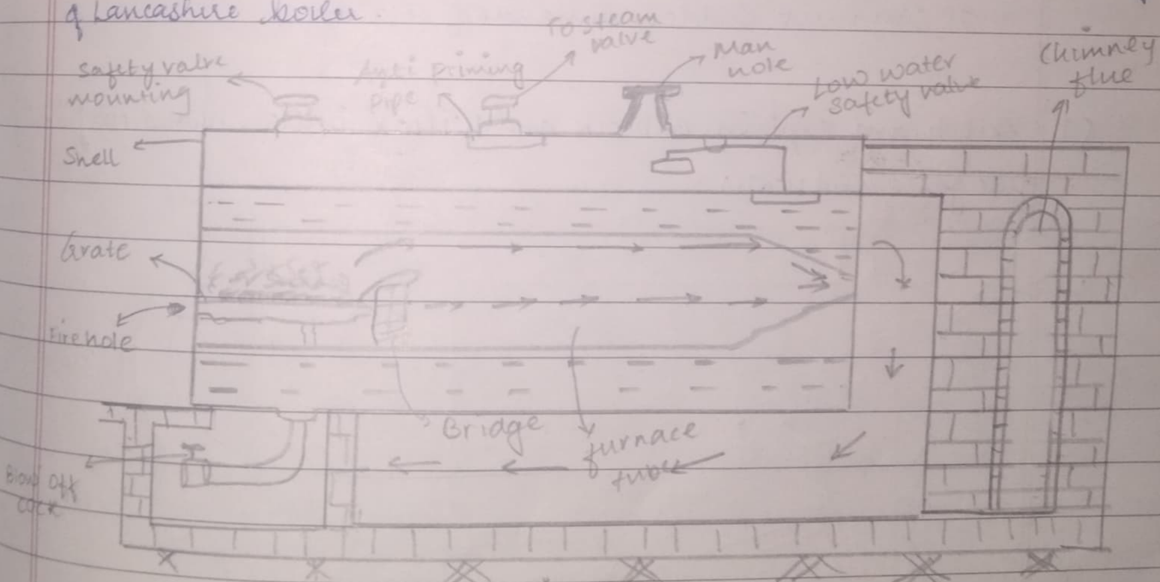
Assignment.

Q) State any 5 differences between water tube and fire tube boiler.

FIRE TUBE BOILER	WATER TUBE BOILER
> Hot flue gas flows through the tubes that are surrounded with water	> Water flows within the tubes and are surrounded by hot flue gas.
> Internally fired boilers	> Externally fired boilers.
> Low evaporating capacity, hence it takes more time to generate steam	> High evaporating capacity, hence the generation of steam is quicker.
> For the given power, it occupies more space	> For the given power, it occupies less space
> Sustainable for less impure feed water	> Require feed water treatment plan.

Q) Describe with the aid of neat diagram, the construction and working of Lancashire boiler.



