NEPAL ENGINEERING COUNCIL

LICENSE EXAMINATION PREPARATION COURSE
FOR
CIVIL ENGINEERS
on
Hydropower Engineering

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8.6 Hydro-Electric Machines and Powerhouse

8.6.1 Hydro-mechanical equipment and their functions;

8.6.2 Types of turbines and performance characteristics;

8.6.3 Selection of turbine and their specific speed;

8.6.4 Preliminary design of Francis and Pelton turbines;

8.6.5 Scroll case and draft tubes;

8.6.6 Generators (types, rating); governs; pumps and their performance characteristics;

8.6.7 Powerhouse (types, general arrangements, dimensions).

8.6.1 Hydro-mechanical equipment

Hydro-mechanical equipment are defined as those equipment which convert either hydraulic energy into mechanical energy or mechanical energy into hydraulic energy.

Hydraulic energy to mechanical energy = Turbine

Mechanical energy to hydraulic energy = Pump

The rotation of turbine rotates the shaft which is coupled with generator. Generator converts the mechanical energy into electrical one.

8.6.2 Types of Turbine

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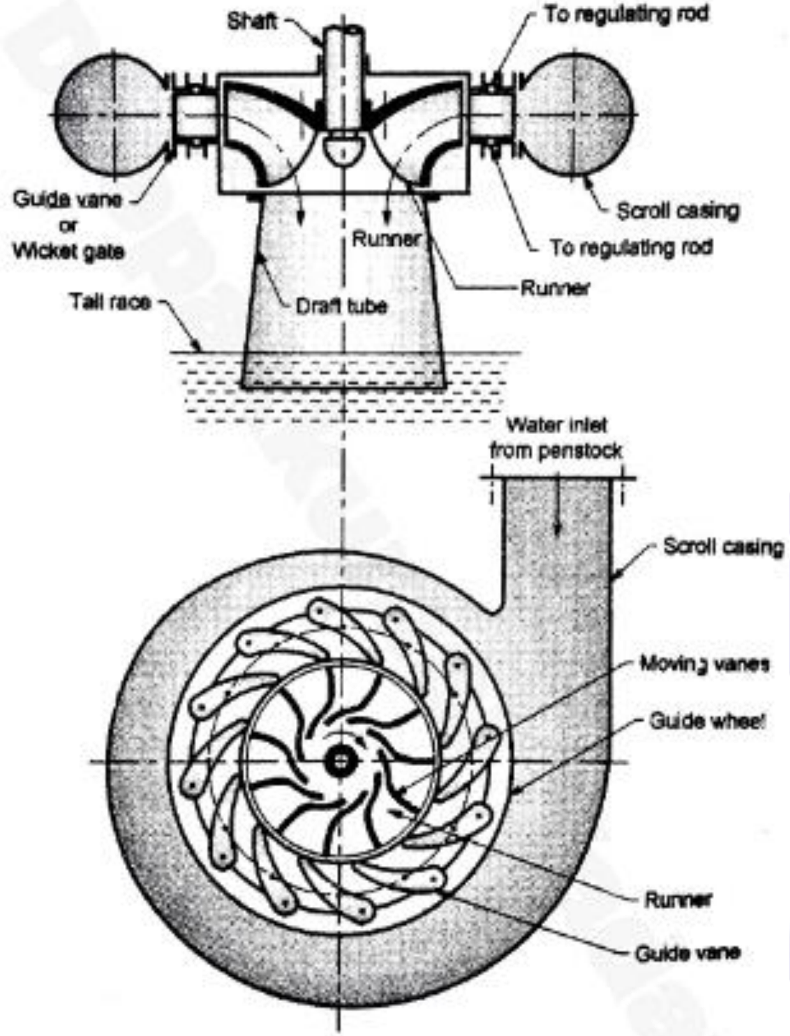
Turbines are the hydro-mechanical equipment that convert hydraulic energy to mechanical energy. This mechanical energy is used in running an electric generator which is coupled to the shaft of the turbine.

Electric generator convert mechanical energy to electric energy.

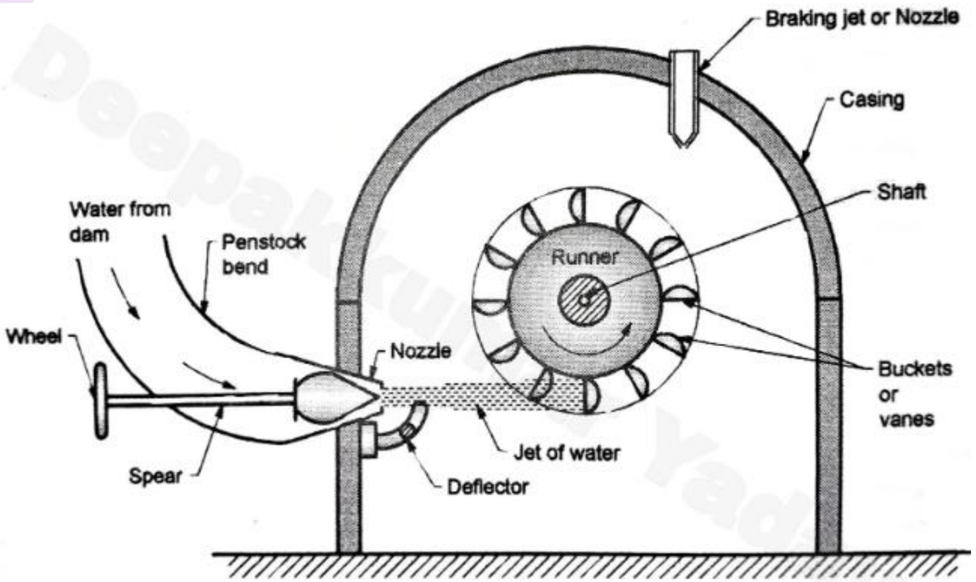
Classification of turbines:

A. Based on inlet energy:

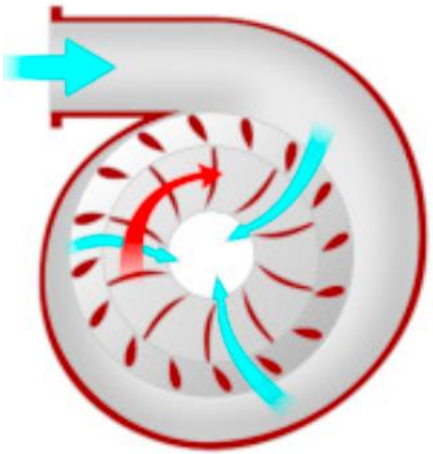
1. Impulsive or velocity turbine: pressure less turbines, energy of water is converted to kinetic in the form of water jet issuing from nozzle/s and hitting the wheel vanes, runners. Flow in atmospheric pressure. Those turbines in which water entering possesses the kinetic energy only like Pelton turbine, Turgo turbine.
2. Reaction turbine or pressure turbine: : High pressure turbine, flow in high pressure. The turbine in which water entering possesses the kinetic as well as pressure energy like Francis turbine, Kaplan turbine.

