POWER STATION ENGINEERING

Semester: 6th

STUDY MATERIAL

POWER STATION ENGINEERING

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Introduction :-

→ Powerstation also referred as generating station or power plant is an industrial facility for the generation of electric power. power plant is also used to reffer to the engine in ships, aircraft & other large vehicles.

→ At the centre of nearly all power stations is a generator, a rotating m/c that converts mechanical energy into electrical energy by creating relative motion betn a magnetic field & a conducter.

* Energy :-

→ Energy is defind as it is the capacity of doing work. As we already know that energy neither be created nore be destoryed only it can transforms from one form to another.

→ Energy Exists in various forms. for ex Mechanical, thermal, electrical, solar, wind etc.

→ **POWER** :- It can be defind as it is the rate of flow of energy with respect to time & can state that a powerplant is a unit built for production & delivery of a flow of mechanical & electrical energy.

Sources of Energy :-

There are various types of energy such as -

(1) fuel — (a) solid :- coal
(b) liquid :- petrol, diesel, kirosine etc
(c) gasses :- LPG & CNG

(2) Energy stored in water that is Hydraulic Energy.
(3) Neclear Energy.
(4) Wind power Energy.
(5) solar Energy.
(6) Tidal power Energy.
(7) Geothermal energy
(8) Thermo electric power.

TYPES OF POWER STATION :-

→ The power stations are classified into 2 types.

① central power station

② captive power station.

① central power station :-

→ The electrical energy available from these stations is meant for general sale to the customers who wish to purchase it.

② Captive power station :-

→ This type of power station is run by a manufacturing company for its own use & its O/P is not available for general sale

⊙ Fuel :-

→ Generally fuels are the substance which are used for generating the heat energy by conversion.

→ The principle conversible elements of each fuel are carbon & hydrogen.

→ The fuels are classified into 3 different types.

(a) solid fuel (coal, coke)

(b) liquid fuel (diesel, petrol, kirosine)

(c) gaseous fuel (LPG, CNG)

1. solid fuels :-

→ Coal :- The main constituents of coal are carbon, hydrogen, oxygen, nitrogen, sulphur, moisture & ash. Coal passes through different stages during its formation from vegetation. Different stages of coals are

1. Peat
2. Lignite or brown coals
3. Bituminous.
4. Semi bituminous.
5. Anthraxide.

1. Peat :- It is the 1st stage in the formation of coal.
→ It contains huge amount of moisture therefore it is dryed for about one to two months before it is put to use.
→ It is used as a domestic fuel in europe & power generation in Russia.

2. Lignite or brown coals :-
→ These are the intermediate stage betn the peat & coal.
→ These are associated with high moisture, high ash & low heat containts.
→ Lignites are usually amorphous in char. & impose transport difficulties as they break easily.

3. Bituminous coals :-
→ It burns with long yellow & smoking flames & has high percentage of volatile matter.
→ The calorific value of bituminous coal is 31350 kg/kg.
→ It may be of two types ① caning
② Noncaning

4. Semi bituminous coal :-
→ It burns with a very small amount of smoke.
→ It contains 15-20 % of volatile matter.
→ It is softer than anthraside.

5. Anthracite :-

→ It is very hard coal & has a shining black lustre.
→ It ignites slowly unless the furnesh temp. is high.
→ It is noncaking & has fixed percentage of carbon.
→ It burns either with very short blue flames or without flames.
→ The calorific value of this fuel is 35500 KJ/kg. & as such is very suitable for steam generation.

• Coke :-

1 - It is the solid residue left after the destructive distilation of wood or certain kinds of coals
2 - It is mainly used in blast furnance to produce heat & at the same time
3 - It consist of carbon, suephur, small quantity of S_2, N_2 & P.

• Energy stored in Water :-

→ The energy contain in flowing of water is a form of hydraulic energy or in the form of mechanical energy. It may exist as the kinetic energy or as potential energy of the water at some elevation w.r.to a lower dattom level.
→ Hydraulic plants are slowly increase in order, although the no of new plants of this type built is quite small.
→ Water power is quite chiefe where water is available in abundance.
→ Although the capital cost of hydroelectric powerplant is higher as compare to other types of power plants.

• **Neuclar energy (necluar power) :-**

→ It is the large amount of energy that can be released from a small mass of active material.

→ Complete fission of 1 kg of uranium contains the energy equivalent of 4500 tones of coal or 2000 tones of oil.

→ The Necluar power is not only available in abundance but it is cheaper than the power generated by convenctional sources.

• **Wind power :-**

→ The man has been served by the power from winds for many centuries but total amount of energy generated in this manner is small.

→ The expence of installation & variability of operation have tended to limit the use of wind mill.

→ In india the wind velocity along coast line has a range 10-16 kmph & a survey of wind power has revealed that wind power is capable of exploitation for pumping water from deep wells or for generating small amount of electric energy.

→ Modern wind mills are capable of working on velocities as low as 3-7 kmph while max^m efficiency is attained at 10-12 kmph

Charecterstics of wind power / energy :-

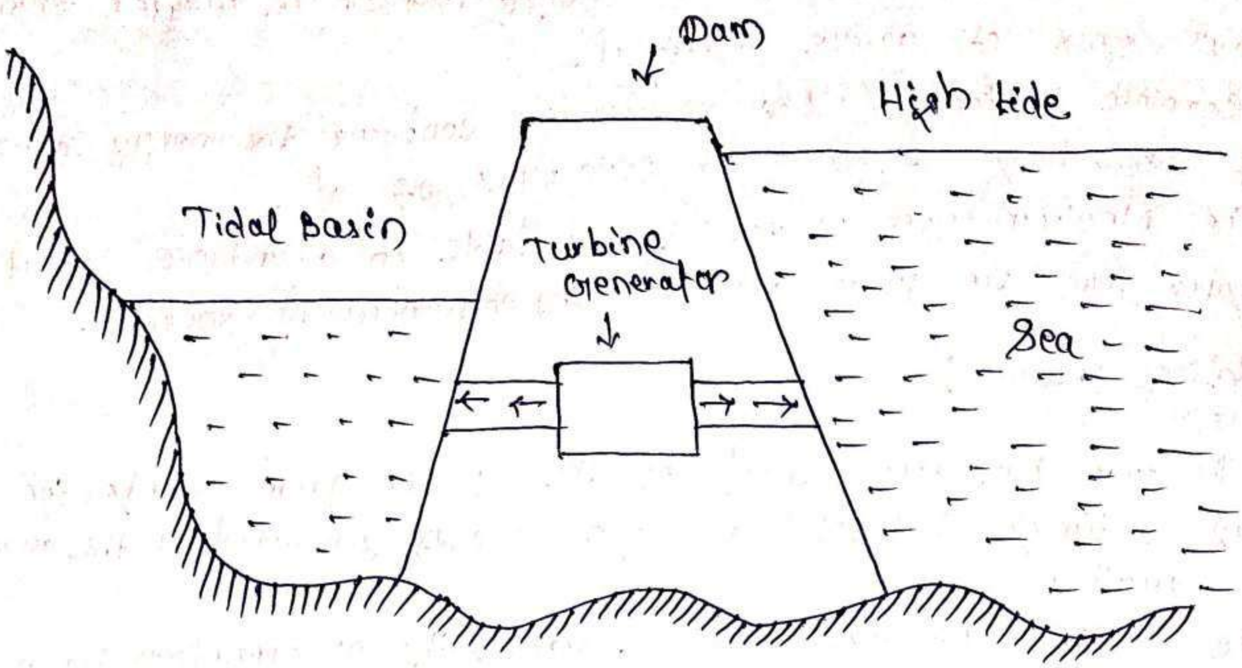
① No fuel provision & transport are required in wind energy system.

② It is a renewable source of energy.

③ Wind power systems are nonpolluting.

④ Wind power systems, upto a few kw, costs can be competative with convectional electricity.

• Tidal power energy :-



1 → The rise of fall of tides offers a means for storing water at the rise & discharging the water at fall.
2 → The use of tides for electric power generation is partical in a few favourably situated sites where the geography of an inlet of bay favours the construction of a large skilled hydroelectric plant.
3 → To harness the tides, a dam would be built across the mouth of the bay in which large gates & low head hydraulic turbine would be installed.
4 → At the time of high tide the gets are opened automatically. After the tide has receeived the turbine is operated & then the water is discharging to the tidal basin then the gates are closed.
5 → With this type of arrangement the generation of electric power is not contineous.

• **Geothermal power :-**

→ In many places on the earth natural steam escapes from surface vents. such natural steam wells suggest the posibility of heat or geothermal energy.

→ There are probably many places where no natural steam vent or hot springs are sowing, deep drillings might tap a source of underground steam.

• **Thermoelectric power :-**

When the two ends of a loop of two dissimilars metals are held at different tempratures, an electromotive force is developed & the current closed into the loop. The method by slection of suitable material can also be used for power generation. This method involves low initial cost & neglisible operating cost.

• **Solar power :-**

(1) A lot of work to be utilized solar energy for generation of steam has been done in some countries.

(2) A serious fault of this source of energy is, of course that it is effective only during the daytime, so that if a contineous O/P is needed some large reserver of energy such as a storage battery must be drawn upon at night.

(3) Also the O/P is handicaped if there is clouding weather.

(4) Neverthless, there are some locations in the world where strong solar radiation is received very regularly, such locations offer more intrest to the solar power plant builders.

(5) For developing solar energy two ways have been explod that is the glass lence & the reflector.

