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Power Generation

Name: ______________

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Terminal Examination *course Instructor: Engr.Sanaullah Ahmad*

Note: Attempt all Questions & Draw diagrams where necessary.

Question No 1 **20**

A. With the help of a diagram show different Elements of a Hydropower Plant? CLO 1

B. Water for a small hydroelectric station is to be made available from a pondage with a volume of $5 \times 10^5 m^3$ located at a height uphill to provide water at a head of 100m at a hydraulic efficiency of 85% If the electrical efficiency is 94% and the water supply is available for 8 hours daily, determine the capacity of the generator to be installed at the power station. CLO 2

Question No 2 **20**

A. Classify different hydropower turbines, what are the parameters required for the selection of hydropower turbines? CLO1

B. Select a suitable turbine for a hydropower scheme with available head height of 190m and rated discharge of 2.2 m^2/s with overall efficiency of 85% ? Also determine turbine diameter and jet diameter? Specific speed $Ns = 85.49/(h)^{0.243}$. $Diameter = 38.56\sqrt{h}/n$. *Jet Diameter* $q = (\pi d_j^2 V_j)/4$ where $V_j = \sqrt{2gh}$ CLO 2

Question No 3 **10**

Explain different stages of Nuclear Fuel Cycle? CLO 1

GOOD LUCK

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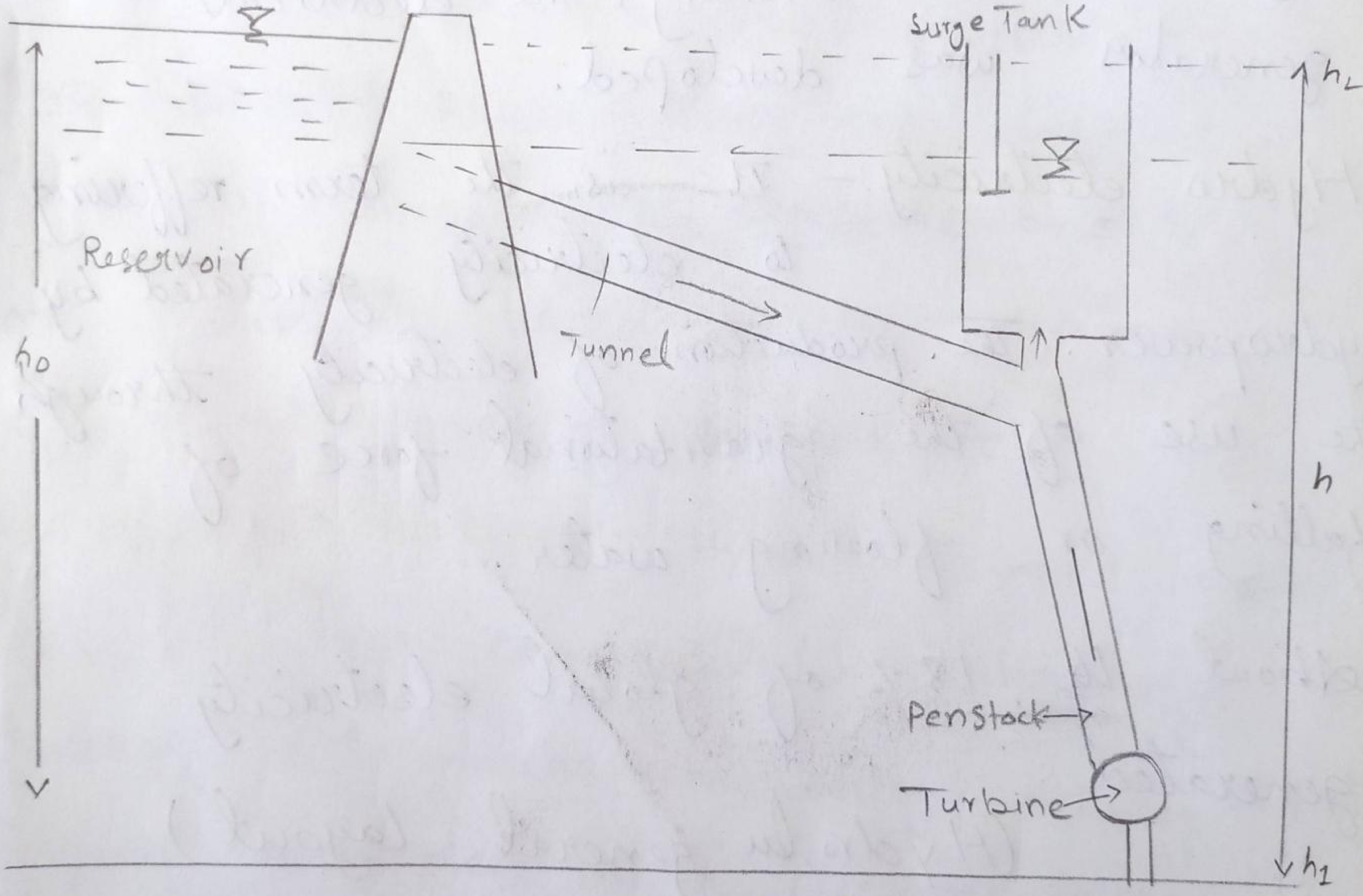
Q.No : 1 (a)