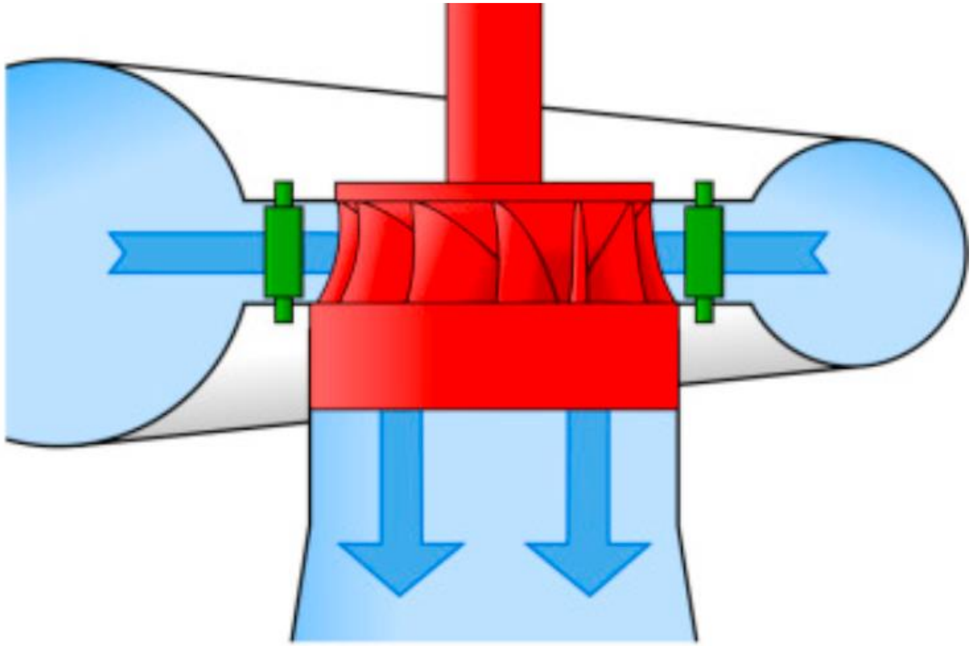


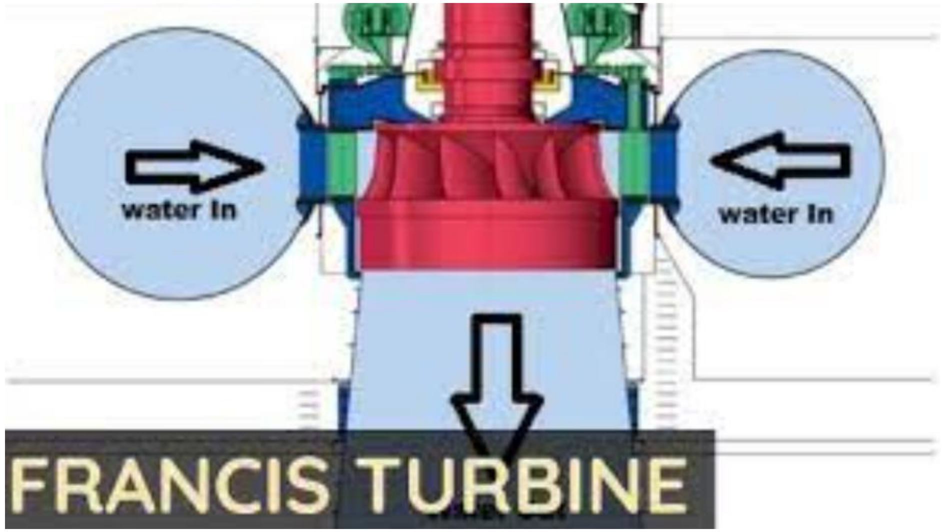
Francis Reaction Turbine

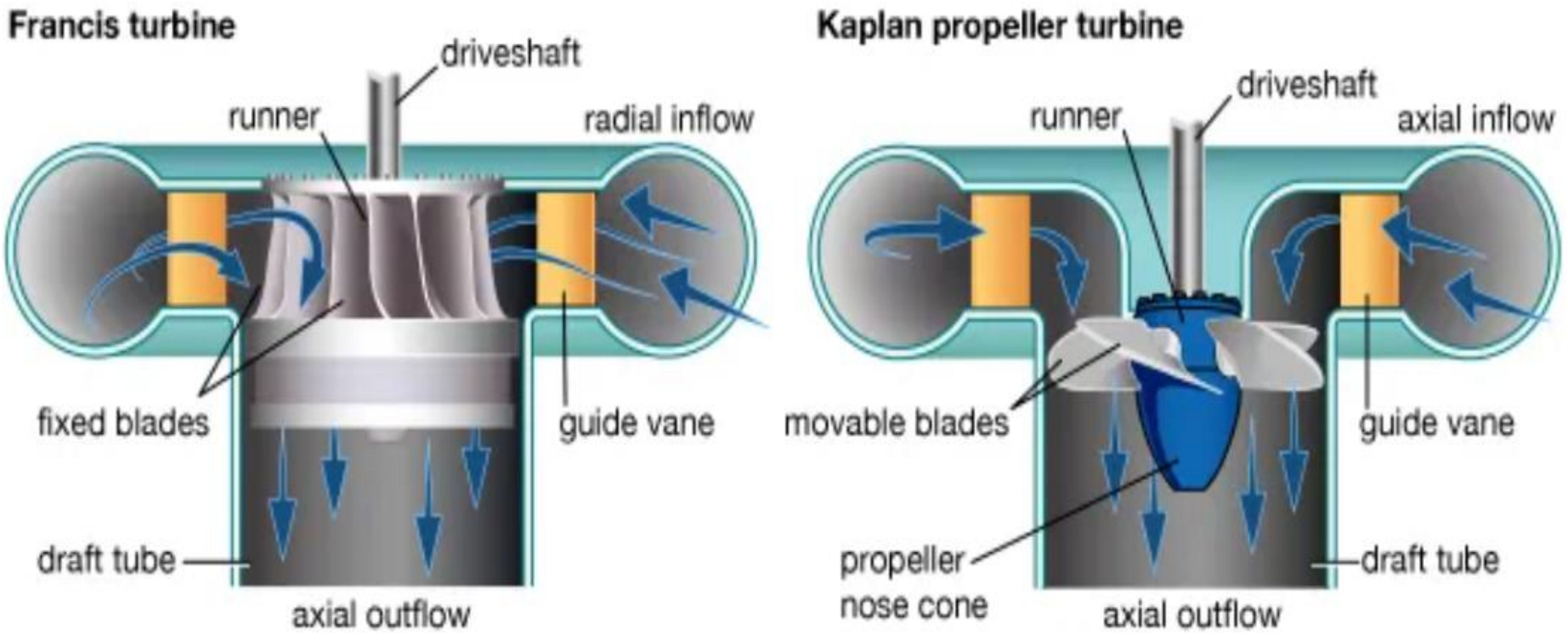


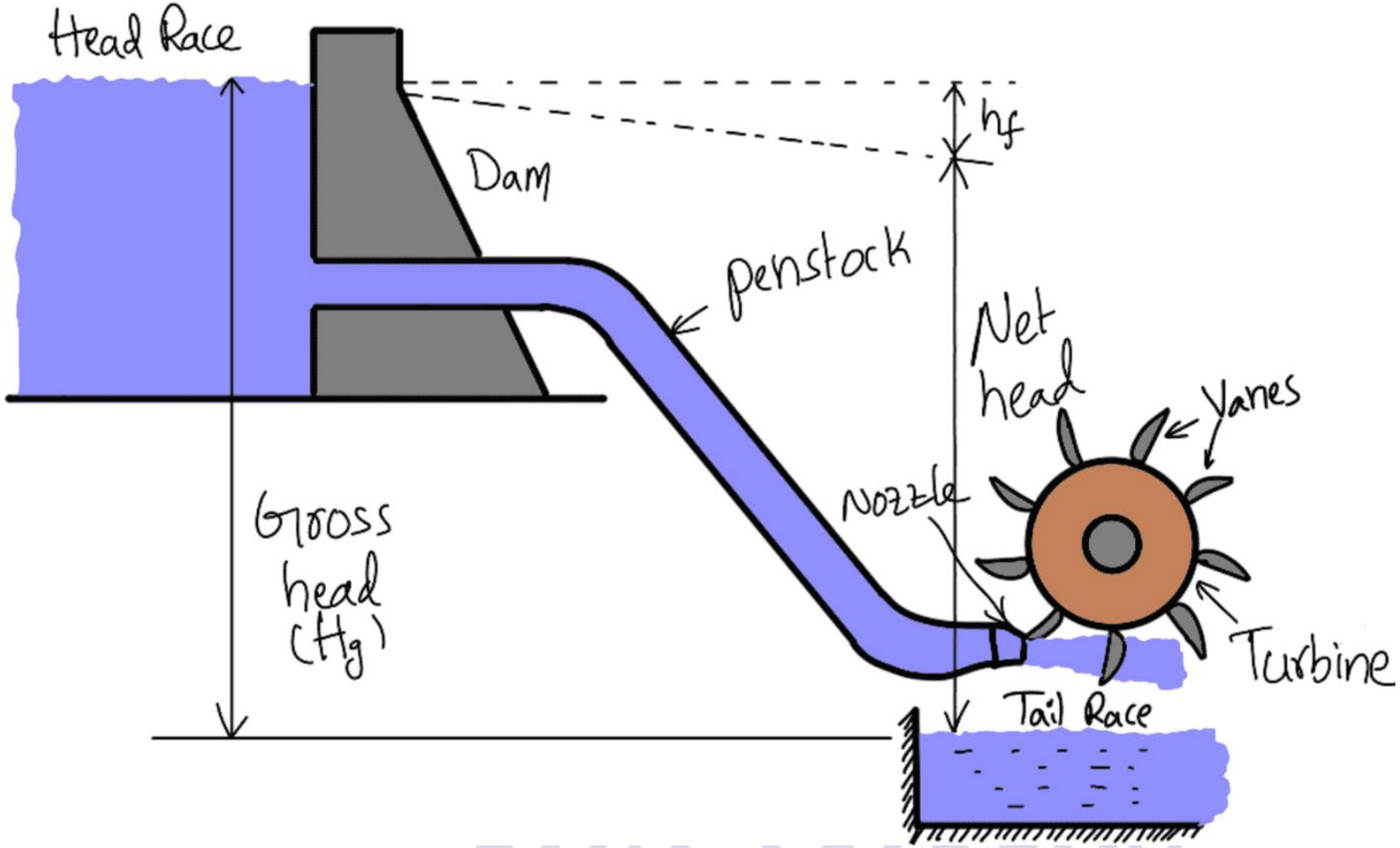
Pelton Turbine






water In
water In
FRANCIS TURBINE

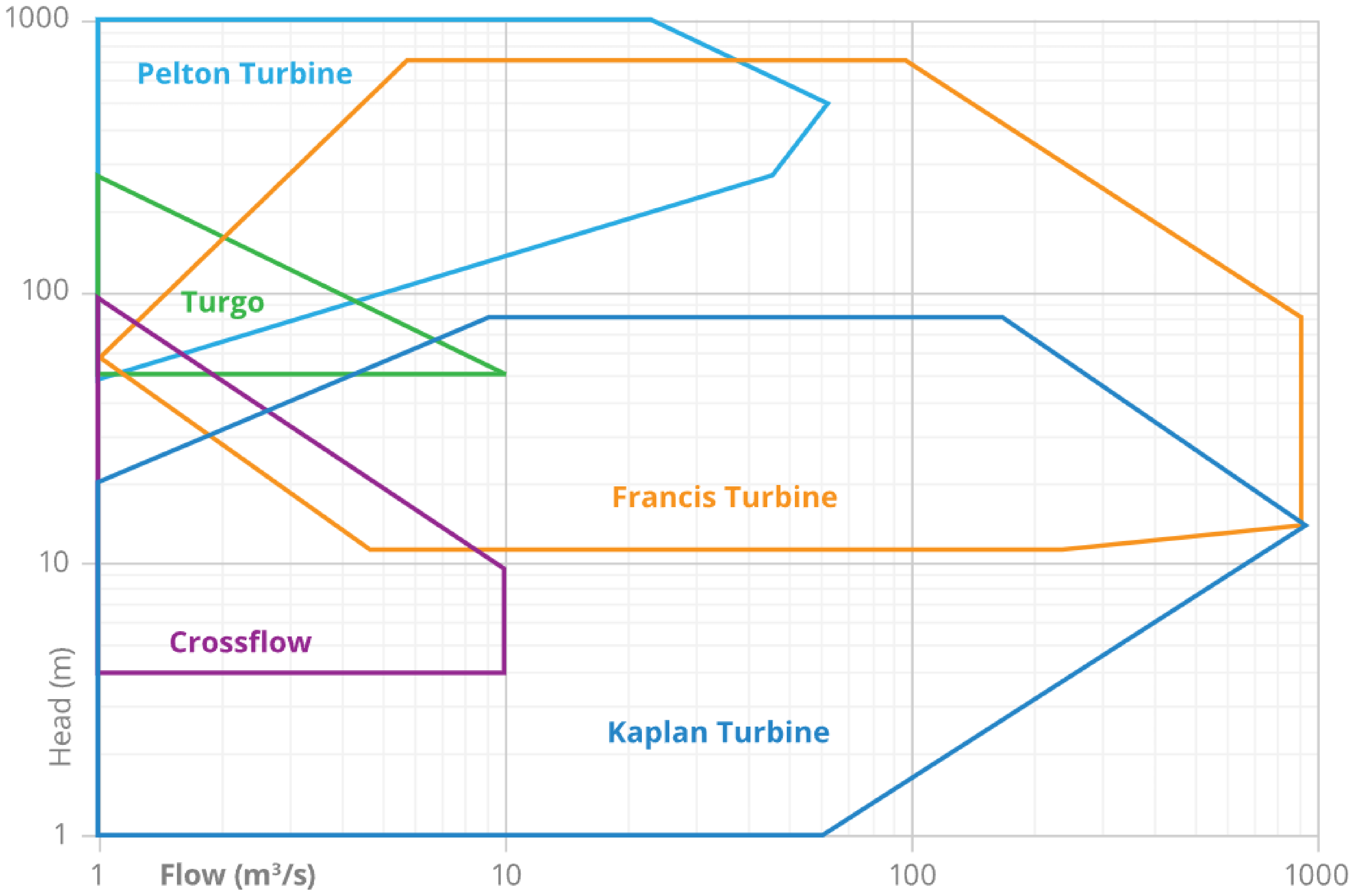

Francis turbine
driveshaft
runner
radial inflow
fixed blades
guide vane
draft tube
axial outflow
Kaplan propeller turbine
driveshaft
runner
axial inflow
movable blades
guide vane
propeller
nose cone
draft tube
axial outflow


Head Race
Dam
h_f
penstock
Net head
Vanes
Nozzle
Gross head (H_g)
Turbine
Tail Race

Classification of Turbines

The h ydraulic turbines can be classified based on t ype of energy at the inlet, direction of flow through the vanes, head available at the inlet, discharge through the vanes and specific speed . They can b e arranged as per the following table:

Turbine Name	Turbine Type	Type of energy	Head	Discharge	Direction of flow	Specific Speed
Pelton Wheel	Impulse	Kinetic	High Head > 250m to 1000m	Low	Tangential to runner	Low <35 Single jet 35 – 60 Multiple jet
Francis Turbine	Reaction Turbine	Kinetic + Pressure	Medium 60 m to 150 m	Medium	Radial flow Mixed Flow	Medium 60 to 300
Kaplan Turbine			Low < 30 m	High	Axial Flow	High 300 to 1000


1000
100
10
1
Head (m)
Pelton Turbine
Turgo
Crossflow
Francis Turbine
Kaplan Turbine
1
10
100
1000
Flow (m³/s)

8.6.2 Types of Turbine

B. Based on head (Dandekar book):

1. Low head(<15m): Kaplan
2. Medium Head(15-70m): Kaplan/Francis
3. High head turbine(71-250m): Francis/Pelton
4. Very High head turbine(>250m): Pelton

C. Based on direction of flow

1. Tangential flow – Pelton Turbine
2. Radial Flow [Inward flow – Francis ; Outward flow – Fourneyron turbine]
3. Axial Flow – Kaplan turbine
4. Mixed Flow – Francis turbine

Note: Deriaz turbine does not follow a full axial nor radial direction but is a diagonal mixture of the two.