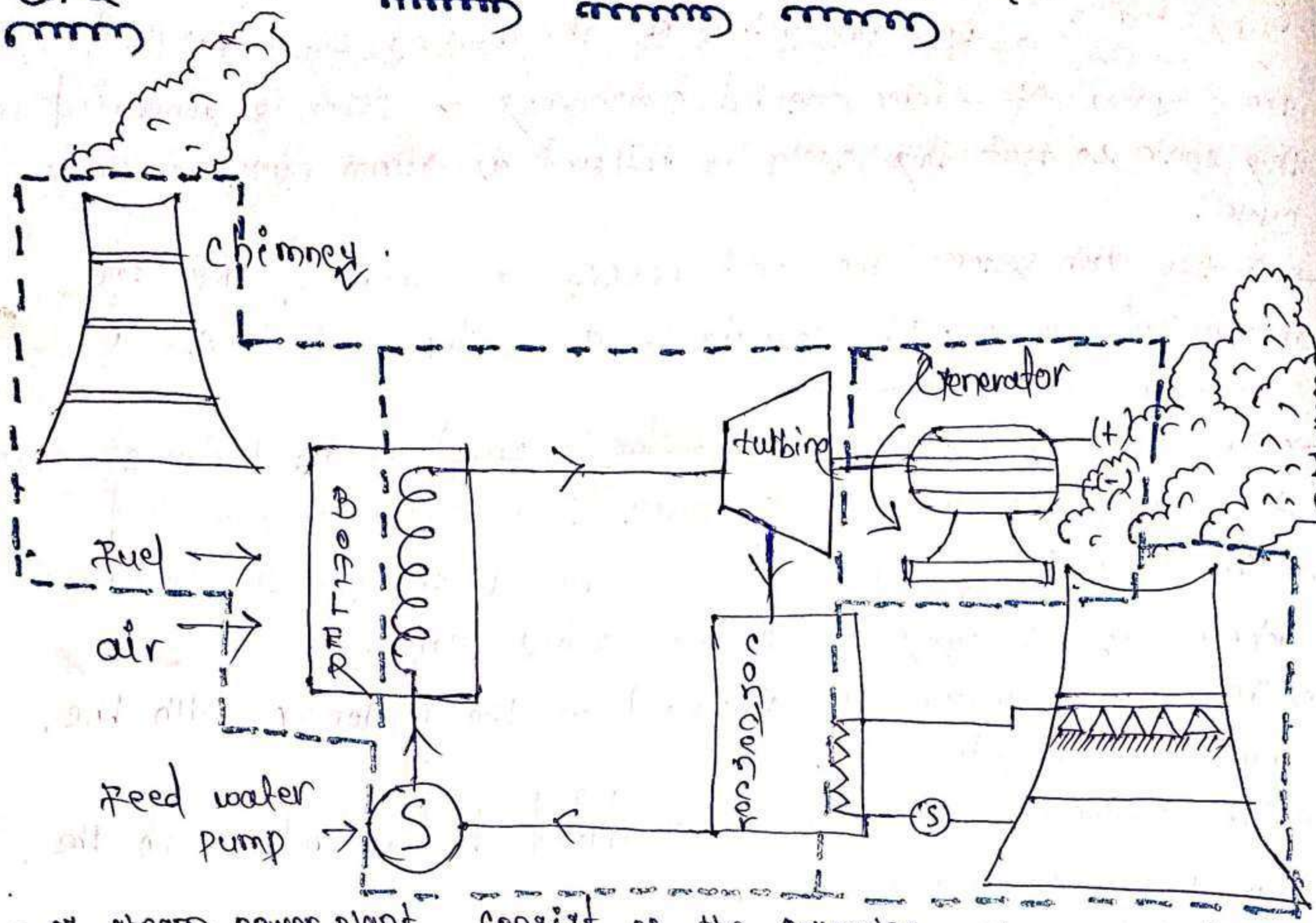
(6) These device concentrate the solar rays to the focal point which is charecterised by a high degree of it which can be

utilised to boil water & generate steam.

(7) Condⁿ for utilization of solar energy in india are favorable since for nearly 6 months of the year, sunshine is uninterrupted during the day. While in the other six months cloudy weather.

(8) Thus a coordination of solar energy with water power can provide a workable plant for most places in india.

Ch-2 →> STEAM POWER PLANT <<-



→ A steam power plant consist of the following main components

1. Boiler
2. steam turbine
3. condenser
4. ~~Fo~~ feed water pump.
5. Electric generator.
6. cooling tower
7. Water circulating pump
8. chimney

→ The above diagram represents the simplified cycle & the basic components of a steam powerplant. To facilitate the thermodynamic analysis the whole plant can be devided into 4 major substations identified fied as subsystem A, B, C & D.

Subsystem A :- It consists of a furnesh & chimney. Its fun^c is to supply heat energy to the boiler. The heat energy may be obtained by burning of fossil fuel.

necluar reaction or by solar energy.

Subsystem B :- In subsystem B the working fluid passes through the series of 4 interconnected components & power is generated in this cycle so that this cycle is reffered as steam cycle or power cycle.

→ In this sub system the heat energy is converted into the mechanical work. It consists of a boiler, a turbine, a condenser & a heat pump.

→ The steam generated in the boiler is passed to the turbine where it expands to a lower pressure thus power is generated.

→ The steam living the turbine is passed through the condenser where it condenses through the cooling water.

→ The cooling water is circulated in the condenser with the help of subsystem C.

→ The condensate is then recirculated to the boiler with the help of feed water pump.

Subsystem C :- It consist of the cooling tower & water recirculation pump. The circulated warm water from the condenser is sent to the cooling tower where its heat energy is rejected to the atmosphere.

Subsystem D :- The subsystem D pertains to generation of electrical energy & thus consist of a generator. The generated electricity is supplied to a power grid through the substations.

• Performance parameters of steam power cycle :-

① Thermal efficiency :-

→ The thermal efficiency of steam power cycle is defind as it is the ratio betn net work O/P & the heat I/P

→ Mathmatically $\eta_{ith} = \frac{W_{net}}{Q_{in}}$

② Back work ratio :-

→ It is the ratio bet^n the pump work & turbine work

then $bwr = \frac{W_P}{W_t}$

③ Work ratio :-

→ It is defind as it is the ratio bet^n net work output & the turbine work.

$$\text{work done} = \frac{W_{net}}{W_t}$$

$$= \frac{W_t - W_P}{W_t} = 1 - \frac{W_P}{W_T} = 1 - bwr.$$

④ specific steam consumption :-

→ It is the amount of steam required to produce one kwh of power or 3600 KJ of work is known as specific steam consumption (SSC) it is also called steam rat

→ It is denoated by (SSC) & it is expressed as

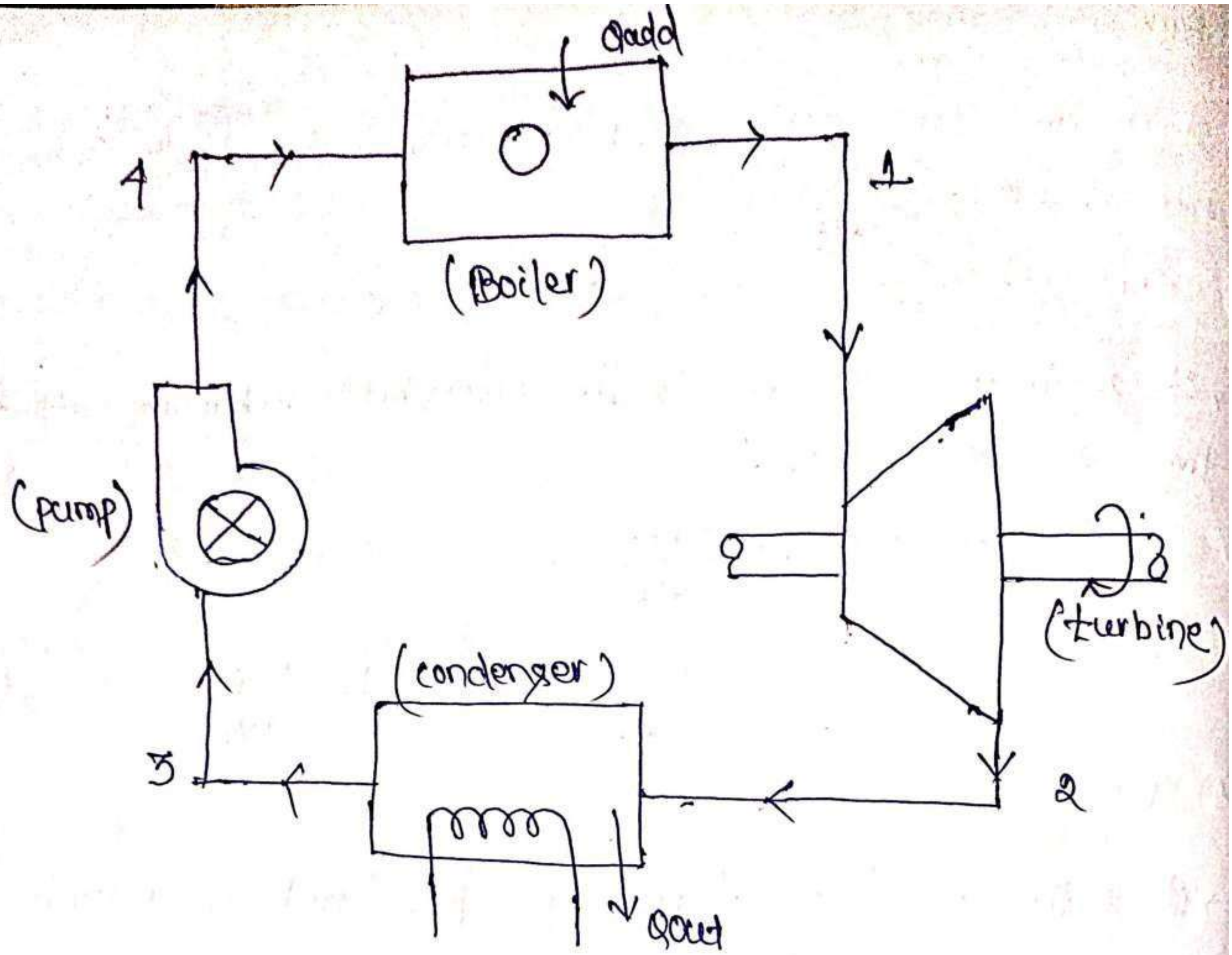
$$SSC = \frac{\text{Mass of steam in KJ/hour}}{\text{Power O/P in kw.}}$$

→ Rankine Cycle :-

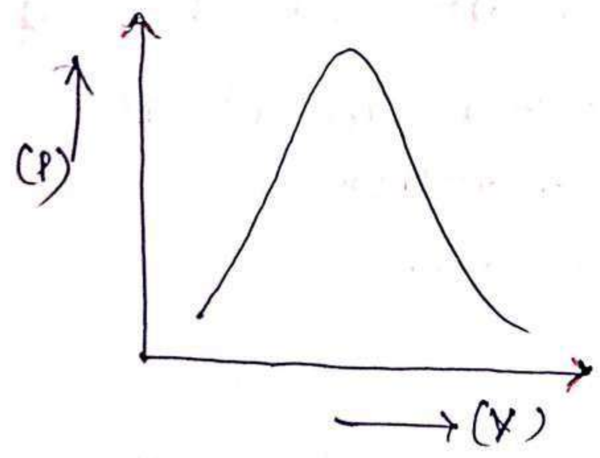
→ The steam power plant is actually operated by rankine cycle. The rankine vapour Cycle is more partical than the other cycle. It consist of 4 Major components for generating the power. The different components are a steam boiler known as steam generator, a steam turbine, a condenser & a pump.