Lancashire boiler

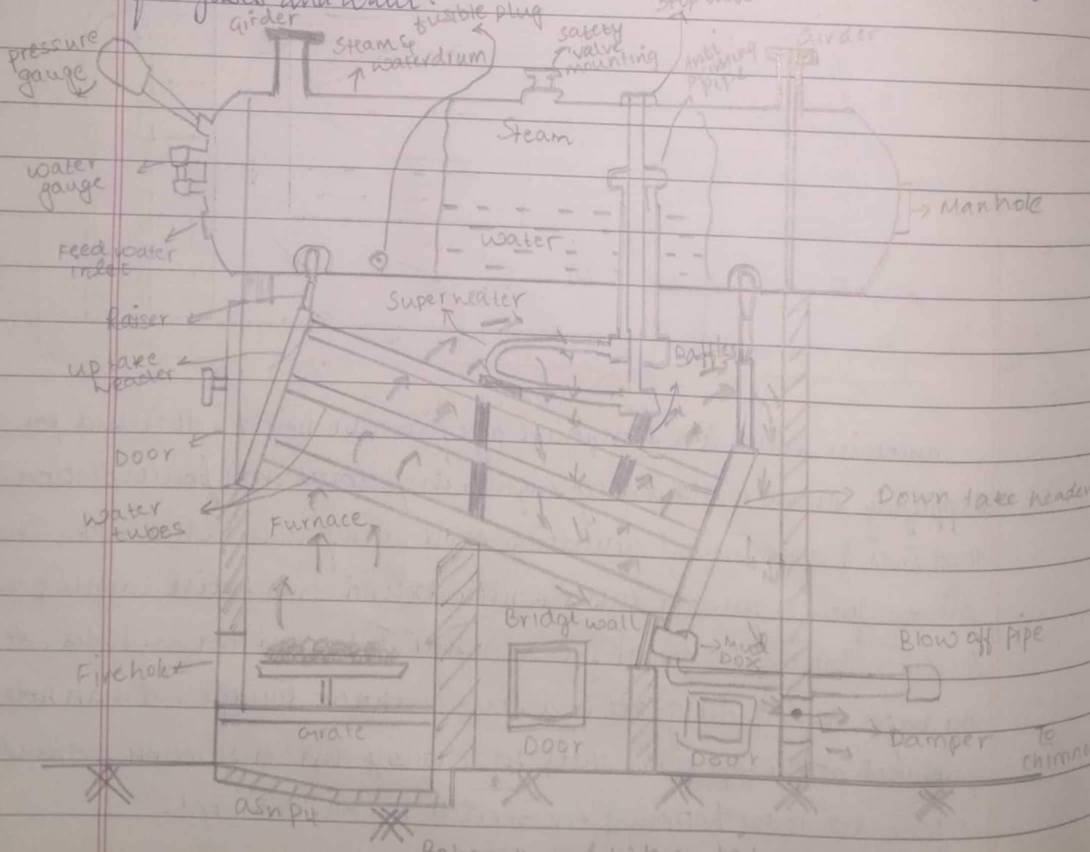
Lancashire boiler is a horizontal type fire tube boiler. It is used for supplying steam to stationary engines in factories and power station. It consists of a horizontal cylindrical shell with flat or dished ends. There are two flues or furnace tubes which extend over entire length of the boiler. There are 2 grates for each flue tube and two fire holes. At the back end of the grate is a low fireback bridge. A man hole is provided at the top of the shell for cleaning and inspection. A mud hole is provided at the bottom of the shell to remove sediment.

Working: The boiler is filled with substantial quantity of water. The fuel is charged through furnace doors. The fuel burns in the grates. The product of combustion first pass through the tubes, then return along the brick built flue under the boiler to the front end. Here the hot gases divide and flow along the two side flues to the rear end and then pass to the chimney. The steam is accumulated in the steam space above the surface of water and can be tapped off through the steam stop valve connected to an anti priming pipe.

Advantages

- It is simple in design and reliable
- It is easy to operate
- It is easy to clean and inspect
- Less maintainence
- Heating surface area per unit volume of the boiler is considerably large
- It can meet sudden demands of steam.

Q) Sketch and explain Babcock and Wilcox boiler. Show the path of the flue gases and water.



Babcock and Wilcox boiler

This is one of the most popular type of water tube boiler employed both for both large as well as small power stations. The steam and water drum is suspended from iron grinders resting on iron column. A super-heater is placed between the drum and water tubes for the purpose of super heating the steam. The steam is taken from the steam space through a perforated pipe (anti priming pipe) and downwards into the superheater, entering the superheater at the upper part. The furnace is placed below the uptake header. Baffles are introduced across the water tubes to act as deflectors, which cause the furnace gases to cross the tubes 3 times before leaving the boiler.

Working: The boiler is filled with substantial quantity of water. The coal is charged through the fire hole. The coal burns in the ~~gate~~ grate. The hot gases of combustion first raise up, then move down and once again rise up due to the presence of baffles. It finally escapes through the smoke chamber to chimney. The hot water and steam moisture rise up through the ~~uptake~~ uptake header into the ~~header~~ boiler shell where steam separates from water and collects in the steam space. From the steam space it is led to superheater tubes and steam can be tapped off through steam stop valve.

Q. Differentiate between boiler mountings and accessories. Give 2 examples of each.

A. Boiler mountings: They are required to provide the safety of the boiler and to control the process of steam generation. Generally they are mounted over the boilers.

ex: pressure gauge, stop valve

Accessories: They are required for increasing the efficiency of the boiler and for the proper working of plant. Generally they are not mounted directly to the boiler

ex: superheater, injector

Q. What are the advantages of superheated steam.

A.
- It reduces the specific steam consumption of the engines and turbines
- It reduces condensation losses in the pipe and engine cylinder
- It eliminates the erosion of turbines blades
- It increases the efficiency of steam plant.