8.6.2 Types of Turbine

Impulse (Pelton) Turbine	Reaction (Francis) Turbine
All the available fluid energy is converted to kinetic energy by efficient nozzle forming jet.	Only fraction of energy is transformed into kinetic energy before fluid enter into the runner.
Blades are in action when in front of nozzle.	All blades are in action at all time.
When does not run full with water and air has free access to bucket.	Water completely fills the vane passage throughout the period.
Unit is installed above the tailrace.	Unit is installed and submerged below the tailrace.
Work is done completely due to velocity change.	Work is changed due to velocity and pressure change.
Turbine components are easily accessible and repair maintenance is easier.	Components are not easily accessible and repair – maintenance is difficult.
Turbines are relative small in size and run with more speed.	Turbine are relative larger in size and run with lower speed.
Suitable for high head	Suitable for lower head

8.6.3 Selection of Turbine and their Specific Speed

The selection of type of turbine depends upon:

- Head available
- Flow of water
- Specific speed
- Efficiency
- Water quality
- Conveyance or maintenance
- Deposition of turbine shaft

8.6.3 Selection of Turbine and their Specific Speed

Head	Head Range (m)	Suitable turbine	Notes
Very low head	3 - 10	Bulb turbine	Kaplan turbines are also suitable but uneconomical for very low heads
Low head	10 - 60	Kaplan Turbine	Propeller turbines are also suitable up to 15m head but there should not be load variations.
Medium head	60 - 150	Francis turbine	-
High head	150 - 350	Pelton or Francis turbine	One of them is decided based on the specific speed.
Very high head	>350	Pelton turbine	-

8.6.3 Selection of Turbine and their Specific Speed

Specific speed (Ns)

It is the speed at which the machine produces 1 HP (unit power) under 1m head (unit head). It is an important parameter for the design of the turbines as it includes all the basic parameters i.e. speed, power and head of the turbine.

Specific speed (Ns)

$$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}$$

Ns = Specific Speed (rpm)
N = Speed of actual turbine (rpm)
P = Power (generally in HP)
H = Effective water head (m)

1 hP = 746 Watt

8.6.3 Selection of Turbine and their Specific Speed

Synchronize speed (N):

Since the generator and turbines are directly coupled, the rated speed of the turbine is same as that of the synchronous speed of the generators.

Rotational speed of the turbine which is synchronized with frequency of the energy system to which it is connected. The frequency of energy system should be equal to frequency of each number of pole pair.

Synchronous speed (N) = $120f/N_p$ (rpm)

- Where, f = 50 HZ , N_p = number of magnetic poles (in Pair) ,

8.6.3 Selection of Turbine and their Specific Speed

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Specific speed for different turbines

i) For Fransics turbine

$$N_s = \frac{2400}{\sqrt{H}}$$

ii) For fixed blade propeller turbine (head < 18 m)

$$N_s = \frac{1030}{H^{\frac{1}{4}}}$$

iii) For adjustable blade propeller turbine *i.e.*, Kaplan turbine,

$$N_s = \frac{1475}{H^{\frac{1}{3}}}$$

The specific speeds of different types of turbine are shown below;

Types of turbine	Specific speed
Less than 30	Single jet pelton turbine
30-50	Multi jet pelton turbine
50-260	Francis turbine
260-860	Kaplan turbine

8.6.3 Selection of Turbine and their Specific Speed

Based on Efficiency

Efficiency of turbines = Kaplan Turbine > Francis Turbine > Pelton Turbine

Based on water quality

Quality of water is more important for impulse turbine than reaction turbine.

Based on conveyance or maintenance

Impulse turbine has less cost of maintenance than that of reaction turbine.

8.6.3 Selection of Turbine and their Specific Speed

<table>
<tr><th>Flow</th><th>Energy</th><th>Head</th><th>Specific speed</th><th>Example</th></tr>
<tr><td>Tangential</td><td>Impulse</td><td>High head
(300 m and above)</td><td>Low
(0 – 60 RPM)</td><td>Pelton Wheel turbine</td></tr>
<tr><td>Radial</td><td>Reaction</td><td>Medium
(30 m to 300 m)</td><td>Medium
(60 – 300) RPM</td><td>Francis turbine</td></tr>
<tr><td rowspan="3">Axial</td><td rowspan="3">Reaction</td><td rowspan="3">Low
(less than 30 m)</td><td>High</td><td></td></tr>
<tr><td>(300 – 600) RPM</td><td>Propeller turbine</td></tr>
<tr><td>(600 – 1000) RPM</td><td>Kaplan turbine</td></tr>
</table>

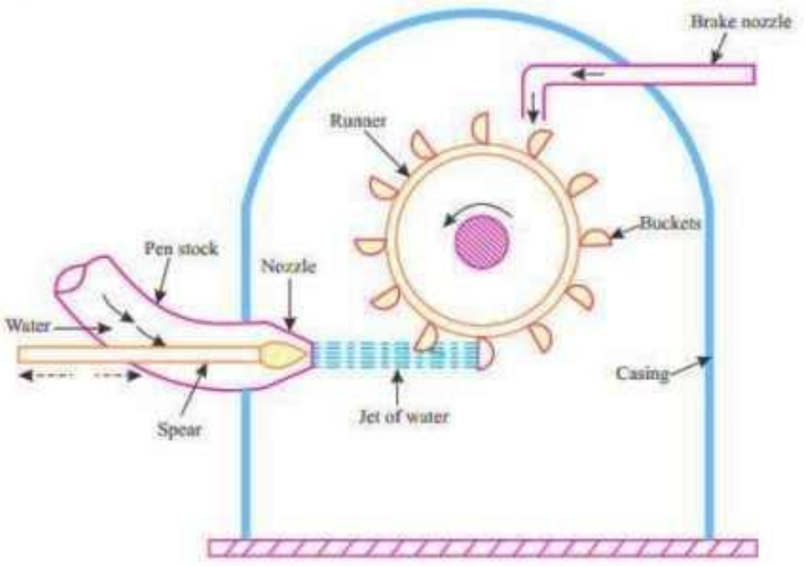
8.6.4 Preliminary design of Pelton & Francis Turbine

Pelton Turbine:

Pelton turbine is a tangential flow impulse turbine in which the pressure energy of water is converted into kinetic energy to form high speed water jet and this jet strikes the wheel tangentially to make it rotate

Components of Pelton turbine:

- Nozzle and Flow Regulating Arrangement
- Runner and Buckets
- Casing
- Braking Jet