→ Here In this cycle we are using a pump instead of a compressor operating in carnot Cycle.

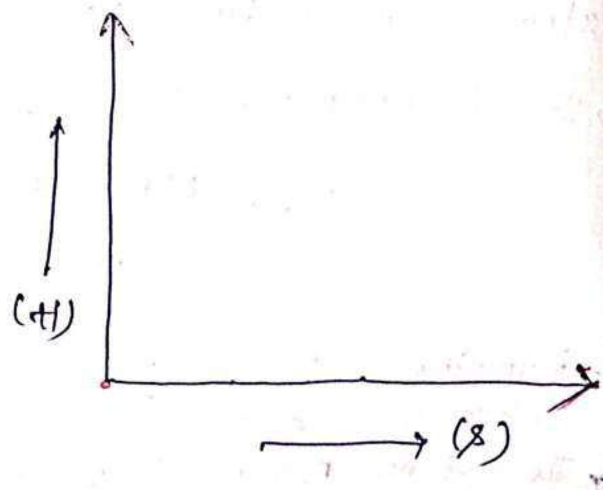
→ The high pressure & temp saturated steam generating from the boiler is passes into the turbine where it gets expanding.



Qadd
(Boiler)
1
(turbine)
2
(condenser)
Qout
3
(pump)
4



(P)
(V)



(H)
(S)

at expansion the steam looses its temp & pressure. The low pressure steam then enters into the condenser. In the steam is converted into the condenser there is cooling water arrangement for condensing the low pressure steam. After that the steam is converted into the liquid form at the exist of condenser.

→ Then the Condensate is allowed to flow through the pump where it compreses & increase the pressure.

→ The above diagram indicates the skimatic arrangement of rankine cycle with P-V & T-S & H-S coordinates

→ The rankine Cycle is operating in 4 different processes named as

process 1-2 → Isentropic expansion Process.

→ This process is known as isentropic expansion process

$$W_t = h_1 - h_2$$

process 2-3 → constant pressure heat rejection process.

→ Here $Q_{rej} = h_2 - h_3$

process 3-4 → Isentropic compression process

→ Here $W_p = h_4 - h_3$.

process 4-1 → constant pressure heat addition process.

→ Here $Q_{add} = h_1 - h_4$.

*) We know that $\eta_{th} = 1 - \dfrac{Q_{out}}{Q_{in}}$

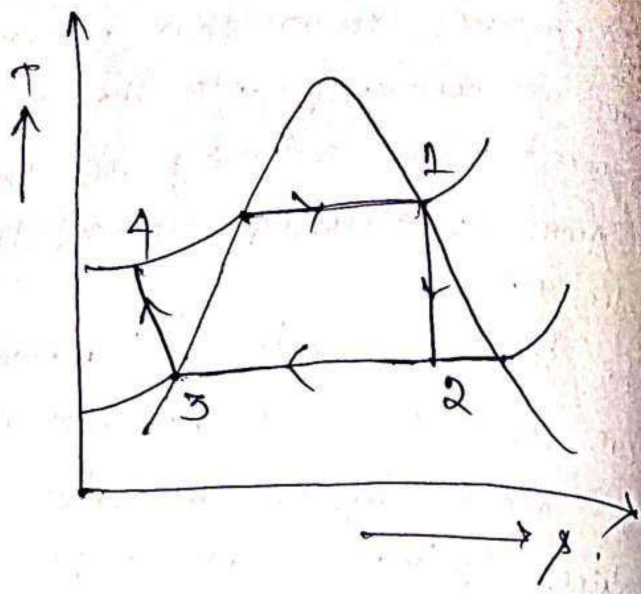
$$= 1 - \frac{h_2 - h_3}{h_1 - h_4}$$

→ Here at state-1 :-

$P_1 = ?$

$h_1 = h_{g1} =$ KJ/Kg.

$s_1 = S_{g1} =$ KJ/KgK



→ at state-2 :-

$P_2 = ?$

$s_1 = s_2$

$h_{f2} =$ KJ/Kg.

$h_{fg2} =$ KJ/Kg.

$S_{f2} =$ KJ/KgK

$S_{fg2} =$ KJ/KgK.

$$\boxed{h_2 = h_f + x h_{fg}}$$

$s_1 = s_2 = (S_f + x S_{fg}) = x$

→ at state-3 :-

$h_3 = h_{f3}$

$v_{f3} = ?$

→ at state-4 :-

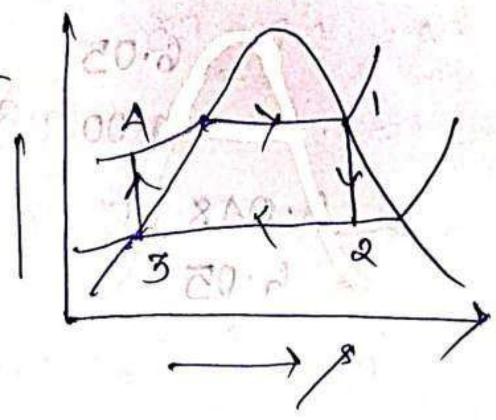
$W_P = h_4 - h_3$

$\Rightarrow h_4 = W_P - h_3$

$W_P = v_{f3}(P_4 - P_3)$

$= v_{f3}(P_1 - P_2)$

Q) A steam power plant has boiler & condenser pressure of 60 bar & 0.1 bar respectively. steam coming out of the boiler is dry & saturated. The plant operates on the rankine cycle. calculate the thermal efficiency of the point.



Given) Here $P_1 = 60 \text{ bar} = 60 \times 100$
$= 6000$

$\& P_2 = 0.1 \text{ bar}$
$= 0.1 \times 100 = 10.$

→ Here at state 1 :-

$P_1 = 60 \text{ bar}$

$h_1 = h_{g1} = 2784.3 \text{ kJ/kg}$

$S_1 = S_{g1} = 5.8892 \text{ kJ/kgK}.$

→ Then at state 2 :-

$P_2 = 0.1 \text{ bar}$

$h_{f2} = 191.83 \text{ kJ/kg}$

$h_{fg2} = 2392.8 \text{ kJ/kg}$

$S_{f2} = 0.6493 \text{ kJ/kg K}.$

$S_{fg2} = 7.5009 \text{ kJ/kg K}.$

→ Then at state 3 :-

$P_3 = 0.1 \text{ bar}$

$h_3 = h_{f3} = 191.83 \text{ kJ/kg}.$

$V_{f3} = 0.001010 \text{ m}^3/\text{kg}.$

→ Then <u>at state 4 :-</u>

$$W_P = h_4 - h_3$$

$$h_4 = W_P - h_3$$

$$= 6.05 + 191.83$$

$$= 197.88 \text{ kJ/kg}$$

$$W_P = V_{f_3}(P_1 - P_2)$$

$$= 0.001010(6000 - 10)$$

$$= 6.049 \text{ kJ/kg}$$

approx $= 6.05$ kJ/kg

then $h_2 = (h_{f_2} + x\, h_{fg_2})$

$$h_2 = 191.83 + x \times 2392.8$$

$$\Rightarrow h_2 = 191.83 + (0.6985 \times 2392.8)$$

$$\Rightarrow h_2 = 1863.20 \text{ kJ/kg}$$

$$S_2 = (S_{f_2} + x\, S_{fg_2})$$

$$5.8892 = (0.6493 + x \times 7.5009)$$

$$\Rightarrow x = \frac{5.8892 - 0.6493}{7.5009}$$

$$\Rightarrow x = 0.6985 \text{ (unitless)}$$

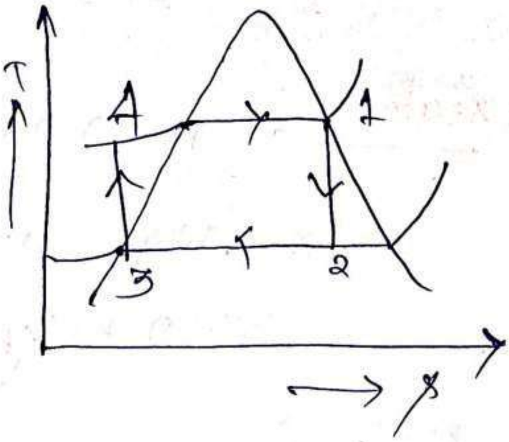
∴ efficiency of $\eta_{th} = 1 - \dfrac{h_2 - h_3}{h_1 - h_4}$

$$= 1 - \frac{1863.20 - 191.83}{2784.3 - 197.88}$$

$$= 0.35 \%$$

$$= 35\% \text{ Ans}$$

→ A steam power plant works bet^n pressure 40 bar & 0.05 bar. If the steam supplied is dry saturated & the cycle of operation is rankine cycle, find the cycle efficiency.



→ Here $P_1 = 40$ bar

$= 40 \times 100 = 4000$

$P_2 = 0.05$ bar

$= 0.05 \times 100 = 5$

→ In process 1 :-

$P_1 = 40$ bar

$h_1 = h_{g1} = 2801.4$ kJ/kg

$S_1 = S_{g1} = 6.0701$ kJ/kg K.

→ In state-2 :-

$P_2 = 0.05$ bar

$h_{f2} = 137.82$ kJ/kg

$h_{fg2} = 2423.7$ kJ/kg

$S_{f2} = 0.4764$ kJ/kg K

$S_{fg2} = 7.9187$ kJ/kg K.