Q. List the boiler mountings and accessories and also mention their use

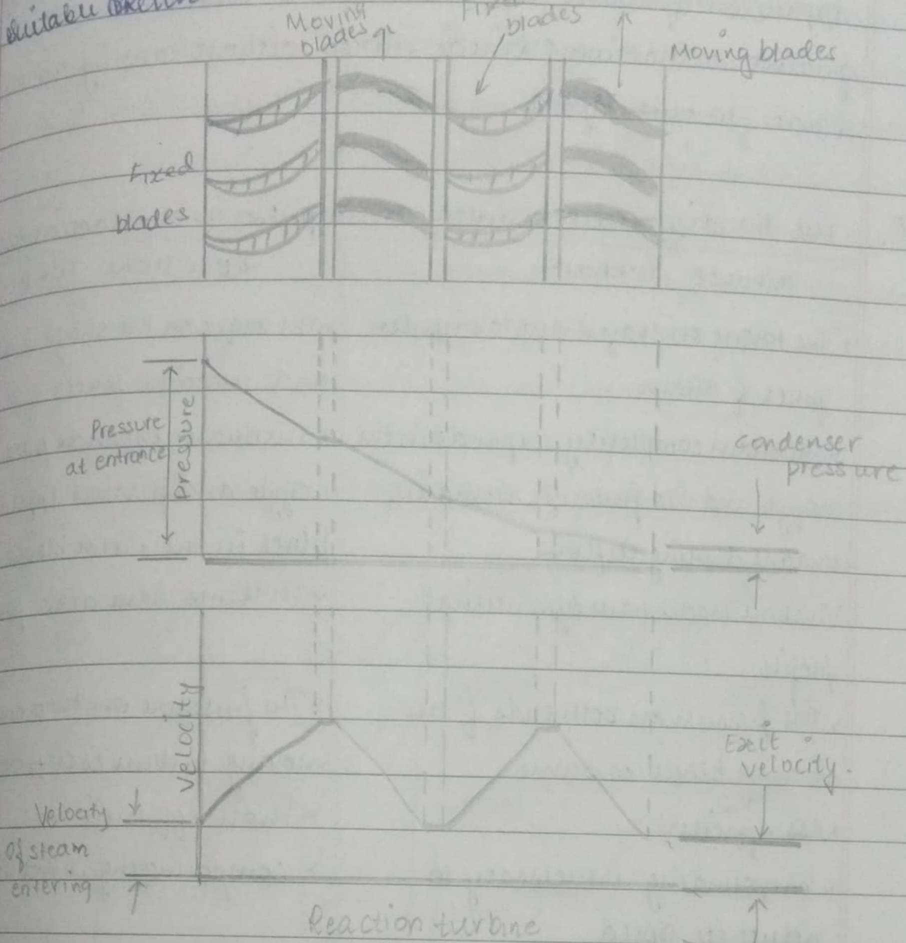
A.
- Water level indicator or water gauge: indicate the level of water & enable the attendant to regulate the supply of feed water
- Pressure gauge: measure the pressure of steam inside boiler
- Steam stop valve: regulate the flow of steam
- Feed check valve: control the supply of water to the boiler and prevent the water to escape from boiler.
- Blow off cock: To empty the water when it is to be inspected and to discharge the mud scale or sediments at the bottom of boiler
- Fusible plug: protect the boiler against the damage due to overheating for low water level.
- Safety valve: not permit the pressure in the boiler to rise above a fixed value and having reached the valve will allow excess of steam to escape as fast it is generated by the boiler.

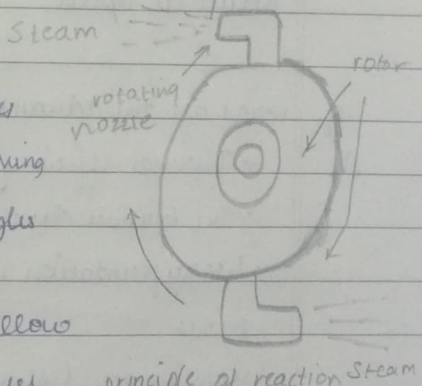
Q. What do you mean by compounding of steam turbines? What are the different methods of compounding?

A. A method of reducing the speed of the impulse turbine to the practical limits is called compounding.

different methods of compounding
- Velocity compounding
- Pressure compounding
- Pressure - velocity compounding

Q) Describe the working principle of reaction turbine with a suitable sketch





principle of reaction turbine

In reaction turbine there's a gradual pressure drop. The reaction turbine includes rows of stationary guide blades and moving blades. The fixed guide acts as ~~nozzl~~ nozzles ~~which~~ while the fixed blades alter the direction of the steam as well as to allow steam to expand. As the steam passes over the moving blades they absorb its kinetic energy.

The steam entering at one end of the turbines passes first through a row of fixed guide blades, which direct the steam against the first row of moving blades. The steam does work against the blades as they remove, its pressure falls and volume increases, then redirected by row of fixed blades in a stator to the next row of moving blades on rotor. Thus steam expands and works on the blades and again the pressure falls. In each stage, the expansion of steam was restricted to the extent that allowed the greatest extraction of kinetic energy without causing the turbine blades to over speed.