8.6.4 Preliminary design of Pelton & Francis Turbine

Steps for Pelton Turbines,

(i)Determination of nozzle velocity or jet inlet velocity

- V1 = $C_v\sqrt{2gH}$, where C_v ranges from 0.96 – 0.99, H is net head

(ii)Calculate Velocity of runner (Tangential vel of turbine),

- v= $\phi\ \sqrt{2gH}$, generally ϕ= 0.46 ranges(0.43-0.48) called speed factor or ratio
- Find No of jet maxm-6 nos

(iii)From continuity equation

$$Q = A_j \times V_j$$

Where Area of jet $A_j = \pi d_j^2/4$

iv) Calculate diameter of runner wheel D, jet ratio (m) =D/d,

where m is pitch dia of pelton turbine wheel to dia of jet, m = 10 to 15

8.6.4 Preliminary design of Pelton & Francis Turbine

v) No of bucket on runner, N_b= 15+D/2d

vi) Bucket Spacing, S= $\pi D/N_b$

vii) Velocity of runner, v= $\phi \sqrt{2gH}$, generally ϕ= 0.46 called speed factor

viii) Calculate N from v= $\pi DN/60$

ix) No of poles (Np)= 120f/N, where, f=50hz

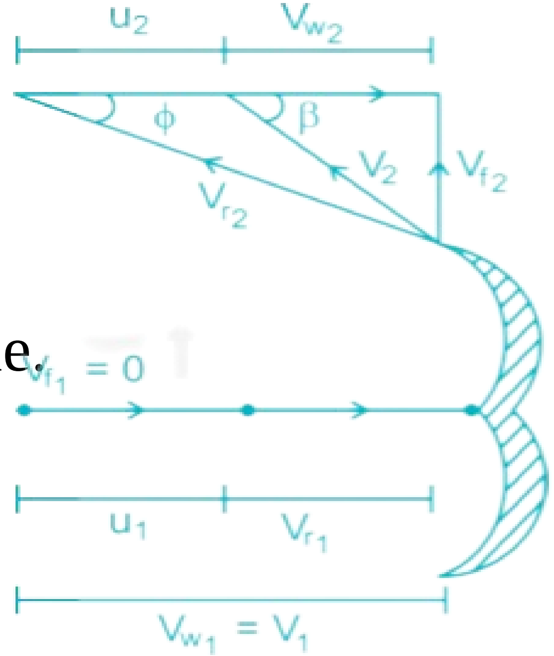
x) Corrected N= $120f/N_p$ (N_p in even no)

xi) Specific speed (Ns)= $N\sqrt{P} / H^{5/4}$ where, P = power in Hp.

The width of the bucket for a Pelton wheel is generally five times the diameter of the jet. The depth of the bucket for a Pelton wheel is generally 1.2 times the diameter of the jet.

8.6.4 Preliminary design of Pelton & Francis Turbine

The angle of deflection of jet through the bucket varies between 160 to 170°



Work Done and Efficiency of Pelton Turbine:

- The efficiency of turbine is determined from velocity triangle.
- max hydraulic efficiency when velocity of wheel **is half of the velocity of jet of water at inlet**.

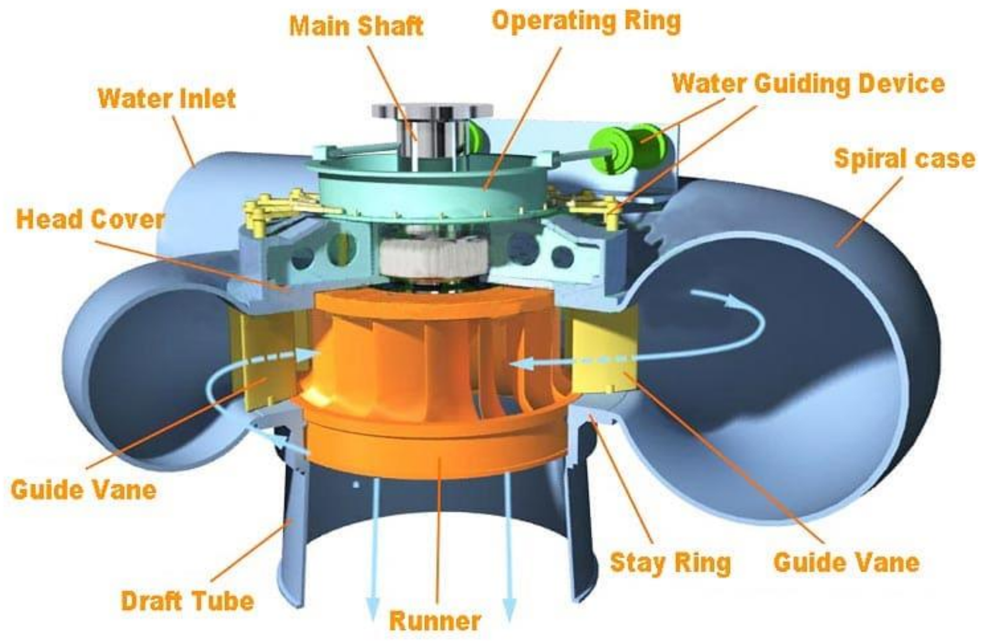
8.6.4 Preliminary design of Pelton & Francis Turbine

Francis Turbine:

The Francis turbine is a mixed flow-type turbine in which the water passes through the curved guide vanes under pressure and creates a high curved rotational flow at the outlet

Components of Francis turbine:

- Spiral Casing.
- Guide Vanes.
- Runner Blades.
- Draft Tube.



8.6.4 Preliminary design of Pelton & Francis Turbine

Steps for Francis Turbine:

(i) $N_s = 2400/\sqrt{H} = ...$ (Metric system)

(ii) $P = \eta\ rQH$

(iii) $N_s = N\sqrt{P} / H^{5/4}$

(iv) $N_p = 120f/N$ (Whole even number)

(v) $N_{synchro...} = 120f/N_p$

8.6.4 Preliminary design of Pelton & Francis Turbine

The design steps for Francis turbine is:

(i) The ratio of width to diameter of where is given as,

$$\eta = B_i/D_i$$

where, n varies from 0.10 to 0.40

(ii) The flow ratio is given by,

$$C_m = V_i / \sqrt{2gH}$$

where, V_i is flow velocity at Inlet tip and it varies from 0.15 to 0.30

(iii) The speed ratio,

$$\phi = \overline{v} / \sqrt{2gH}$$

Where $\overline{v}$ is peripheral velocity of flow and ϕ is speed ratio varies from 0.6 to 0.9