$S_2 = S_{f2} + x S_{fg2}$

$6.0701 = 0.4764 + x \times 7.9187$

$$x = \frac{6.0701 - 0.4764}{7.9187} = 0.7063$$

$$h_2 = h_{f2} + x\, h_{fg2}$$

$$h_2 = 137.82 + 0.7063 \times 2423.7$$

$$= 1849.6 \ \text{kJ/kg}.$$

At state 3 : $P_2 = 0.05$ bar

$$h_3 = h_{f3}. \quad V_{f3} = 0.001005 \ \text{m}^3/\text{kg}$$

$$= 137.82 \ \text{kJ/kg}$$

At state 4 :

$$W_P = h_4 - h_3$$

$$h_4 = W_P + h_3$$

$$= 4.014 + 137.82$$

$$= 141.834 \ \text{kJ/kg}.$$

$$W_P = V_{f3}(P_1 - P_2)$$

$$= 0.001005(4000 - 5)$$

$$= 4.014$$

$$\eta_{ith} = 1 - \frac{h_2 - h_3}{h_1 - h_4}$$

$$= 1 - \frac{1849.6 - 137.82}{2801.4 - 141.834}$$

$$= 0.35 \% \quad = 35 \%$$

*) Reheat cycle :

→ If the steam expands completly in a single stage then steam coming out from the turbine is very weight wet. The wet steam carries suspendent moisture particle which are heavier than the vapour particles, thus deposited on the blades & causing its erosion.

→ In order to increase the life of the turbine blades it is necessary to keep the steam dry during its expansion.

→ It is down by allowing the steam to expand to an intermediate pressure in a high pressure turbine, & then taking it out & sending back to the boiler where it is reheated at constant pressure, untill it reaches the inlet temp. of the 1st stage as shwon in skimatic diagram.

→ This process is called re heating & the cycle is known as reheat rankine cycle.

→ Due to reheating the work o/p of the turbine increases, thus improving the thermal efficiency.

Working : The reheat cycle is designed to take advantage of higher boiler pressure by eleminating the proplem of excessive moisture content in the exhaust s

The working of reheat cycle consist of a boiler, high pressure turbine, low pressure turbine, condenser & a heat water pump. The above skimatic diagram represents the steam enters at state - 1 in the 1st stage of turbine (Hp) & expands isentropically to the state - 2.

At state 2 the quality of steam is either slidely dry or just wet & thus it is taken back in the boiler & is reheated to the original superheated temp t_3.

then this reheated steam is further expanded in the low pressure turbine in the process 3-4.

Then the cycle is continued as the rankine cycle.

Regenerative Cycle :-

→ In a simple rankine cycle is significant amount of heat is added for sensible heating of compressed liquid coming out the pump.

→ The mean temp at which sensible heat added is much lower than the source temp. thus the efficiency of the rankine cycle is much lower than that of carnot vapour power Cycle.

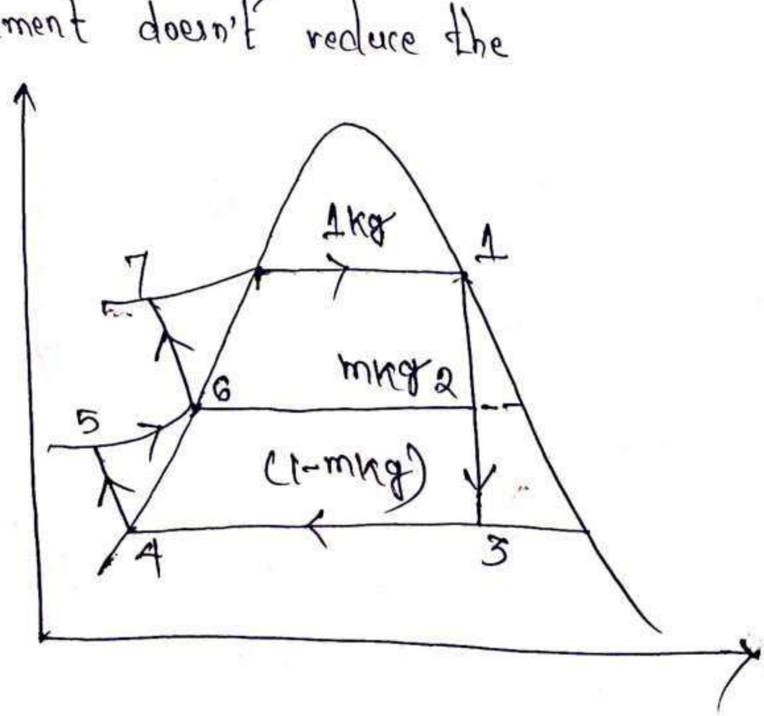
→ The efficiency of the rankine cycle can be improved by heating the feed water regeneratively.

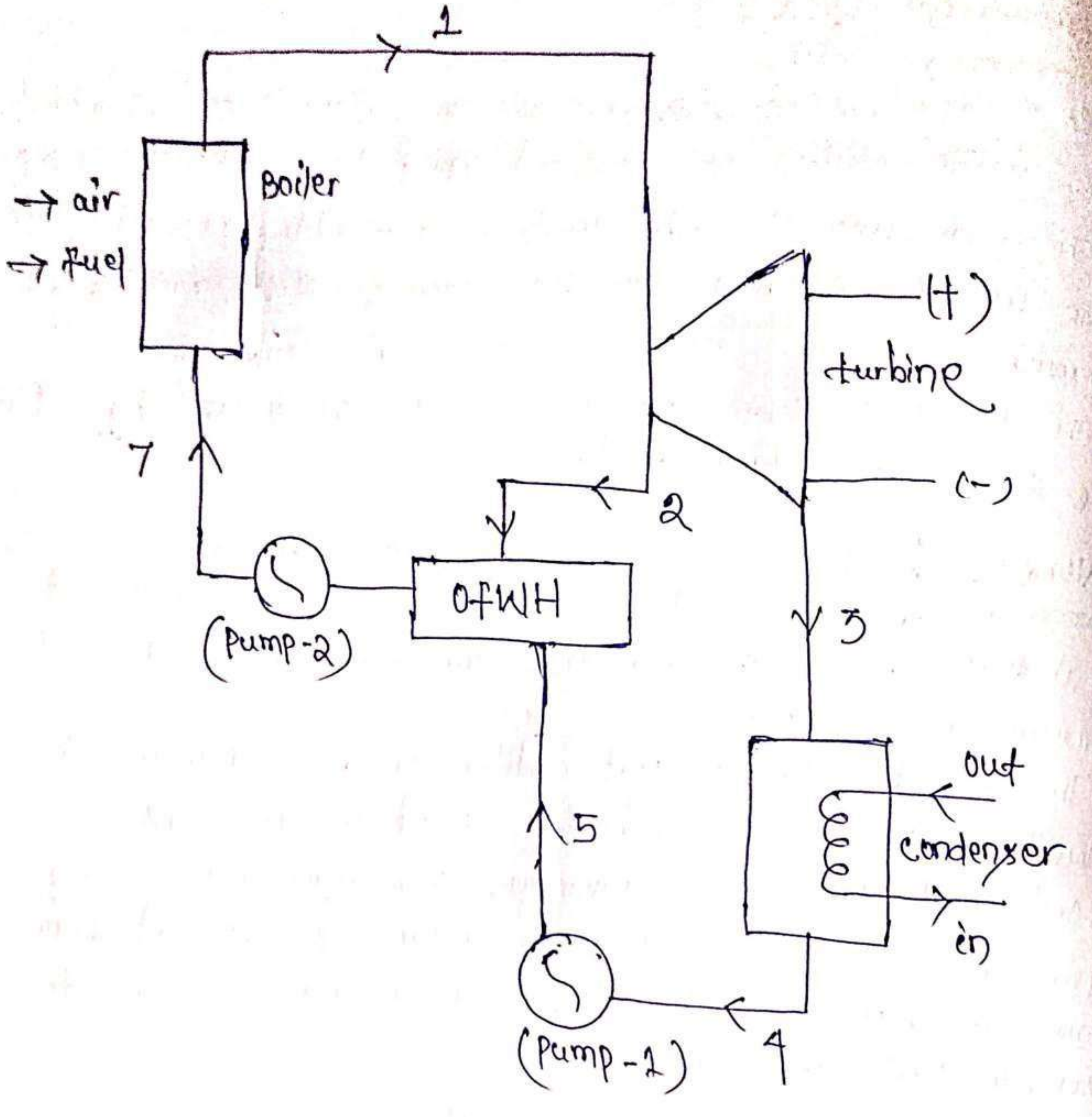
Working :- The mean temp of heat addⁿ in the rankine cycle can be improved by increasing the heat supplied at high temp such as increasing super heat, increasing boiler pressure & reheat.

→ The Mean temp Of the heat addition can also be increased by decreasing the amount of heat supplied at lower temps.

→ In actual practice the advantage of regenerative heating principle is used by extracting a part of expanded steam from the turbine & it is used for heating of feed water in separate feed water heaters.

→ This Arrangement doesn't reduce the




1
→ air
→ fuel
Boiler
(+)
turbine
(−)
7
2
OFWH
(Pump-2)
3
out
5
condenser
in
(Pump-1)
4

Water level indicator :-

1→ The water level indicator is located infront of the boiler in such a position that the level of water can easily be seen to the attaindaned.

→ Two verieties of water level indicators are used on all boilers.

→ A water level indicator consist of a strong glass tube with reading.

→ The upper & lower ends of these tubes are connected to the two gun metal. The upper pipe has a steam cock & the lower pipe has a water cock.

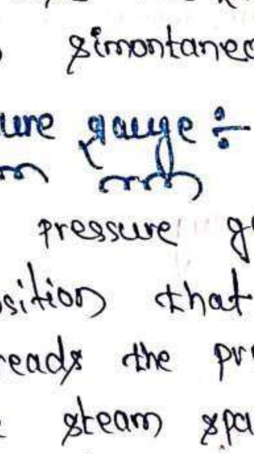
→ During the boiler operation the steam cock & the water cock remain opened.