Q. List the differences between an impulse and reaction turbine

A

IMPULSE TURBINE	REACTION TURBINE
> The torque on shaft is due to impulse force of steam	> The torque on the shaft is due to impulse and reaction forces of steam
> The steam completely expands in the nozzle and its pressure remains constant during its flow	> The steam expands partially in the nozzle and further expansion takes place in the rotor blade.
> Turbine blades have symmetrical profile	> Turbines have aero-foil profile
> The pressure on both ends of the moving blade is same	> The pressure on two ends of the moving turbine is different
> less efficient	> more efficient
> compounding is necessary to reduce its speed	> compounding is not necessary.

Q. what are the advantages of steam turbines over other prime movers.

A. > Thermal efficiency of the steam turbine is higher

> The turbine develops power at uniform rate so no need of flywheel

> heavy foundation is not required due to the absence of reciprocating parts

> less noise, less maintainence and more effi

> less floor space

> Suitable for large power plants

> Greater range of speed is possible

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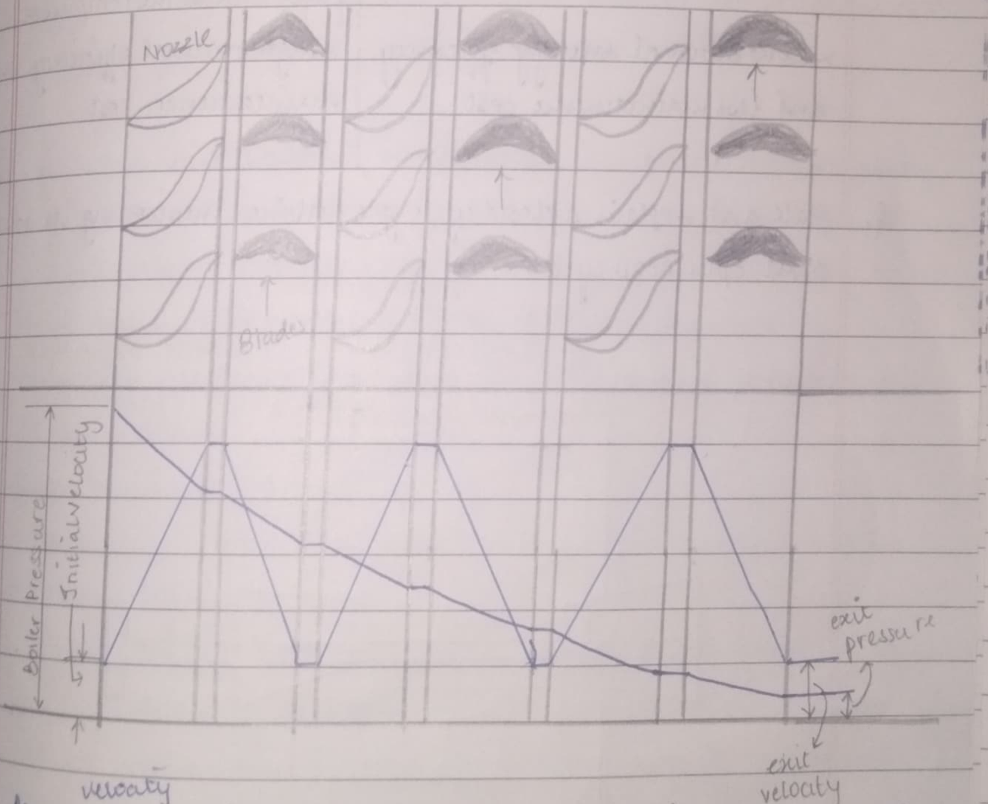
Q) Explain the working principle of operation of impulse turbine

A) Impulse turbine consists basically of a rotor mounted on a shaft that is free to rotate in a set of bearings. The outer rim of rotor carries a set of curved blades and the whole assembly is enclosed in a casing. Nozzle direct steam against the blades and turn the rotor. The energy to rotate an impulse turbine is derived from the kinetic energy of the steam flowing through the nozzles. The term impulse means that the force that turns the turbine comes from the impact of the steam on the blades.