8.6.4 Preliminary design of Pelton & Francis Turbine

iv) Diameter of turbine,

$$D = 84.6\, \phi \sqrt{H} / N$$

Where $\phi = 0.0197\, N_s^{2/3} + 0.0275$

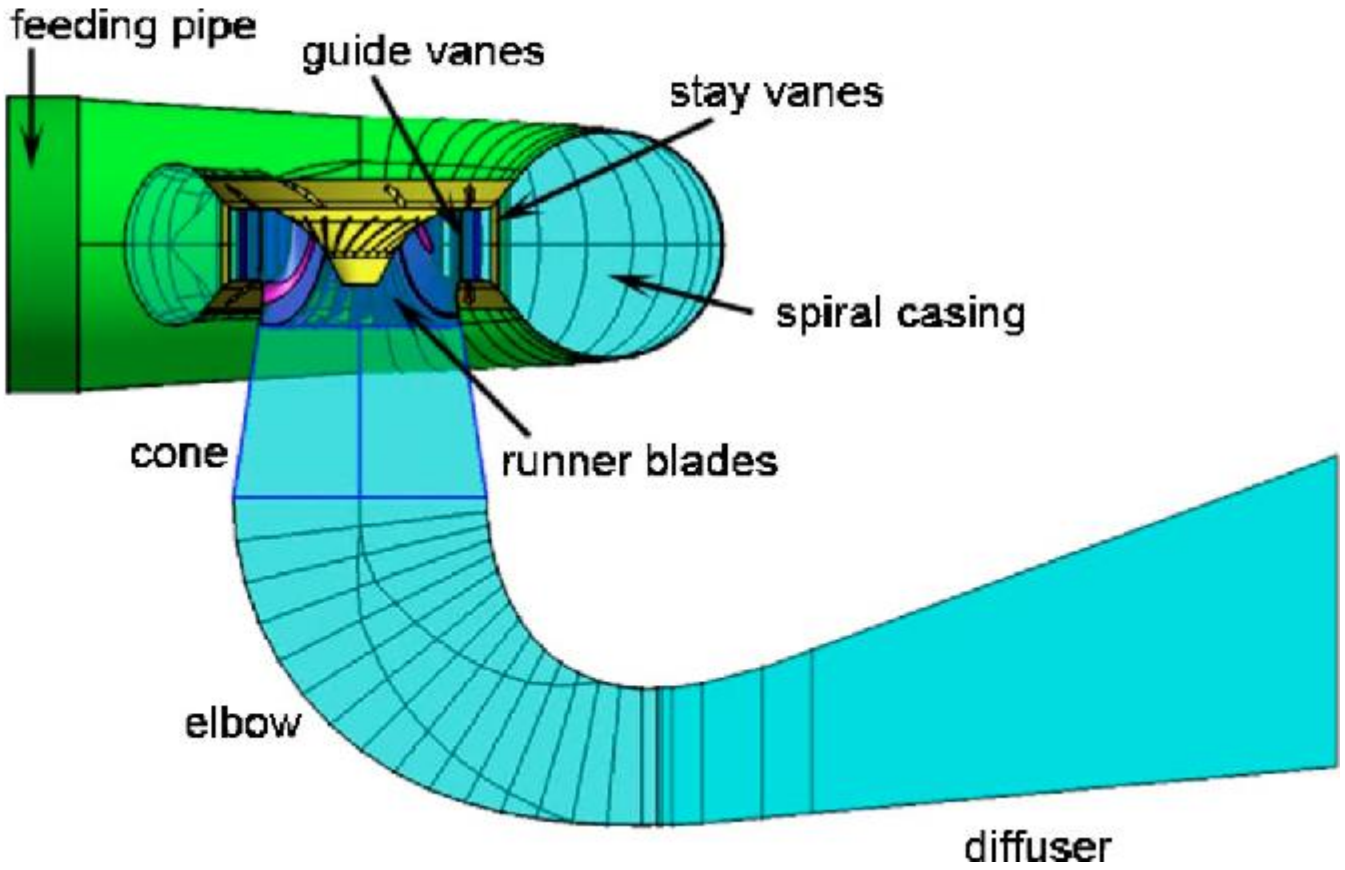
The design discharge through the turbine,

$$Q = \pi\, B_{inlet}\, D_{inlet}\, V_{inlet}$$

$$Q = \pi\, B_{outlet}\, D_{outlet}\, V_{outlet}$$

$$V_{inlet} \approx V_{outlet}$$

8.6.5 Scroll Case and Draft Tube



8.6.5 Scroll Case and Draft Tube

Scroll case/ volute case:

- The spiral-shaped steel intake that surrounds the turbine's runner. It guiding the flow of water from the penstock(Water inlet) to turbine blade. Also called spiral case or volute case.

Importance:

The numerous openings at regular intervals throughout its length allow the working fluid to impound on the blades of the runner.

- Flow Control
- Pressure Recovery
- Turbulence Reduction

8.6.5 Scroll Case and Draft Tube

Draft tube:

- The conduit which connects the runner exit to the tailrace where the water is being finally discharged from the turbine is called Draft tube. Draft tube is also called straight divergent tube
- The draft tube is the pipe of gradually increasing area which connect outlet of the runner to the tailrace
- It is used to discharging water from exit of the turbine to the tailrace.

Importance:

The primary function of the **draft tube** is to reduce the velocity of the discharged water to minimize the loss of kinetic energy at the outlet.

- Energy Recovery
- Efficiency Improvement
- Cavitation Prevention

8.6.5 Scroll Case and Draft Tube

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Why it is needed?

- In an impulse turbine the available head is high so there is no effect in the efficiency when the turbine is placed above the tail race
- But in the reaction turbine if the net head is low and if the turbine is placed above the tail race there can be an appreciable loss in available pressure head
- If the exit pressure is lower than the pressure of fluid in the tailrace, a backflow of fluid into the turbine can result in significant damage.
- This can be reduced by placing the diffusing pipe at the exit of runner, thus the pressure head is increased by decreasing the exit velocity, and the overall efficiency is improved.
- Turbines need to have a minimum amount of water to propel them in order to produce enough energy. without these tubes, the pressure could drop because of lack of water, and in turn the entire turbine could fail to work

8.6.5 Scroll Case and Draft Tube

Efficiency

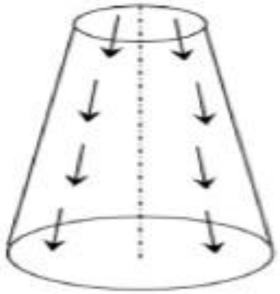
The efficiency of the draft tube is defined as the ratio of actual conversation kinetic head into pressure head in the draft tube to the kinetic head to the inlet of the draft tube.

$$EFFICIENCY = \frac{\left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) - h_f}{\frac{V_1^2}{2g}}$$

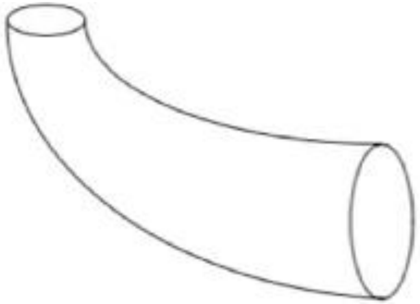
Types of draft tube

- Conical or divergent draft tube
- Simple Elbow type draft tube
- Elbow draft tube with circular inlet and rectangular outlet
- Hydracone or Moody spreading draft tube

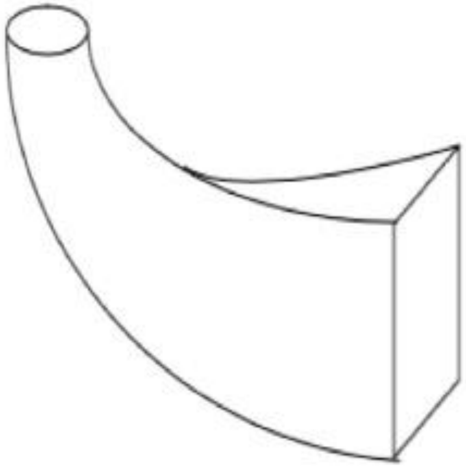
8.6.5 Scroll Case and Draft Tube



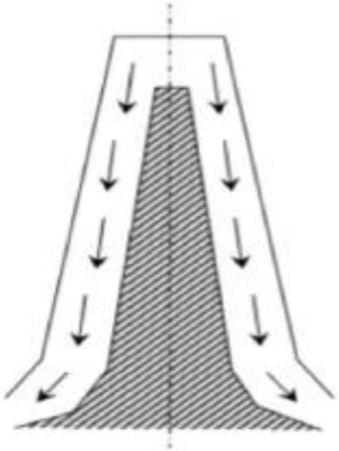
Simple Conical Draft Tube



Simple Elbow Draft Tube



Elbow Draft Tube with Varying Cross Section



Moody draft tube

8.6.5 Scroll Case and Draft Tube

Conical or divergent draft tube:

- The shape of the tube resembles that of a frustrum of a cone. It is commonly used in the Francis turbine. The cone angle varies from 4° to 8°.The efficiency of the conical tube is about 85% to 90%.