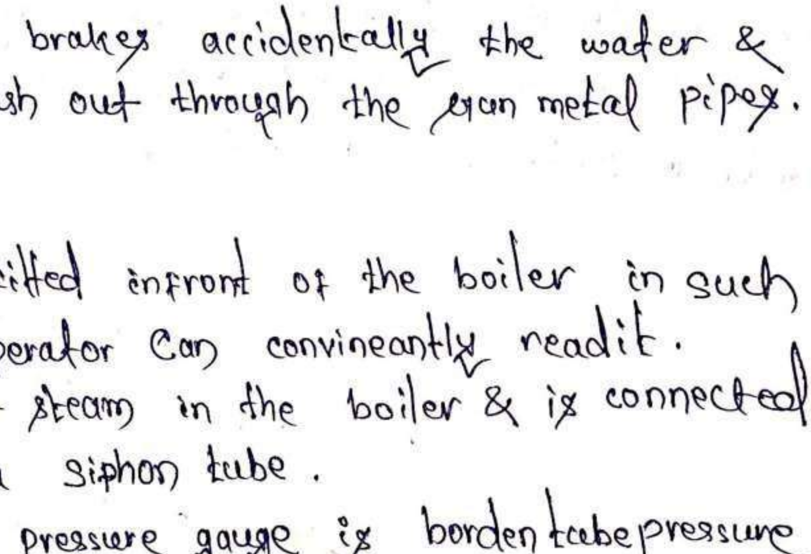
→ In case the glass tube brakes accidentally the water & steam simontaneously. rush out through the gun metal pipes.

Pressure gauge :-

1- A pressure gauge is fitted infront of the boiler in such a position that the operator can convineantly readit. It reads the pressure of steam in the boiler & is connected to the steam space by a siphon tube.

2- The most commonly used pressure gauge is borden tubepressure gauge.





3 – The bordon tube pressure gauge consist of an eliptical spring, one end of this tube is connected to the siphon tube & the other end is connected by leavers & gears to the pointer.

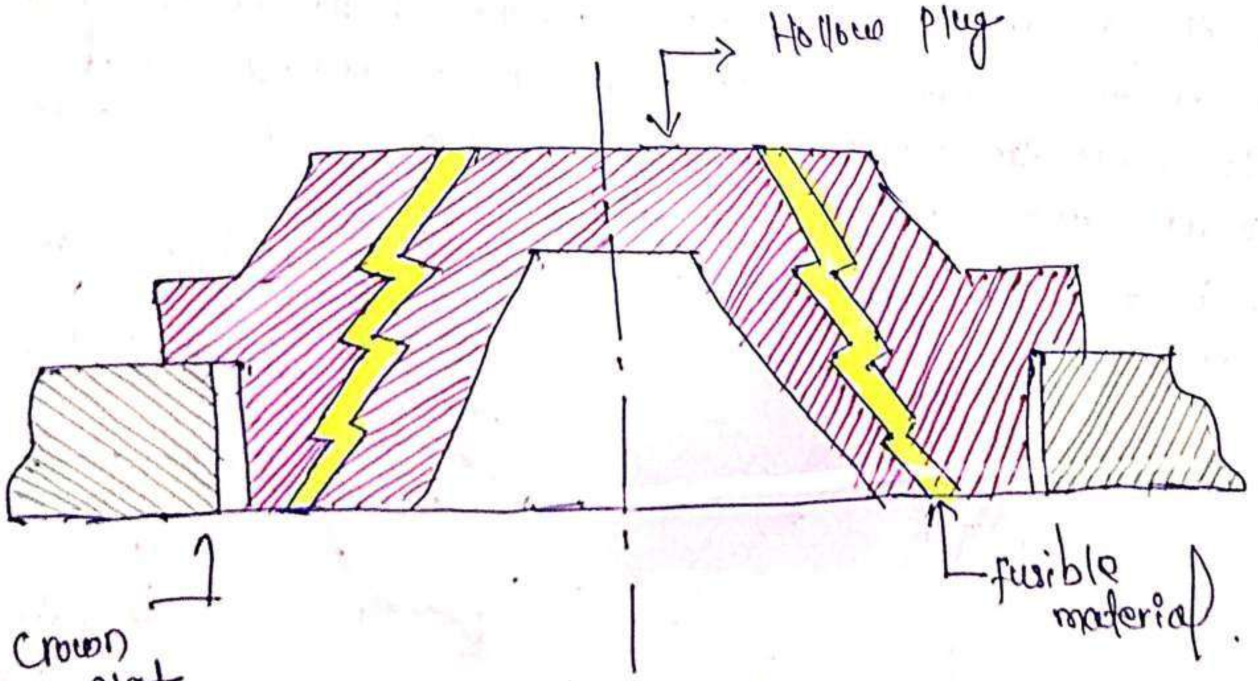
4 – When the fluid pressure is acts on the bourdon tube it tries to make its crossection change from eliptical to circular.

5 – In this process the leaver end of the tube moves out as indicated by an arrow.

6 – The tube movement is magnified by the mechanism & given to pointer to move over a circular skell & indicating the pressure.

Fusible plug :- It is very important safety device which protects the fire tube boiler shell against over heating.

→ It is located Just above the furnesh in the boiler, it consist of a gunmetal plug fixed in a gun metal body with a fusible molten metal.



(fusible plug)

3 → During the normal boiler operation the fusible plug is covered by water but when the water level falls too low in the boiler it uncovers the fusible plug.

→ The furnesh gases heat of the plug the fusible metal of the plug melts.

→ The water then rush through the hole & extinguish the fire before any major damage occurs to the boiler due to over heating.

Feed check valve :

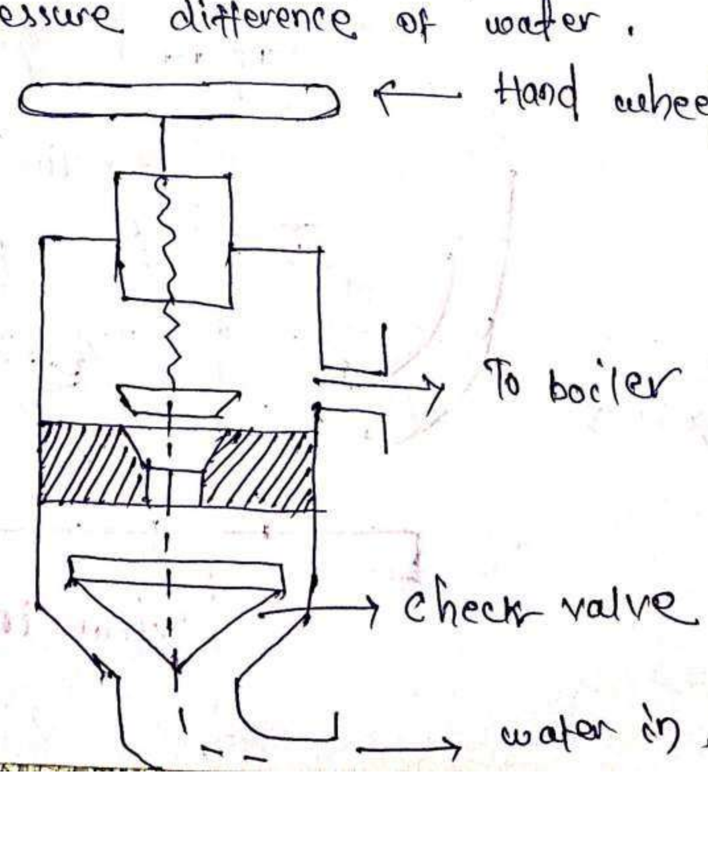
→ The feed check valve is fitted to the boiler slightly below the working level in the boiler.

→ It is used to supply high pressure feed water through the boiler.

→ It also prevents the returning of feed water from the boiler.

→ A feed check valve consist of two valves ① feed valve. ② check valve.

the feed valve is operated by a hand wheel for its opening & closing where as the check valve operates automatically up & down under the pressure difference of water.



steam stock valve :-

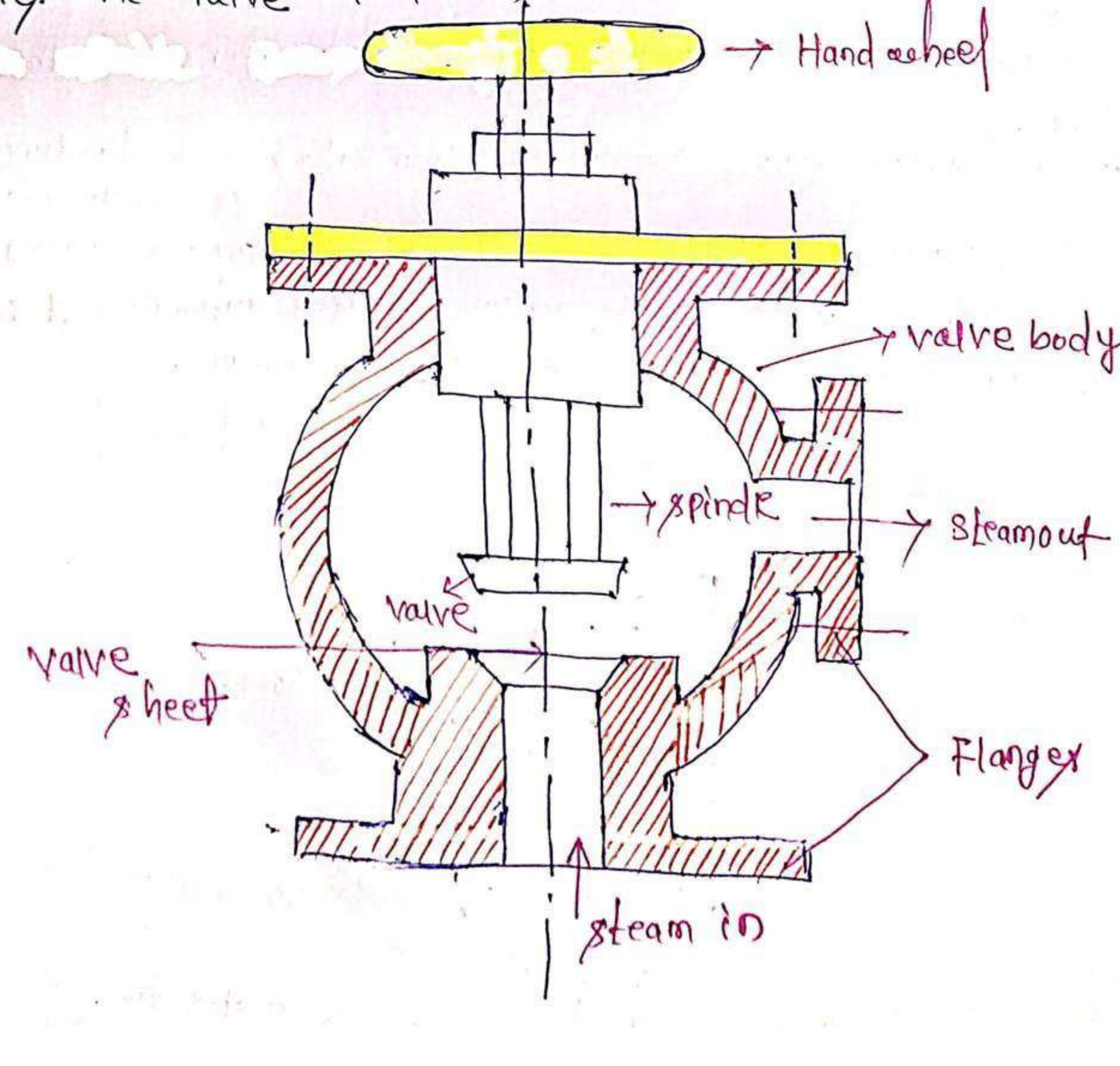
→ The steam stock valve is located on the highest part of the steam space.

