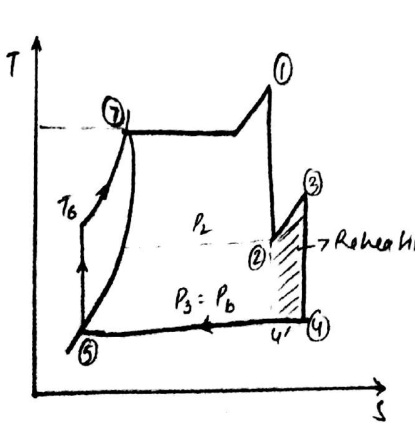
(e) The freezing point of the liquid should be below room temperature so that it does not get solidified while flowing through the pipelines.

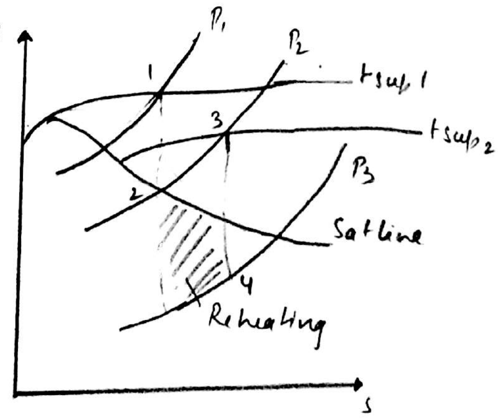
(f) The fluid should be non-toxic, non-corrosive, not excessively,

2(a) REHEAT RAKINE VAPOUR POWER CYCLE

Steam is formed in the boiler by supplying heat from external source. The steam at P_1 and T_1 enters the turbine and expands isentropically to a certain pressure P_2 and temperature T_2. From this state the whole steam is drawn out of the turbine and is reheated in a reheater to a temperature T_3. This reheated steam is readmitted to the turbine, where it is expanded to condenser pressure isentropically. From the condenser the hot water is pumped back to the boiler. Thus the cycle repeates







Work done by the turbine

$W = W_T = (H_1 - H_2) + (H_3 - H_4)$

Heat supplied $Q_s = (H_1 - H_5) + (H_3 - H_2)$

$\eta = \frac{W_T}{Q_s} = \frac{(H_1 - H_2) + (H_3 - H_4)}{\ldots}$

6 Data given:

$P_1 = 150$ bar

$t_{sup1} = 550°C$

$P_3 = 0.1$ bar

$x = 0.95$

To find:

$P_2 = ?$, $\eta_{th} = ?$

Steam rate = ?

$H_1 = 3460$ kJ/kg

$H_2 = 2810$ kJ/kg

$H_3 = 3595$ kJ/kg

$H_4 = 2465$ kJ/kg

$H_5 = h_f$ at 0.1 bar

$= 191.8$ kJ/kg

$W = (H_1 - H_2) + (H_3 - H_4) = (3460 - 2810) + (3595 - 2465)$

$= 1780$ kJ/kg.

$Q_s = (H_1 - H_5) + (H_3 - H_2)$

$= 4053.2$ kJ/kg.

$\eta_{th} = \frac{W}{Q_s} = \frac{1780}{4053.2} = 0.43916 = 43.916\%$.

Steam rate $= \frac{1}{W} \times 3600 = \frac{1}{1780} \times 3600 = 2.022$ kg/kWh.

2c **CLASSIFICATION OF IC ENGINE**

1 According to cycle of operation

(a) Otto cycle

(b) Diesel cycle

(c) Dual combustion cycle

2 According to no of strokes

(a) Two stroke engine

(b) Four stroke engine.

3 According to arrangement

(a) horizontal engine

(b) Vertical engine

(c) V- type engine

(d) Radial engine

(e) Inline engine

4 According to their uses

(a) Stationary engine

(b) Portable engine

(c) Marine engine

(d) Radial engine

(e) Aero engine

5 According to the fuel used.

(a) Petrol engine

(b) Disel engine

(c) Gas engine

(d) Biofuel engine

6 According to method of ignition

(a) Spark Ignition (SI) engine

(b) Compression Ignition (CI) engine.

7 According to method of cooling

(a) Air cooled engine

(b) Water cooling engine.

8 According to method of governing

(a) Hit and Miss governed engine

(b) Quality governed engine

(c) Quantity governed engine

9 According to no cylinders.

(a) Single cylinder engine

(b) Multi-cylinder engine.

Automotive Pollutants and their effects on environment

(i) Unburned hydrocarbons

→ These are the direct result of incomplete combustion. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs and aggrevates respiratory problems. It is the most wide spread and interactable urban air pollution.

(ii) Oxides of C

→ Carbon monoxide is a product of incomplete combustion and occurs when the carbon in fuel is partially oxidized rather than fully oxidized to CO_2.