Answer:-

Hydro-power plant :-



History :- Hydro-power plant is power derived from the energy of falling or running water.

first used by Greeks for grinding wheat.

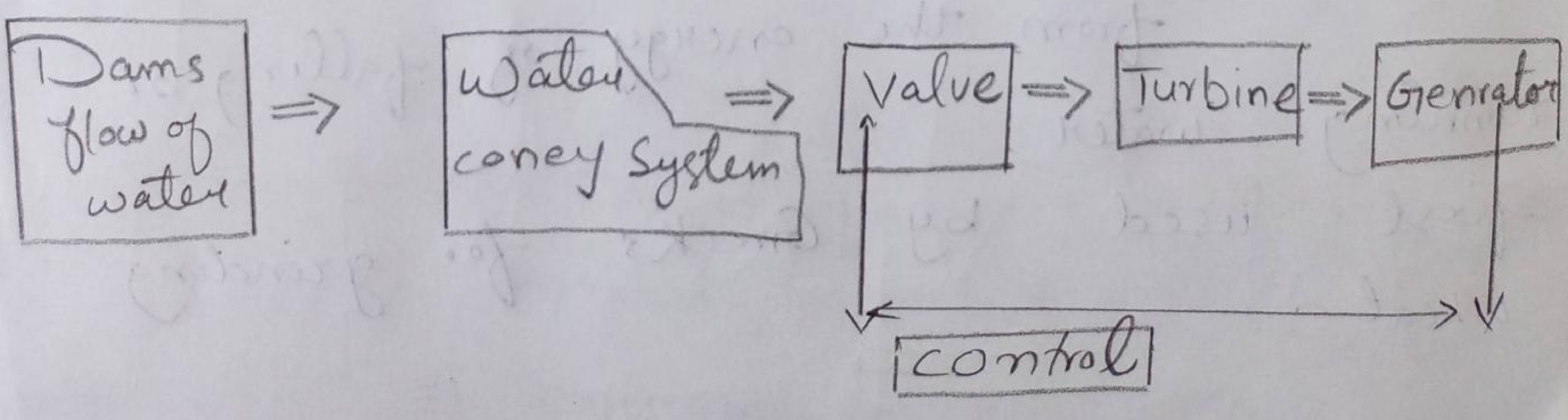
In 1753, french engineer Berdnard forest first give idea about the use of hydropower.

By late 19th Century, The electrical generator was developed.

Hydro-electricity:- It is the term reffering to electricity generated by hydropower. The production of electricity through the use of the gravitational force of falling or flowing water.

About 16 - 18 % of global electricity generated.