Q) With neat sketch, explain the working of pressure velocity compounding

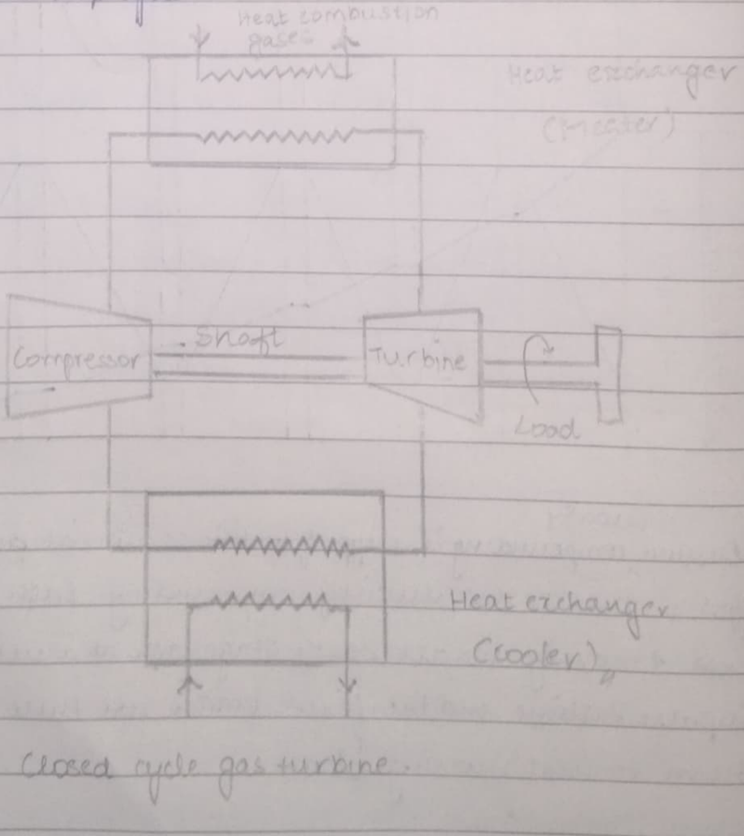


Pressure velocity compounding is a ~~type of turbine~~ combination of the above 2 types; pressure and velocity compounding. Each stage consists of fixed & moving blades. Each stage acts as a velocity compounding impulse turbine and the fixed blades are there to guide the steam to next moving blades.

Q. Differentiate between open cycle and closed cycle gas turbines

OPEN CYCLE	CLOSED CYCLE
• Internal combustion parts	• External combustion plants
• Fresh working fluid is continuously drawn into the cycle	• Same working fluid is used continuously in the cycle
• Heat is added directly to the working fluid by the combustion of fuel	• Heat is added to the working fluid by heat exchanger
• Heat exchangers are not required for simple system.	• Effective heat exchangers
• The atmosphere acts as sink and no coolant is required	• A coolant is required for pre cooling the turbine exhaust before the working fluid enters the compressor
• Low thermal ~~energy~~ efficiency and less maintainence cost	• High thermal efficiency and high maintainence cost.

Q. State and explain a closed cycle gas turbine mentioning its advantages over open loop cycle.



Closed cycle gas turbine.

The compressed gas coming out from the compressor is heated in the heat exchanger (heater) at constant pressure. The high temperature and high pressure gas is expanded through the turbine doing mechanical work. The gas coming out of the ~~turbine~~ turbine is cooled to its original temperature in a heat exchanger and is fed back to the compressor. Thus the same working fluid is circulated through the plant. most suitable fluid in this turbine is helium

Advantages

- closed cycle gas turbines have high thermal efficiency
- Same working fluid can be continuously used in closed cycle gas turbines.
- here the working fluid is not mixed ~~&~~ hence the corrosion and erosion of the turbine blades are avoided

Q. what is gas turbine? What are the essential components of gas turbine plant? how is a gas turbine different from a steam turbine.

A. A gas turbine is a rotatory machine, which is similar to steam turbine. In gas turbines, the hot gases produced by combustion are directly used to drive the turbine without producing steam.

essential components of gas turbines

- compressor • heat exchange • combustible fuel • Turbine
- cooler • Shaft.

- Steam turbines are bulky hence occupy more space where as gas turbines occupy less space. Hence used in locomotives
- In gas turbine, gases produced by fuel are directly used to run turbines but in steam turbines, this gas are used to produced steam and steam is used to run turbine.
- large quantity of water is required in steam turbine whereas in gas turbine water is not that much required.
- steam producing process takes more time compare to productions gas in gas turbine

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Q. How are water turbines classified? What is the speciality of Kaplan turbine

A. 1. According to the type of energy at inlet

(I) Impulse or velocity turbine,

(II) Reaction or pressure turbine

II. According to the direction of flow of water through runner

(I) Tangential flow turbine

(II) Radial flow turbine

(III) Axial flow turbine

(IV) Mixed flow turbine

III. According to the available water head at inlet.

(I) High head turbine.