→ It regulates the steam supply for use. The steam stock valve can be operated manually or automatically.

→ A hand operated steam stock valve is shown a bellow figure & consist of a cast iron body & two flanges at right angles.

→ One flange is fastened to the boiler shell & the other end is fastened to the steam pipe.

→ A steel valve connects the hand wheel through the spindle. When the hand wheel is rotated the spindle also rotated & carries the valve up & down.



Blow of cock :-

→ The func of the blow of cock is to discharge mud & other sediments deposited in the bottom most part of the water space in the boiler, while the boiler is in operation.
→ It can also be used to drain-off the boiler water.
→ Hence it is mounted at the lowest part of the boiler.
→ When it is open water under the pressure rushes out thus carrying sediment & mud.

Man hole & mud box :-

→ The man hole is provided on the boiler shell at a convineant position so that a person can enter through it, inside the boiler for cleaning & inspection purpose.
→ The mud box is placed at the bottom of the boiler to collect mud discharged to the blow of cock.

Boiler accessories :-

→ The boiler accessories are those devices which are heated either inside or outside the boiler to improve the performance of a boiler.
→ The accessories are mounted on the boiler or in the boiler to increas its efficiency.
The following accessories are normally use on a modern boiler.

1. superheater
2. Economiser
3. Air preheater
4. Electro static precipitator

superheater :-

→ It is a heat exchanger in which products of it of converfion are utilized to dry the weight steam & to make it superheated by increasing its temp.

→ During superheating of the steam pressure remains constant & its volume & temp increase.

→ A superheater consist of a set of small diameter U-tubes in which steam flows & takes up the heat from hot flue gasses.

→ superheaters are classified as convective, radiant & of combination type.

→ In the convective superheater the heat is transfer to the surface of the superheater by convection.

→ In a radiant superheater the heat of converfion is transfered to the surface of the superheater by thermal radiation. These are used in high pressure boilers.

→ In a combination type of super heater the heat is transferred to the surface of the tubes by both modes of heat transfer. The radiant superheaters are occusanally used.

Economiser :-

→ An economiser is a heat exchanger used for heating the feed water before it enters to the boiler.

→ The economiser recovers some of waist heat of hot flue gasses going to the chminey thus it helps in improving the boiler efficiency.

→ It is placed in the path of flue gasses at the backside of the boiler Just before the aire preheater.

→ The most commonly used economiser is greens economiser & is shown in below fig.

(A) Greens economiser consist of a set of vertical cast iron pipes Joint with horizontal lower & upper headers.

(B) The cold feed water flows through the vertical pipes via the lower header.

(C) The hot flue gasses passover then transferring heat to the water. The heated water is supplied to the boiler via the upper header.

→ Each economiser is equipped with a safety valve, a drain valve, a release Valve, Pressure gauge & thermometers.

Air preheater :-

→ The func of an airpreheater is similar to that of economiser. It recovers some portion of the waste heat of hot flue gasses going to the chimney & transfers the same to the fresh air before it enters the convertion chamber.

→ Due to preheating of air the furnesh temp increases. It results in rapid convertion of fuel with less smoke & ash.

→ The high furnance temprature can permit a low grade fuel with less atmospheric pollution. The air preheater is placed between the economiser & the chimney.

Electro static precipitator :-

→ An electro static precipitator is a Filtaration device that removes fine particles (like dust & smoke).

→ The working principle of electro static precipitator is quiet simple. It has two sets of electrodes one is (+ve) & another is (-ve).

→ The -ve electrodes are in the form of rod or wireness.

+ve electrodes are in the form of plates.

→ The +ve plates & -ve electrodes are placed vertically in the electrostatic precipitator. Alternatively one after another.

→ The medium of the electrodes is air & due to high negetivity of -ve electrodes there may be a Corona discharge sorround the -ve wire mesh.

→ An electro static precipitator doesn't contribute directly to the production of electricity in the thermal power plant, but it helps to keep the atmosphere clean.

→ Hoppers are fitted below the ESP chamber for collecting dust particles.

Draught system/ Boiler draught :-

→ We have already discussed the formation of steam & the conversation of fuels, It may be noted that the rate of steam generation in a boiler is depend upon the rate at which the fuel is burnt.

→ The rate of fuel burning depends upon the availablity of oxygen or in other words availability of fresh air.

→ The fresh air will enter the fuel bed, if the gasses of combersion are exhausted from the combersion chamber of the boiler.

→ This is possible only if a difference of pressure is maintained. this difference of pressure is known a draught & the system is known as boiler draught system.

purposes of boiler draught :-

→ The main objects of producing draught in a boiler are -

① to provide an adiquet supply of air for fuel converfion.

(2) to exhaust the gasses of Comvertion from the ,, chamber.

(3) To discharge these gasses to the atomosphere through the chimney.

Classification :- In general the draught system may be classified into the following two types.

① Natural Draught
② Artificial Draught

Natural Draught :-

→ It is the draught produced by a chimney along due to the difference of the densities betⁿ the hot gasses inside the chimney & cold atmospheric air outside it. The outside air is flow through the furnance into the chimney & it will push the hot gasses to pass through the chimney. It is also known as chimney draught.

→ Artificial draught :-

→ The Artificial draught may be induced or forced. In this case the draught produced by a fan or blower is known as Fan draught. The artificial draugh is provided when the natural draught is not sufficient.

Comparision betⁿ.

Forced draught	Induced draught
→ The fan is placed before the fire grate.	→ The fan is placed after the fire grate.
→ The pressure inside the furnance above the atmospheric pressure.	→ The pressure inside the furnance is below the atmospheric pressure.
→ It sucks the fresh air & forces it into the convertion chamber.	→ It sucks hot gasses from the convertion chamber & forces them into the chimney.
→ It requires less power as the Fan has to handle fresh air only. moreover volume of air handle is less because of low temp.	→ It requires more power as the fan has to handle hot air & flue gasses. moreover the volume of air & gasses is more because of high temp of the air & gasses.
→ The flow of air through the furnance is more uniform	→ The flow of air through the furnance is less uniform.

→ As the likages are out toward therefore there is a serious danger of blow out when the fire doors are opened & the fan is working.	→ As the licages are inward therefore there is no danger of blow out. But if the fire-doors are opened & the fan is working there will be a heavy air infiltraction

Advantages ÷

→ It is more economical.

→ It is better in control.

→ The flow of air through the furnance is uniform.

→ Its rate of convertion is very high.

→ Low grade fuel can be used.

→ It is not affected by the atmospheric temp.

→ It reduces the amount of smoke.

→ It reduces the hight of Chimney.

→ It increases efficieny of the plant.

Dis advantages ÷

→ Initial cost is high.

→ Running cost is also high.

→ It has increased the maintainance cost.

Balanced draught ÷ It is an improved type of draught, & is a combination of induced & forced draught. It is produced by running both induced & forced draught fans simontaneously.

Steam primeover :- A steam turbine is a device that extracts thermal energy from pressurised steam & uses it to do useful mechanical work.

→ The steam turbine is a form of heatengine that derives much of its impocovement in thermodynamic efficiency from the use of multiple stages in the expansion of the steam.

→ The turbine generates rotarymotion & it is particularly suited to be used to drive an electrical generator.

Advantages :-

→ The following are important adv. & dis adv. of steam turbine.

1. Since the steam turbine is a rotary heat engine, it is particularly suited to be used to ~~p~~ drive an electrical generator.
2. Thermal efficiency of a steam engine or steam turbine is usually higher than that of a reciprocating engine.
3. Very high power to wet ratio compare to reciprocating engines.
4. Few work moving parts that reciprocating engines.
5. Steam turbines are suitable for large thermal powerplant. They are made in veriety of sizes upto 1.5 gw. Turbines used to generate electricity.
6. In general turbine moves in one direction only, with vibration than a reciprocating engine.
7. Steam turbines have greater reliability, particularly in appl^n s where sustained high power o/p is required.

Disadvantages :- Although approximately 90% of all electricity generation in the world is by use of steam turbines they have also some disadvantages.

① Relatively high cost.
② The m/c parts are too expensive.
③ They have longer startup than gas turbines & chearly than reciprocating engines.
④ Mechanically steam turbines are less efficient than reciprocating engines at part load operations.
⑤ Less responsive to changes in power demand.
⑥ Skilled workers are to be needed to operate & maintain it.

Elements of steam turbine :

→ For the proper functioning of the steam turbine the following elements are important from the subject point of view.
① Rotor or shaft
② Cylinder or casing
(3) Blades
(4) Bearings
⑤ Governer
⑥ control valve & safety valve
⑦ Turbine turning gear
⑧ Lube oil system
⑨ Gland sealing system.

Rotor or shaft : Rotor or shaft is an integral part of the steam turbine that carries the blading to convert the thermal energy of the steam into the rotatry motion of the shaft.
→ Rotors are used to transmit torque produced in each stage of turbine to the generator.
→ The rotor consist of rotating blades which are fastened to the wheel through a specialy desiged attachment. The blades may

be semicircular in shape & multiple pins to hold the blades to the disc or wheel & these discs may be shrunk feet on to a shaft.