Simple Elbow type draft tube:

- It may be in the form of a simple elbow type or elbow tube with a circular inlet and a rectangular outlet section. The latter type is used in the Kaplan turbine with an efficiency of about 70%.

Hydra cone or Moody spreading draft tube:

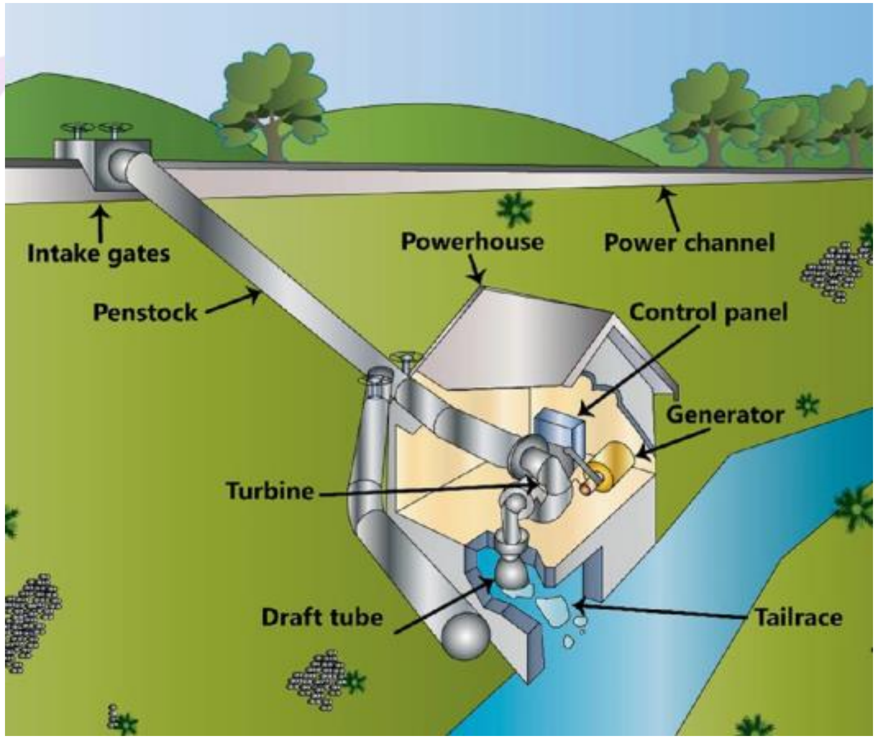
This is a modification of conical tube and a solid conical cone is provided in the centre of the tube with a flare at the bottom end. It allows a large exit area without excessive length. The solid core at the centre enables full flow and reduces the eddy losses. The efficiency of the tube is about 85%

8.6.5 Scroll Case and Draft Tube

Tail race:

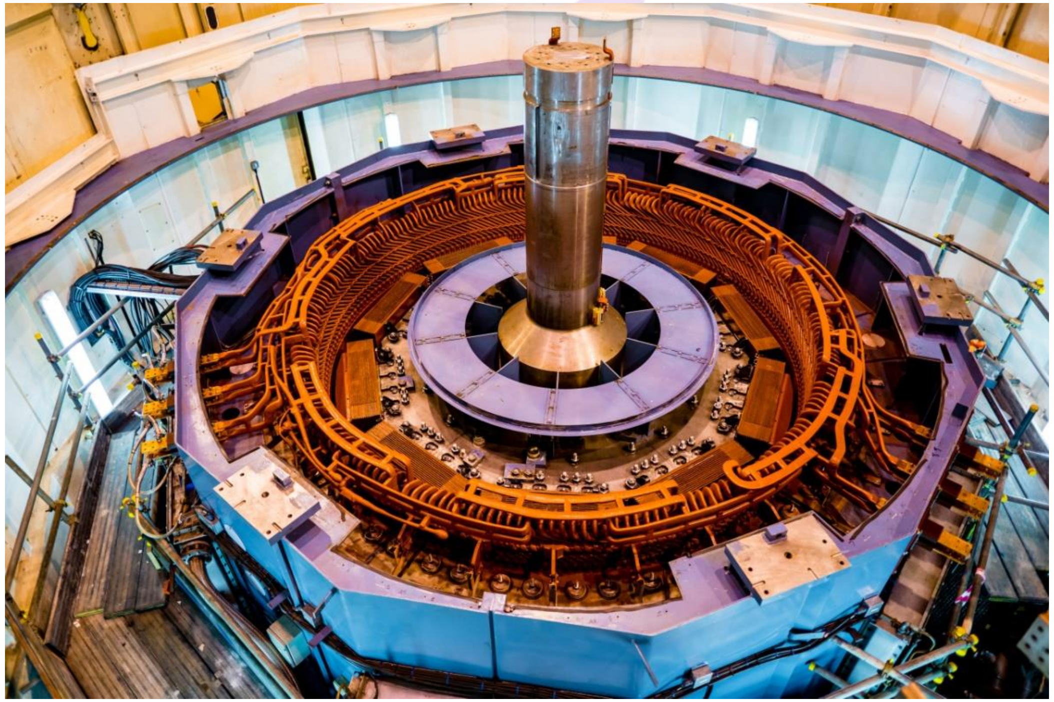
The channel that carries water away from a hydroelectric plant or water wheel containing tail water is called tail race.

The water in this channel has already been used to rotate turbine blades or the water wheel itself.



8.6.6 Generators

The device that converts mechanical energy to electrical energy for use in external circuit is called generators. The 1st generator is Faraday disk built in 1831, by Michael Faraday.



8.6.6 Generators

Rating of Generator

The set of specified values specified for particular generator modify by manufactures is known as rating of generator.

It must capable of supplying power output is an accurate way that is anticipated by manufacture.

The standard units of generator rating expressed in Kilo Volt Amperes (KVA).

8.6.6 Generators

Governors

The operation by which the speed of turbine is kept constant under all working condition is possible by Governor.

It regulates the rate of flow through turbine as per the changing load condition of turbine.

The process of providing any arrangement which will keep the speed constant and will regulate the range of flow as per the loading condition on generator is done by governor.

8.6.7 Pumps

The device which will cause increase in energy of the flow due to the external mechanical energy applied to it is known as pumps

8.6.7 Pumps

Types:

1. Centrifugal pump – pump which raise water form lower level to higher level by action of centrifugal force

2. Reciprocating pump- positive displacement pump where certain volume of liquid is collected in enclosed volume and is discharged using pressure to the required application.

8.6.8 Powerhouse

A power house is a facility or building where electricity is generated on a large scale. It is a crucial component of a power generation system and houses the equipment and machinery necessary for generating electricity

Within a power house, various components and systems work together to generate electricity. These may include:

1. Turbines: These machines convert the energy from a moving fluid, such as steam, water, or gas, into mechanical energy.
2. Generators: These devices convert the mechanical energy produced by the turbines into electrical energy through the process of electromagnetic induction.