(Hydro lic general layout)



Components of hydro power plant :-

i) fore bay :- A forebay is a basin area of hydro power plant where water is temporarily stored before going intake chamber. The storage of water in fore bay decided based on required water demand in that area. The water stored on the up stream side of dam can be carried by penstocks to power house. In this case the reservoir as act as a fore bay.

ii) Pen stock :- Pen stocks are like large pipes. laid with some slope which carries water from intake structure or reservoir to the turbines. They run with some pressure so, sudden closing or opening of penstock gates can cause water hammer effect to the penstock.

iii) Surge Chamber:- A Surge Chamber or Surge tank is a cylindrical tak which is open at the top to control the pressure in penstock. It is connected to penstock as closed as possible to the power house. There are different types of surge tank available and they are selected based on the requirments of plant, length of penstock etc.

iv) Hydralic turbines:- Hydralic turbines, a device which can convert the hydralic energy into mechanical energy which again converted into electrical energy by coupling the shaft of turbine to generator.

v) Power house:- Power house is a building Provided to protect the hydralic and electrical equipments.

Q no (1)(b)

Sol:- Given that:

available volume at pondage $V = 5\times10^5 m^3$

available head : $h = 100 m$

Hydralic efficiency : $85\% \rightarrow 0.85$

Electrical efficiency : $95\% \rightarrow 0.95$

over all efficiency $= 0.85 \times 0.95 = 0.80$

Required :

capacity of generator $E = ?$

using $E = \eta \rho g h v$

$E = 0.8 \times 1000 \times 9.81 \times 100 \times 5 \times 10^5$

$E = 3.92 \times 10^{11}$ W-s .

QNo 2(a)

Answer:-

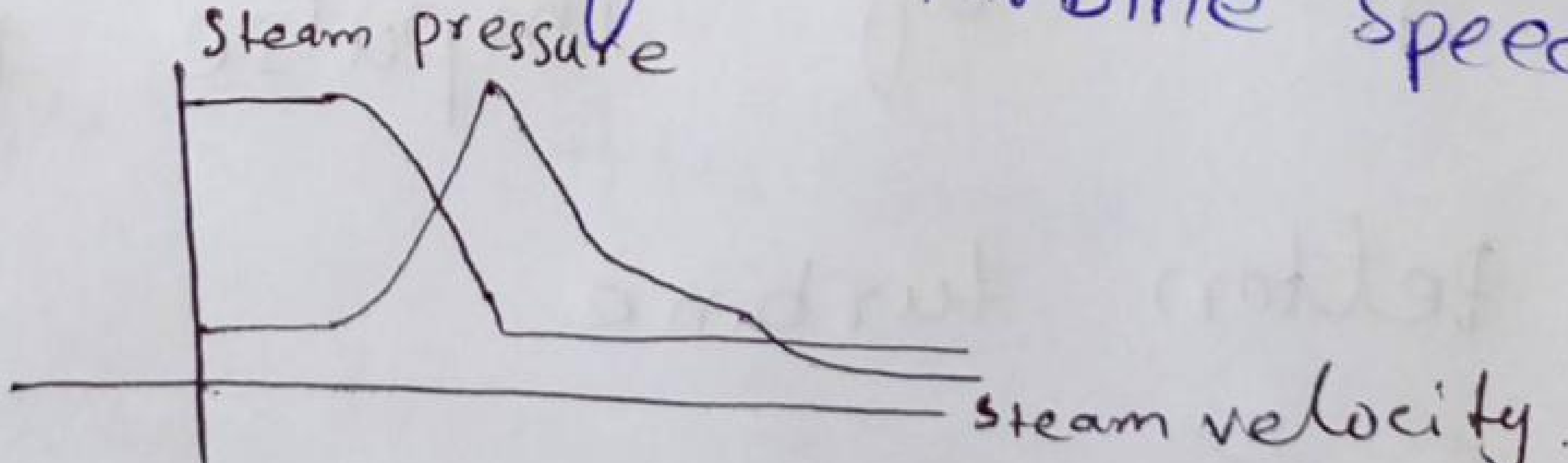
Turbines:- It is a rotatory ~~mechanically~~ mechanical device that extracts energy from a "fluid flow" and converts it into useful work.