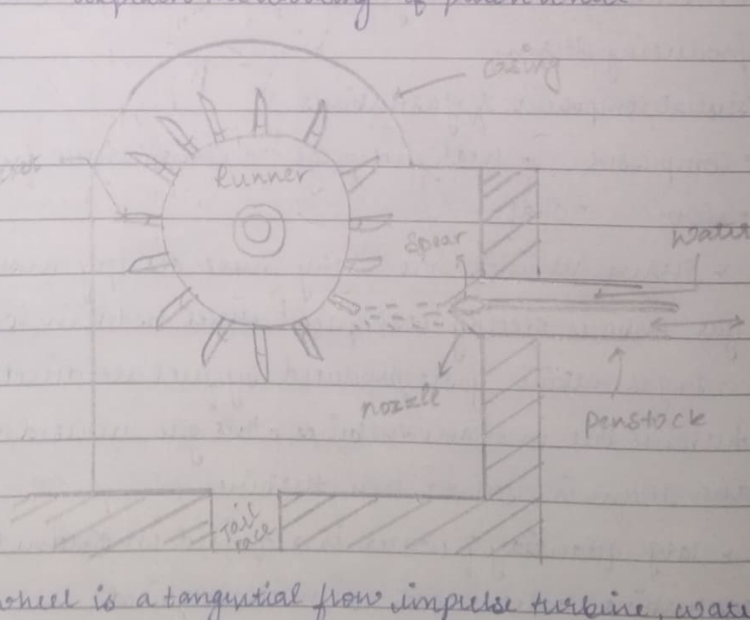
(II) Medium head turbine.

(III) Low head turbine.

The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. Power is recovered from both the hydrostatic head and from the kinetic energy of the flowing water

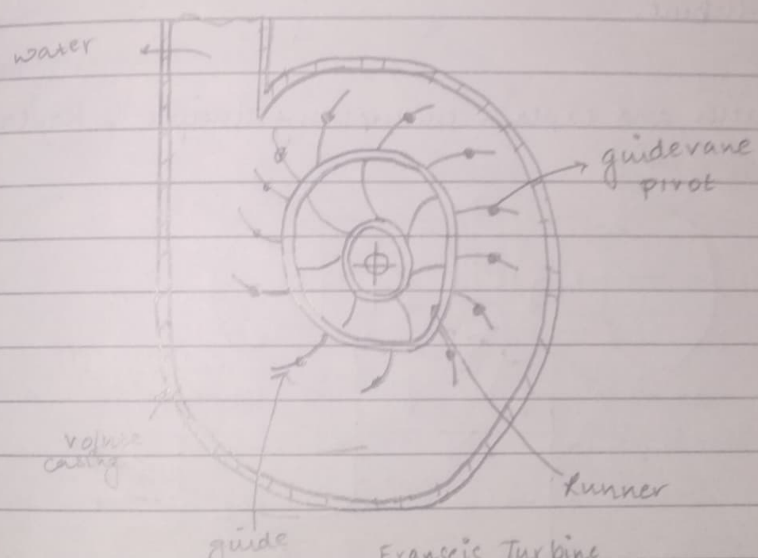
Q. Sketch and explain the working of pelton wheel

A.



Pelton wheel is a tangential flow impulse turbine, water flows along the tangent to the path of runner. It operates under a high head of water and therefore it requires a comparatively less quantity of water. Water is conveyed from the reservoir to the turbine through a penstock. The penstock is connected to a branch pipe fitted with a nozzle. A powerful jet issue out of the nozzle, impignes impinges on the bucket provided at the periphery of wheel. The shape of the bucket is that of a double hemispherical cup having dividing wall known as splitter at the centre. The splitter divides the impinging jet 2 halves, which are deflected backward as there is no variation in flow, the fluid partly fills the buckets, and it remains in contact with the atmosphere. The nozzle is provided with a spear mechanism to control the quantity of water. The actual energy transfer from jet to wheel is by changing the momentum of the stream. The water after imparting its energy to the turbine is discharged into the tail race