CO_2 is the product of complete combustion. CO_2 doesnot directly impair human health but it is a green house gas that traps the earth heat and contributes to global warming.

(iii) Oxides of Nitrogen

→ Nitrogen oxides are the compounds of N_2, NO_x is produced when fuels burn at high temperature, high pressure and excess oxygen in the engine combustion chamber. Disel vechicles are the dominant exhaust source NO_x.

(iv) Oxides of Sulphur

Many fuels used in CI engine contains small amount of Sulphur. When exhausted in the form SO_2, SO_3, they contribute to the acid rain problem of the world. It also damages forest.

(v) Soot and Smoke

→ Smoke is the visible product of combustion which is due to poor combustion. Any volume in which fuel is burned at relative fuel air-ratio greater than 1.5 in disel engines produces soot. If this soot once formed finds sufficient oxygen, it will

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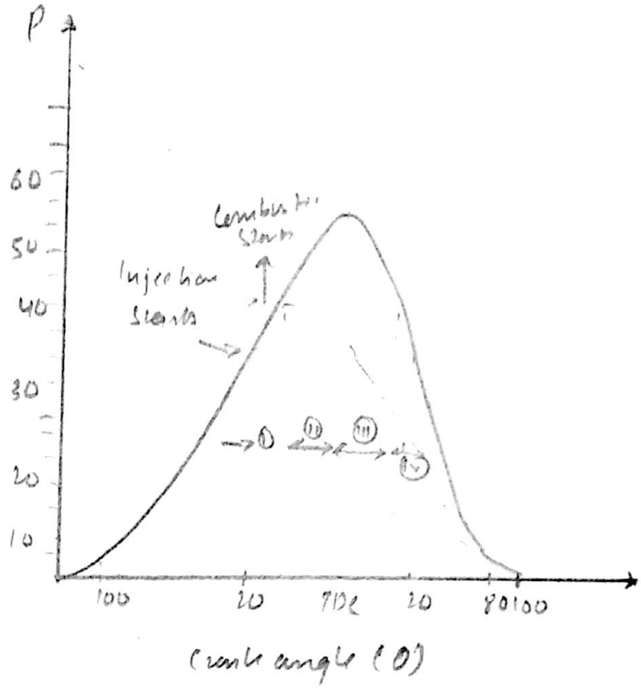
COMBUSTION IN C I ENGINE

(I) Ignition delay period



→ The delay period is counted from the start of injection to the point where the p-θ curve departs from motoring curve. The delay period is divided into physical delay and chemical delay. In physical delay the fuel is atomised, vapourised mixed with air and raised in temp. In chemical delay period reaction start slowly and then acceleration until ignition takes place the delay period exerts a great influence in the CI engine combustion phenomenon.

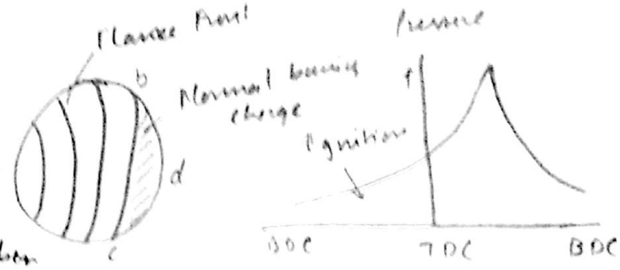
(II) Uncontrolled combustion

→ This period is counted from the end of delay period to the point of maximum pressure on the p-θ diagram. In this stage, the rise of pressure is rapid because during period the droplets of fuel have time to spread themselves out over a wide area. and they have fresh air all around them.

(III) Controlled combustion : At the end of second stage of combustion, the temperature and pressure are so high that the fuel droplets injected in the third stage burn almost as they enter and any further pressure rise can be controlled by purely mechanical means.

IV After burning: The combustion continues even after the fuel injection is over because of poor distribution of fuel particles. This burning may continue in the expansion stroke upto 70° to 80° of crank travel from T.D.C. This continued burning is called as after burning.

Detonation



Detonation is due to the auto ignition of the portion ~~flame front proceeds across the chamber the p.~~ of the unburned charge in the combustion chamber. As the normal flame front proceeds across the chamber, the pressure and temperature of the unburned increases due to the compressed ~~charge~~ by the burned portion of the charge. This releases energy during auto ignition causes a high pressure differential in the combustion chamber and a high pressure wave is released from the auto iginition. This phenomena is known as detonation.

Effects

(I) The engine parts are subjected to high pressure waves which may cause heavy damage to the piston and the connected components.

(II) It creates heavy vibrations of the engine and creates undesirable noise which is always objectionable.

(III) Auto ignition overheats the spark plug. Due to this, ignition of charge takes place before spark occurs.

(IV) More heat is lost to the coolant as the dissipation rate is rapid.