Types of hydro power turbines:-

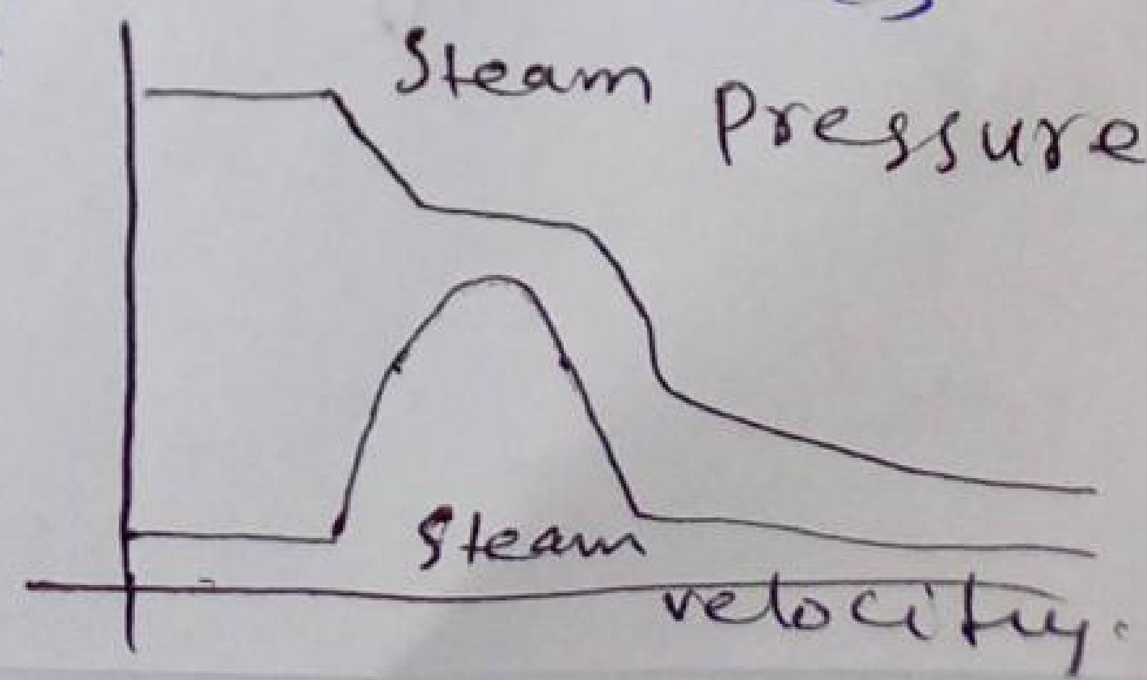
i) Impulse turbine

ii) Reaction turbine

Impulse: The steam velocity is very high and therefore turbine speed is very high.



Reaction:- The steam velocity as well as pressure is utilized



1) Impulse turbine :- The impulse turbine generally uses the velocity of water to move the runner. The water stream hits each bucket on the runner.

An impulse turbine, ~~at inlet~~ is generally Suitable for high head, low.

In impulse turbine, at inlet, only kinetic energy available. But in reaction turbine, at inlet kinetic energy as well as pressure energy both are available.

Types of impulse turbine.

i) Pelton turbine

ii) Cross - flow turbine,

2) Reaction turbine:-

A reaction turbine develops power from combine action of pressure and moving water. The running is placed directly in the water stream flowing over the blades rather then striking each individually.

Reaction turbines are generally used for sites with ~~lowo~~ lower head and higher flows than compared with the impulse turbines.

Types of Reaction turbine:-

i) Popeller Turbine

ii) Francis Turbine

iii) Kinetic Turbine.

QNo 2(b)

Sol:- Given that

Head $h = 190\ m$

Discharge $q = 2.2\ m^2/s$

overall efficiency $= 85\% = 0.85$

$N_s = 85.49/(h)^{0.243}$

Diameter $n = 38.56\sqrt{h}$

Required :-

$P = ?$ $n_s = ?$ $N_s = ?$

$$n_s = \frac{85.49}{(h)^{0.243}}$$

$$n_s = \frac{85.49}{(190)^{0.243}}$$

$n_s = 23.88\ rpm$.

The output power obtained by using.

$P = \eta \rho q g h$ Watts.