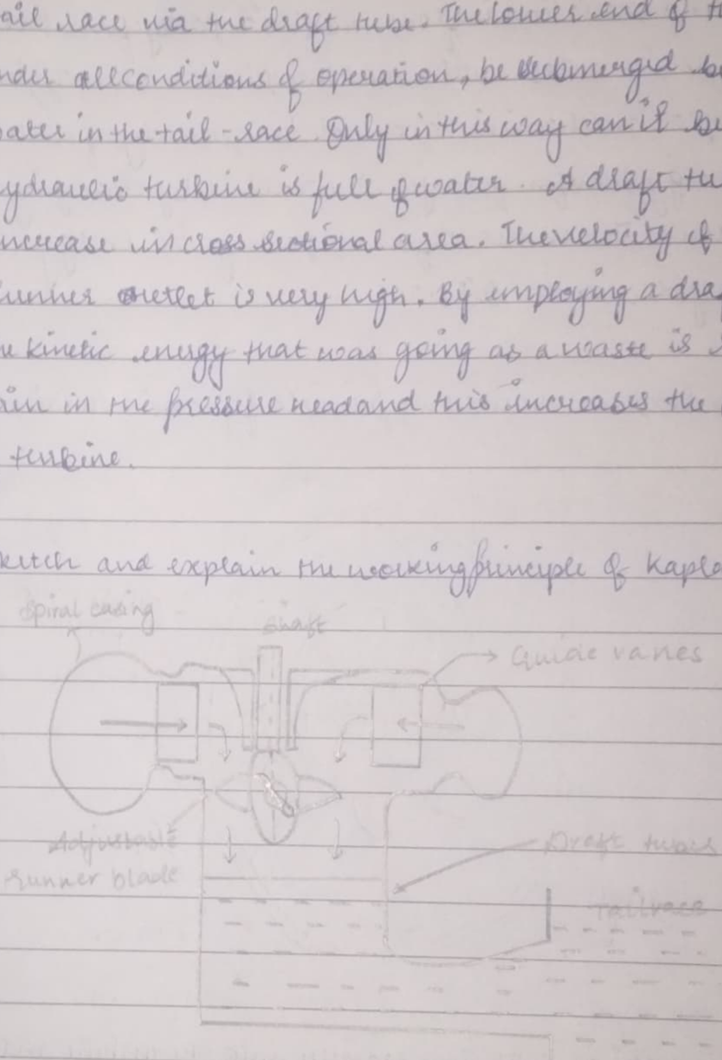
Q. Sketch and explain the working principle of francis turbine.



Franscis Turbine

In franscis turbine, water flow radially into the turbine and exits the turbine axially. It is suitable for intermediate heads and intermediate rate of flow. Some smaller machines of this type have horizontal shafts, the majorities have vertical shafts. The fluid enters the casing which completely surrounds the runner. The cross sectional area of the volute decreasing along the fluid path in such a way as to keep fluid velocity constant in magnitude. From the volute, the fluid passes between the stationary guide vanes called wicket gates mounted all around the periphery of the runner. The function of these guides is to direct the fluid on the runner at ~~reg~~ required angle. The radial flow acts on the runner vanes, causing the runner to spin. The guide vanes may be adjusted to alter the flow rate through the machine. In its passage through the runner, the runner blades deflect the fluid so that its angular momentum is changed. From the centre of the runner the fluid is turned into the axial direction and flows to tail race via the draft tube. The lower end of the draft tube must under all conditions of operation, be submerged below the level of water in the tail-race. Only in this way can it be ensured that the hydraulic turbine is full of water. A draft tube has gradual increase in cross sectional area. The velocity of water at the runner outlet is very high. By employing a draft tube, a part of the kinetic energy that was going as a waste is recovered as a gain in the pressure head and this increases the overall efficiency of turbine.

Q Sketch and explain the working principle of Kaplan turbine



Axial flow turbine is used for low heads, at high rotational speeds and large rates of flow. Kaplan turbine is an axial flow reaction turbine having a small number of blades, usually has from four to six and closely resembles a ship's propeller. The blade angle may be varied by turning the blades about their own axes. The turbine is enclosed in a spiral casing which receives water from mains. From the casing the water is ~~directional~~ directed to the runner blades by guide vanes. The arrangement of guide vanes is similar to that of a francis turbine. When both guide vane and the runner blade angle may thus be varied, a high efficiency can be maintained over a wide range of operating conditions. Kaplan ~~turb~~ turbine operates in an entirely closed conduit from inlet to tail-race.

Q. differentiate between impulse and reactions turbines.

A

IMPULSE TURBINE	REACTION TURBINE
→ There is no pressure change of the fluid in the turbine rotor blades	→ The pressure of the water changes as it passes through the turbine rotor blades
→ The entire water energy is converted into kinetic energy	→ no energy conversion
→ Work done is by the change in kinetic energy of jet	→ Work done is partly by the change in the velocity head and almost entirely by the change in pressure head.
→ The water flows through the nozzle and impinges on the buckets	→ The water is guided by the guide blades to flow over moving vanes
→ Draft tube is not necessary	→ draft tube is necessary.
→ Newton's ii Law describes the transfer of energy	→ Newton's iii Law describes the transfer of energy

Q2 define radial flow, axial flow and mixed flow water turbine.