Cylinder or Casing :

→ The turbine cylinder have two withstand the pressure of steam & for this reason they are robust design with thick wall.
→ In order to assemble the turbine & to deassemble it for maintainance the casing must split in some ways
→ To overcome the need for a very heavy flanges in high pressure cylinder, Instead of being split horizontally the entire outer casing of the high pressure turbine is shaped like barrel.

Blades :

→ A turbine generally consist of rows of stationary blading & rows of rotating rotating blading.
→ The purpose of stationary blading is to direct the flow of passing steam to the rotating blading at the proper angle.
→ There are two types of turbine blading

1. Impulse blading
2. Reaction blading.

→ The size of blades of high pressure turbine is smaller than the low pressure turbine.

Bearings : Bearing are provided to support the turbine rotor inside housing installed in turbine shells.
→ There are different types of bearing for small steam turbines- roller bearing, Jurnal bearing & thrust bearing
→ Thrust bearing is located on the mainshaft of the turbine, the thrust bearing absorbs axial thrust of the turbine & generator rotors connected to the

Governer :- The governer is one of the basic parts of the steam turbine its main funᶜ is to control the operation of steam & the flowe rate of the steam.

→ The governer are of 2 types (A) speed sencing governer &
(B) pressurer sencing governer.

control & safety valve :-

→ The control device is broadly devied into governer device & a safety device.

→ The governer device regulates the output & speed of the turbine generator. while safety device will protect the turbine from the outer hazards & stops the ~~g~~ turbine generator quickly.

Turbine turning gear system :-

→ During the start up of turbine, turning gear can be started & stoped by push button & indication is also available on TCP (total control pannel).

→ When turbine speed ~~of~~ up beyound 2800 rpm the system automatically disengaged & it will come in autostand by.

Lube oil system :- Lube oil system is designed to provid oil to lubricate all bearings.

→ To provide pressure oil for operation of the governing protection system & for turning gear system,

→ The lube oil system mainly consist of oil resorvoied, oil ejectors, Oil pump, oil releif valve etc.

Gland sealing system :-

→ It is used as a precaution against steam leaking to atmosphere.

Compounding & Governing of steam turbine :-

Compounding of steam turbine :-

Compounding of the steam turbines is the stratege in which energy from the steam is extracted in a no of stages rather than a single stage in a turbine.

→ A compounded steam turbine has multiple stages that is it has more than one set of nozzoles & rotors.

Necessity / Purpose :-

1 → The steam produced in the boiler has sufficiently high enthalpy when superheated.

2 → In all turbines the blade velocity is directly proposnal to the velosity of the steam passing over the blade.

3 → Now if the entire energy of the steam is extracted in one stages that is if the steam is expanded from the boiler pressure to the condenser pressure in a single stage then its velocity will be very high. Hense the velocity of the rotor can reach to the higher limit which is too high for partical uses because of very high vibration.

4 → Moreover at such high speeds the centrifugal force are immense, which can damage the structure of the rotor so that for avoiding this the compounding of the steam turbine is needed.

5 → The compounding is needed also to overcome the wastage of steam

Types :- In an impulse turbine compunding can achieved in the following 3 ways -

① velocity compunding.
② pressure compunding.
③ pressure velocity compunding.

* In a reaction turbine compounding can achieve only by pressure compounding.

HYDEL POWER PLANT

Date:

Introduction :- Hydel power plant also known as Hydro-Electric power station. Normally the power or the electricity is produced or generated from the water source.

Generation of electricity by hydropower (potential energy in ~~stoo~~ stored water) is one of the cleanest methods of producing electric power. Hydro-electricity is the most widely used form of renewable energy.

Advantages and Disadvantages of Hydel Power plant.

Advantages :-

(I) No fuel is required as potential energy in stored water is used for electricity generation.

(II) Neat and clean source of energy.

(III) Very small running changes as water is available free of cost.

(IV) Comparatively less maintenance is required and has longer life.

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(v) Serves other purpose too, such as irrigation.

Disadvantages:-

(I) Very high capital cost due to construction of dam.

(II) High cost of transmission as hydro plants are located in hilly areas which are quite away from the consumer.

Types of Hydro-power plant:

→ Conventional plants

→ Pumped storage plants.

→ Run-of River plants.

General Arrangement of Storage type Hydro-Electric Project:-

In general, a power-plant / power house in hydropower plant may be divided into three areas:-

(1) The main powerhouse structure:- housing the generating units and having either separate or combined generator and turbine room.

(2) Erection bay,

(3) Service areas.

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(1) Main Powerhouse structure:-

→ The generator room is the main feature of power house about which other areas are grouped.

→ It is divided into bays or blocks, with one generating unit normally located in each block.

→ The width (upstream - downstream dimension of the generator room for the indoor type should provide for a passage way with a minimum width of 10 feet between the generators and one powerhouse wall.

→ The height of the generator room is governed by the maximum clearance height required for moving major items of equipments, such as parts of generators and turbines.

→ The elevation of the turbine room floor should be established so as to provide a minimum requirement of 3 feet of concrete over a steel spiral case, or a minimum roof thickness of 4 feet.

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→ In establishing the distance between the generator and turbine room floors, if they are not combined, the size of equipment to be handled in the turbine room, the head room between platforms in the turbine pit and the generator room floor construction should be considered.

(2) Erection Bay :-

(i) In general, the erection bay should be located at the end of the generator room.

(ii) However, no additional space should be required if the access railroad enters from the end of the powerhouse.

(iii) In cases where the elevation of the crane rail would be dependent on the requirement that a transformer with bushings in place be brought under the crane girder.

(3) Service area :-

(i) Service areas include :- offices, control and testing rooms, storage rooms,

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maintenance shop, auxilliary equipment rooms, and other rooms for special uses.

(ii) However in all cases an economic study which should include the cost of any added length of penstock required, should be made before deciding to increase the space between the dam and powerhouse to accomodate these features.

(iii) The offices are freequently located on upper floors and the control room and other service rooms on lower floors.

(iv) The most advantageous location for the maintenance shop is usually at the generator room floor level.

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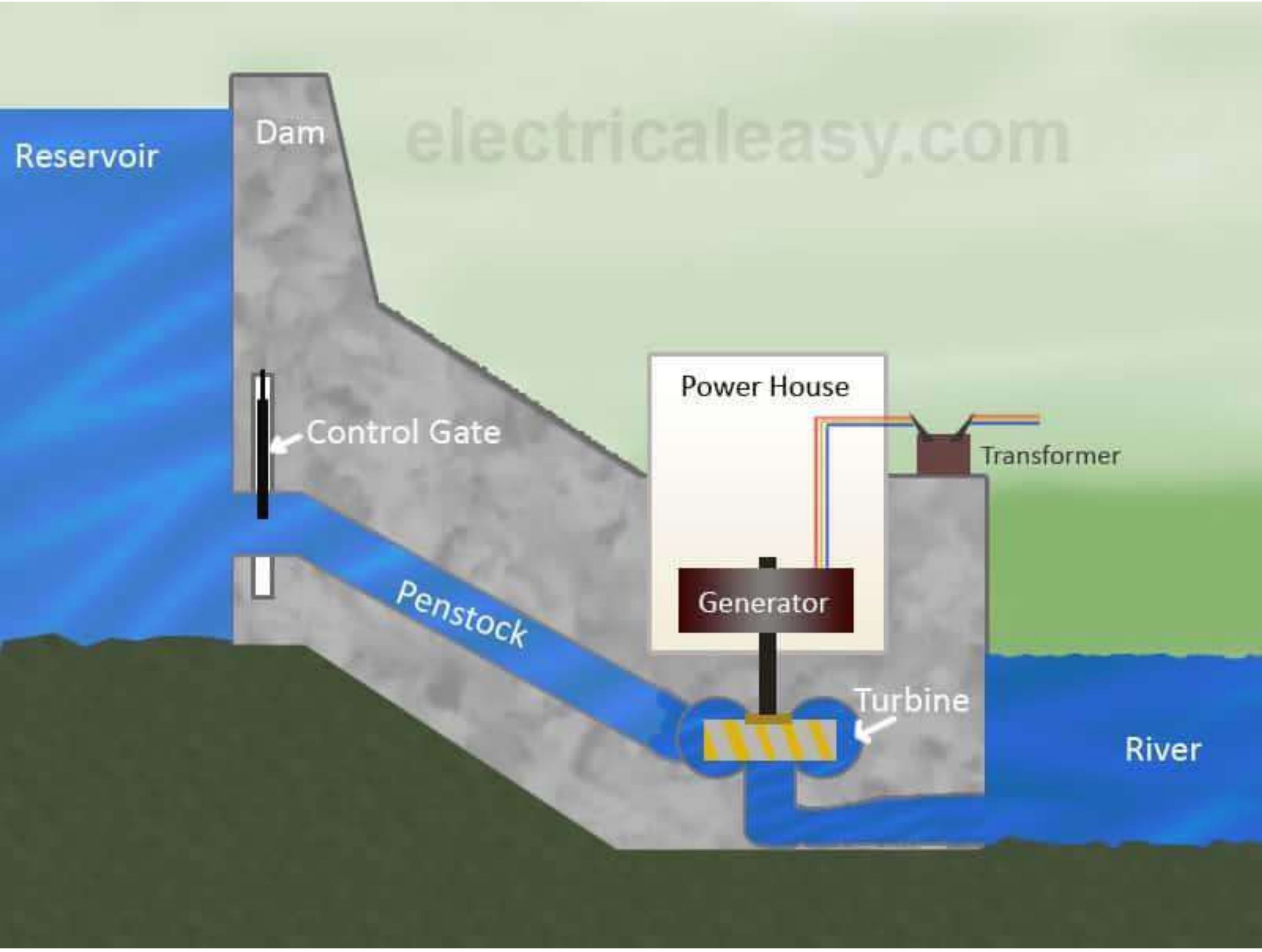

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DIESEL ENGINE POWER PLANT

Date:

Introduction :- A diesel power station (also known as stand by power station) uses a diesel engine as prime mover for the generation of electrical energy.

→ This power station is generally compact and thus can be located where it is actually required.

→ This kind of power station can be used to produce limited amounts of electrical energy.

→ The diesel burns inside the engine and the combustion process moves a fluid that turns the engine shaft and drives the alternator. The alternator in turns, convert mechanical energy into electrical energy.

v.v. Imp.