$P = 0.85 \times 1000 \times 2.2 \times 9.81 \times 190 = 3485.5\,KW$

Now

$$n = n_s \frac{h^{3/4}}{\sqrt{P}} = \frac{23.88 \times (190)^{3/4}}{\sqrt{3485.5}} = 285.32\ rpm$$

An Alternator rated 50 Hz with synchronous Speed aproaching 285.32 rpm but not ~~generated~~ greater is to be selected the no. of poles required are computed by using

$$N_s = \frac{120 f}{P}$$

$$P = \frac{120 \times 50}{285.32} = 21.02\ poles.$$

Selecting 24 poles alternator will rotate 250 rpm.

$$D = 38.56 \sqrt{h} / n$$

$$= 38.56 \times \sqrt{190} / 250 = 2.12 \text{ m}$$

The jet diameter will be callcated

$$q = (\pi d_j^2) V_j / 4 \quad ; \quad V_j = \sqrt{2gh}$$

$$V_j = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 190} = 61.05 \text{ m/s}$$

$$d_1 = \sqrt{\frac{4 \times 2.2}{3.14 \times 61.05}} = 0.214 \text{ m or } 21.4 \text{ cm}$$

So diameter of jet is 20 cm.

Q No (3)

Answer:- Nuclear Fuel cycle:-

Mining and Milling:- uranium is usaully mined by either surface (open cut) or underground mining techniques, depending on the dept at which the ore body is found. From these the mined uranium ore is send to a mill which is ousually located close to mine. At the mill the ore is crushed and ground to a fine slurry which is leached in sulfuric acid to allow the separation of uranium. It is then recovered from solution as uranium oxide (U_3O_8) concentrate. Sometimes this is known as yellow cake.

ii) Conversion :- Because uranium needs to be in the form of a gas before it can be enriched, the U_3O_8 is Converted into gas uranium hexafluoride (UF_6) at a conversion plant.

iii) Enriching :- Needs to enrich uranium to atleast 3% for a power plant.

Two methods of Enriching.

- Gaseous diffusion method:

→ UF_6 gas heated.

→ U238 is heavier than U235

Hexafluriod Gas can be separated into two streams.

- Low velocity U-238
- High velocity U-235.

* Centrifuge Method:-

→ Gas spun in centrifuge.

→ Lighter U-235 will separate from heavier U-238.

IV) Fuel conversion:- Enriched uranium transported to a fuel fabrication plant where it is converted to uranium oxide. (UO_2) powder and pressed into small pellets.

- These pellets are inserted into thin tubes, usually of a Zirconium alloys or Stainless steel, to form fuel rods.
- The rods are then sealed and assembled in clusters to form fuel assemblies for use in the core of the nuclear reactor.

V) Fuel packaging in the core:-

- Rods contain uranium enriched.
- Need Roughly 100 tons per year for a 1000 MW plant.

VI) The Reactor:-

The Reactor core consists of fuel rods and control rods.

→ Fuel rods contain enriched uranium.

→ Control rod are inserted b/w the fuel rods to absorb neutrons and slow chain reaction.

VII) Moderators:- A moderator is required to slow down the neutrons. In nuclear power plants water & graphite acts as the moderator.

viii) Light vs Heavy water:-

→ Normal water is called light water while water containing dueterii is called heavy water.

→ Heavy water is a much better moderator but is very expensive to make.

ix) Boiling water Reactor (BWR)

Heat generated in the core is used to generated steam through a heat exchanger.

The steam runs a turbine just like a normal power plant.

x) pressurized water Reactor:- (PWR)

water in the core heated top 315°c but is not turned into steam due high pressure in the primary loop. Heat exchanger used to transfer heat into secondary loop where water is turned to steam to power turbine.

	BWR	PWR
Electrical output (MWe)	1000	1000
Initial load	135	80
Fuel rods per assembly	50	200
Fuel assemply per core	750	180
Number of control rods	180	45

xi) Uranium reprocessing:-

Reprocessing extract useable fissile U-238.

Most of the spent fuel can be reprocessed.

XII) Nuclear waste Disposal:-

In the US no high level nuclear ~~wasat~~ waste is ever disposed of its sit in specially disigned pools resembles large Swimming pools.

Spent nuclear fuel must be isolated for thousands of years.