• radial flow: having the working fluid flowing mainly along the radii of rotation

• axial flow: turbine in which the flow of working fluid is parallel to the shaft, as opposed to radial turbines, where the fluid runs around a shaft, as in a watermill

mixed flow: an inward flow, reaction-type water turbine, in which the runner vanes are so shaped that they are acted on by the water pressure both axially and radially.

Q. Find the enthalpy of 1 kg steam at 12 bar when steam is
(i) dry saturated (ii) 22% wet (iii) Super heated at 250°C

$C_p = 2.25$ KJ/KgK

(i) $h_g = h_f + h_{fg} \Rightarrow$ ~~7.98~~ $798.43 + \overset{1984.3}{\cancel{198.43\ 198.43}}$

$= 2782.73$ KJ/Kg

(ii) 22% wet

$1 - x = 0.22$; $x = 0.78$

$h_w = h_f + x h_{fg}$

$= 798.43 + 0.78 \times 1984.3$

$= 2346.184$ KJ/kg

(iii) $h_v = h_g + C_p(t_v - t_s)$

$= 2782.73 + 2.25(250 - 187.96)$

$= 2922.32$ KJ/Kg

Q. Find the enthalpy of 0.5 kg steam at a pressure of 10 bar absolute for

(i) 1.5% wet $\Rightarrow x = 0.985$

enthalpy $h_w = h_f + x h_{fg}$

$= 762.61 + 0.985 \times 2013.6$

$= 2746.006$ KJ/Kg

(ii) dry saturated

$h_f + h_{fg} = h_g$

$= 762.61 + 2013.6 = 2776.21$ KJ/Kg

for 0.5 kg $= 1388.105$ KJ/Kg

(iii) $t = 200°C$

$h_v = h_g + C_p(t_v - t_s)$

$= 2776.21 + 2.3(200 - 179.88)$

$= 2822.486$ KJ/kg

for 0.5 kg $= 1411.243$ KJ/Kg.

Q. Find the enthalpy of 1 Kg of steam at 10 bar pressure absolute

(i) Dry saturated $= h_f + h_{fg}$

$= 762 \text{ KJ/Kg} + 2030$

$= 2792 \text{ KJ/Kg}$

(ii) 20% wet => $x = 0.8$

$h_w = h_f + x h_{fg}$

$= 762 + 0.8 \times 2030$

$= 2386 \text{ KJ/Kg}$

(iii) Super heated at 220°c

$h_v = h_g + C_p(t_{sv} - t_s)$

$= 2792 + 2.25(220 - 180)$

$= 2882 \text{ KJ/Kg}$

Q. Determine the specific volume and density of 1 Kg of steam at a pressure of 7×10^5 pa when steam is

(i) Dryness fraction 0.9

$V_w = x V_g + (1-x) V_f$

$= 0.9 \times 0.27268 + \underbrace{0.1 \times 0.0011082}_{\text{neglecting}}$

$= 0.245412 \text{ m}^3/\text{Kg}$

density $= 4.0747 \text{ Kg/m}^3$

(ii) Dry

$V_g = 0.27268 \text{ m}^3 \text{ Kg}$

density $= 3.6673 \text{ Kg/m}^3$

(iii) Superheated to 250 °C

$\Rightarrow \frac{V_u}{T_u} = \frac{V_g}{T_s}$

$V_u = \frac{V_g \times T_u}{T_s} = \frac{0.27268 \times 523}{437.96}$

$= 0.3256 \text{ m}^3/\text{Kg}$

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Q. Define

(i) Dryness fraction: Dryness fraction is the ratio of mass of dry steam in mixture by the mass of mixture

$$x = \frac{m_g}{m_g + m_f}$$

(ii) Specific volume: the volume of unit mass of steam at a given temperature and pressure.

(iii) Enthalpy of superheated steam: It is equal to the sum of sensible heat, latent heat and heat of superheating

i.e. $H_u = h_f + h_{fg} + c_p(t_u - t_s)$

$= h_g + C_p(t_u - t_s)$ KJ/kg

(iv) Internal energy: actual energy stored in the steam.

for saturated steam

$U_u = H_u - 100 p v_g = h_g - 100 p v_g$ KJ/kg

for wet steam

$U_w = H_w - 100 p x v_g = h_f + x h_{fg} - 100 p x v_g$

for superheated steam

$U_u = H_u - 100 p v_u = h_g + C_p(t_u - t_s) - 100 p v_u$ //