Advantages and Disadvantages of diesel Power Plant :

Advantages :-

(I) This is simple in design point of view.
(II) This required very small space.

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(3) It can also be designed for portable use.
(4) It has quick starting facility, the small disel generator set can be started within few seconds.
(5) It can also be stopped as when required stopping small size diesel power ~~stato~~ station, even easier than its starting.
(6) As these machines can easily be started and stopped as when required there may not be any stand by loss in the system.
(7) Cooling is easy and required smaller quantity of water in this type power station.
(8) Initial cost is less than other types of power station.
(9) Thermal efficiency of disel is quite higher than of coal.

Disadvantages :-

(1) As we have already mentioned, the cost of disel is very high compared to coal. This is the main reason

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for which a diesel power plant is not getting popularity over other means of generating power.

(2) Running cost of the plant is also very high.

(3) The plant generally used to produce small power requirement.

(4) cost of lubricants is high.

(5) Maintenance is quite complex and costi high.

(6) Plant does not work satisfactorily under overload conditions for a longer period.

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Different Systems of Diesel Power Plant :-

In addition to diesel generator set or DG set there are many other auxilliaries attached to at disel power station. Let's discuss one by one :

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Fuel Supply System :-

(1) In fuel supply system there are one storage tank strainers, fuel transfer pump and all day fuel tank. Storage tank where oil in stored.

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(II) strainer: This oil then pump to dry tank., by means of transfer pump.
(III) During transferring from main tank to smaller dry tank, the oil passes through strainer to remove solid imprurities.
(IV) from dry tank to main tank there is another pipe connection. This is over flow pipe.
(V) This pipe connection is used to return the oil from dry tank to main tank in the event of over flowing.
(VI) from dry tank the oil is injected in the disel engine by means of fuel injection pump.

Air supply system:-

(I) This system supplies necessary air to the engine for fuel combrustion.
(II) It consist of a pipe for supplying of fresh air to the engine.
(III) filters are provided to remove dust particles from air because these

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particles can act as an abrasive in the engine cyllinder.

Exhaust System :-

(I) The exhaust gas is removed from engine to the atmosphere by means of an exhaust system.

(II) A silencer is normally used in this system to reduce noise level of the engine.

Imp Cooling System :-

(I) The heat produced due to internal combustion, drives the engine. But some parts of this heat raise the temperature of different parts of the engine.

(II) High temperature may cause permanent damage to the machine. Hence, it is essential to maintain the overall temp. of the engine to a tolerable level.

(III) Cooling system of disel power station does exactly so. The cooling system requires a water source, water pump and cooling towers.

(IV) The pump circulates water through

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cyllinder and head jacket.
(v) The water takes away heat from the engine and it becomes hot. The hot water is cooled by cooling towers and is recirculated for cooling.

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Lubricating System :-

(1) This system minimises the wear of rubbing surface of the engine. Here the lubricating oil is stored in main lubricating oil tank.
(ii) This lubricating oil is drawn from the tank by means of oil pump.
(iii) Then the oil is passed through the oil filter for removing impurities.
(iv) From the filtering point this clean lubricating oil delivered to the diff. points of the machine.

Engine Starting System :-

(1) For starting a disel engine, initial rotation of the engine shaft is required.

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(ii) Untill the firing start and the unit runs with its own power.
(iii) For small DG set, the initial rotation of the shaft is provided by handles.
~~but for~~

Governing System:
It is used to control the speed of the engine by changing the fuel provide according to the load increase or decrease.

Fuel Injection System:
We can say that this system is the heart of the disel engine as it can uses as:-

1) Filters that ensuring oil from dirt.
2) Meters the correct quantity of fuel to be injected into the cyllinder.
3) Also regulates the fuel supply.
4) Atomize the fuel oil for better mixing with the hot oil.
5) And finally distribute the atomised fuel properly in the combustion chamber

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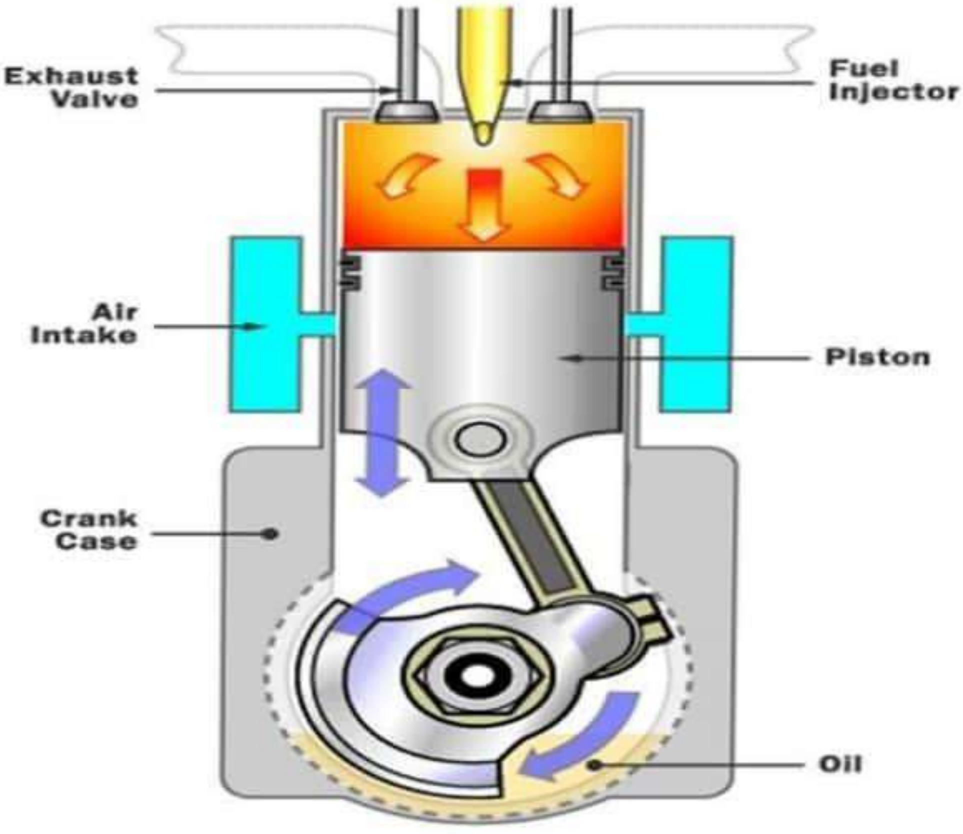
Diesel Engine



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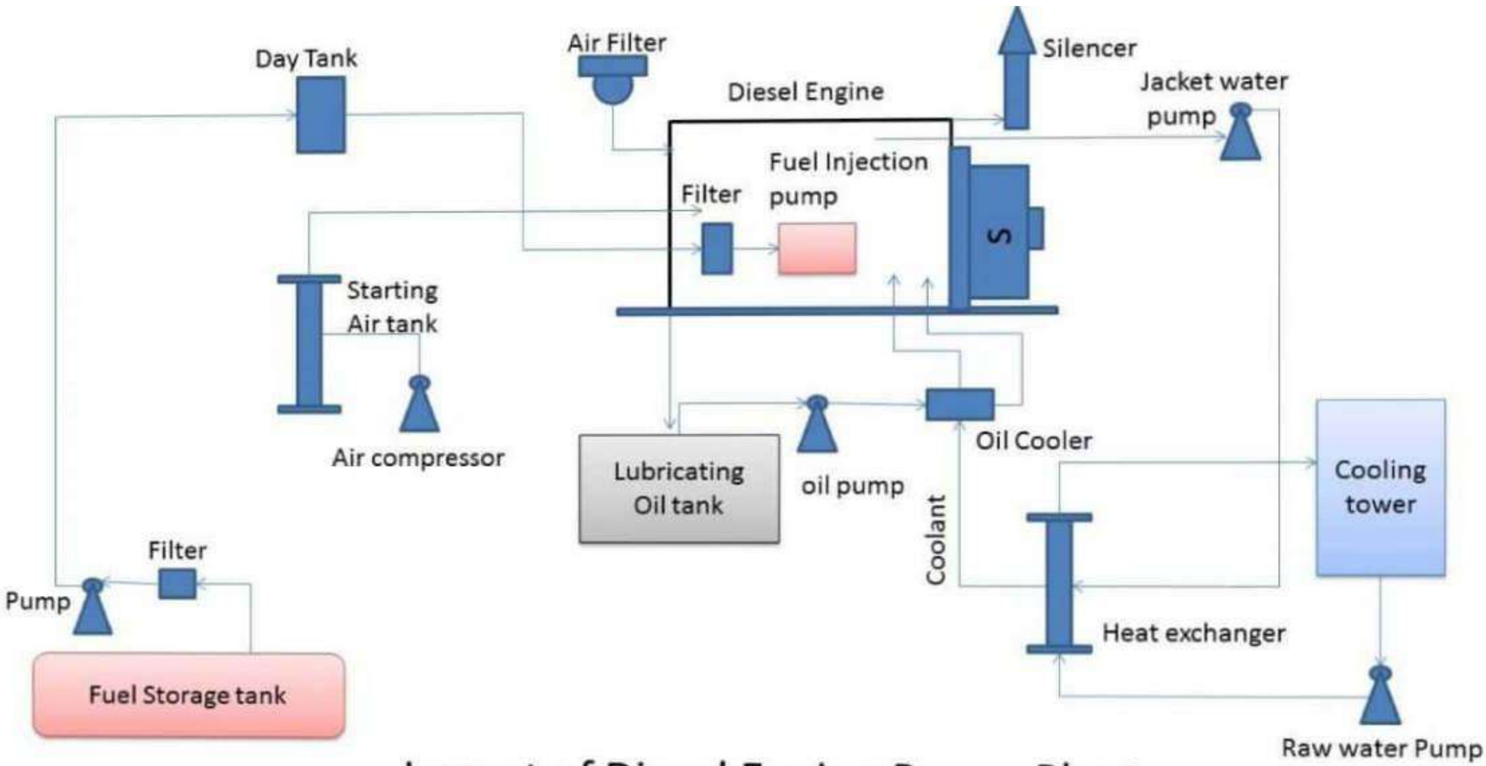

Layout of Diesel Engine Power Plant

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