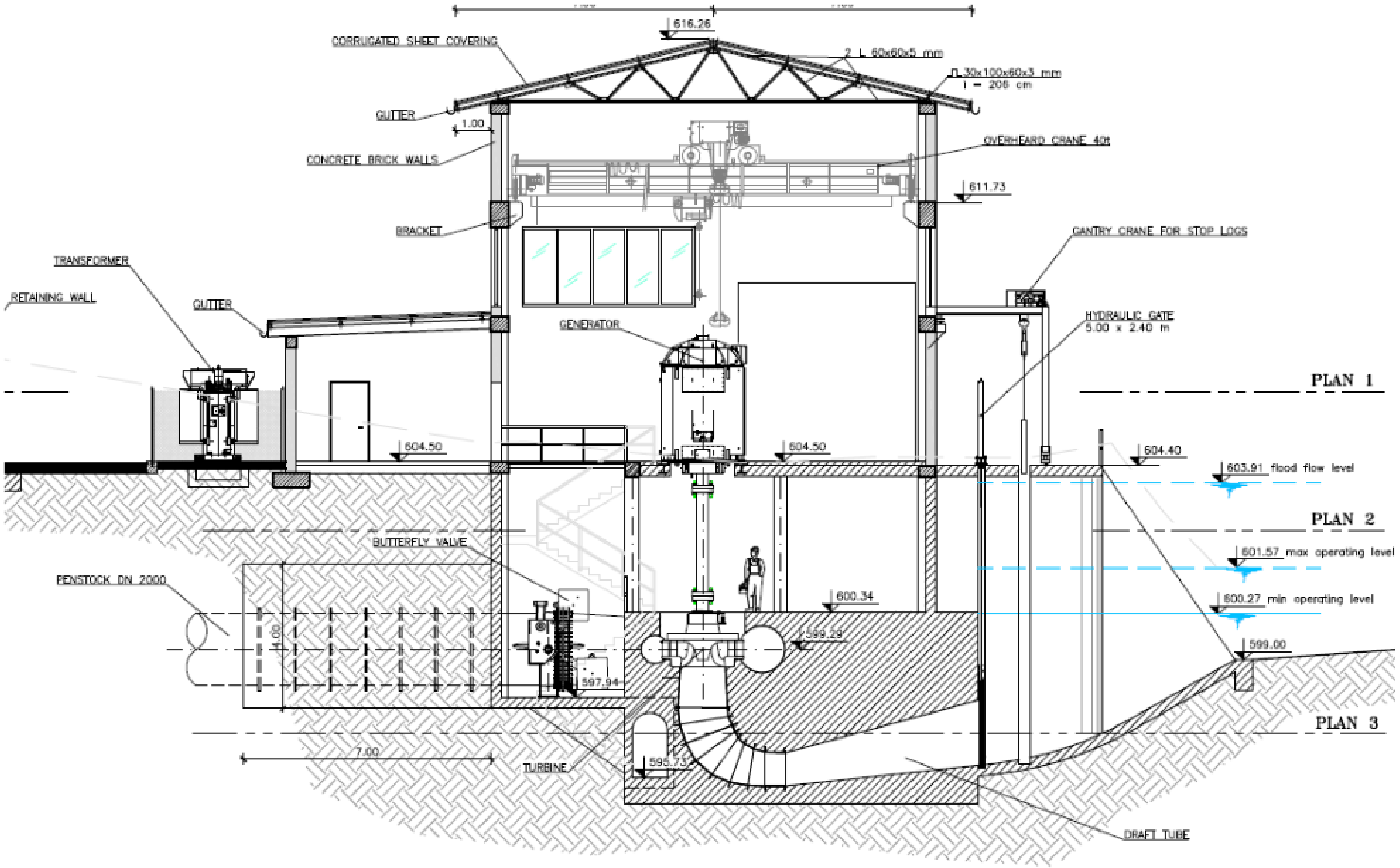
8.6.8 Powerhouse

3. Control systems: These systems monitor and regulate the operation of the power plant, ensuring efficiency, safety, and stability.

4. Transformers: These devices step up or step down the voltage of the electrical energy generated in order to transmit it over long distances or distribute it to consumers.

5. Cooling systems: Power houses often require cooling systems to dissipate excess heat generated during the electricity generation process.

8.6.8 Powerhouse



8.6.8 Powerhouse

Types of power house:

1. Surface Powerhouse

- location of pit in a building above ground
-have less space restriction
-good or strong foundation is required

2. Underground Powerhouse

-location of pit in a building under the ground
-flexible in layout
-safer and less length of penstock pipe is required

8.6.8 Powerhouse

Powerhouse Structure

1. Sub structure
   - situated below turbine level
   - include draft tube, tail water channel, natural drain, drainage gallery
2. Intermediate structure
   - extend form top of draft tube to top of generator
   - includes scroll casing, galleries for auxiliary machine and governor servo-motor
3. Super structure
   - extending from generator floor, called main floor up to roof top
   - includes generator, governor, control room

8.6.8 Powerhouse

Powerhouse Dimension:

Powerhouse contains machine hall or unit bay, erection or loading bay and control bay. The individual dimensioning is as:

Machine hall or unit bay

1. Length

Depends upon no of units, distance between units and size of machines usually total approx. distance is 4.5D to 5D, where D= turbine outlet diameter

Add minimum clearance of 2 to 3m

Therefore, c to c distance between units is taken as 5D+2.5 m

8.6.8 Powerhouse

2. Width

- Usually taken as width of one unit (diameter of generator casing + 2*width of cooling system) and extra passage from wall (approx. 2.5m)

3. Height

- Fixed by head room requirement (about 2 to 2.5 m) for crane operation
- Depends upon height clearance from ground to lifting object, depth of girder and crane system

8.6.8 Powerhouse

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Erection or loading bay

- Space where heavy vehicle can be loaded and unloaded, dismantled part of machine can be placed and where small assembling of the equipment can be done

Control bay

- Control house, send information to operation bay.

Let move to,
Multiple Choice Questions

8.6 Multiple Choice Questions

1. Which component of a hydropower plant is responsible for converting mechanical energy into electrical energy?

a) Generator

b) Turbine

c) Dam

d) Penstock

2. Which component of a hydropower plant is responsible for distributing electricity to the power grid?

a) Transformer

b) Generator

c) Turbine

d) Penstock

8.6 Multiple Choice Questions

3. Which type of turbine is a Francis Turbine?

a) Impulse Turbine

b) Screw Turbine

c) Reaction turbine

d) Turbo turbine

4. Pelton turbine is operated under

a) Low head and high discharge

b) High head and low discharge

c) Medium head and high discharge

d) Medium head and medium discharge

8.6 Multiple Choice Questions

5. Kaplan turbine is operated under

a) Low head and high discharge

b) High head and low discharge

c) Medium head and high discharge

d) Medium head and medium discharge

6. Hydraulic turbine is a device in which fluid power is converted to

(a)hydraulic power

(b)kinetic power

(c)electrical power

(d) Mechanical power

8.6 Multiple Choice Questions

7. Which of the following is not a reaction turbine?
   a) Francis turbine
   b) Kaplan turbine
   c) Pelton wheel turbine
   d) Propeller turbine

8. Hydraulic energy is converted into another form of energy by hydraulic machines. What form of energy is that?
   a) Mechanical Energy
   b) Electrical Energy
   c) Nuclear Energy
   d) Elastic Energy

8.6 Multiple Choice Questions

PANA ACADEMY

9. Which principle is used in Hydraulic Turbines?
   a) Faraday law
   b) Newton’s second law
   c) Charles law
   d) Braggs law

10. Buckets and blades used in a turbine are used to:
   a**)** Alter the direction of water
   b) Switch off the turbine
   c) To regulate the wind speed
   d) To regenerate the power

Explanation: Turbines use blades and buckets to alter the direction of water. It is used to change the momentum of water. As momentum changes, force is produced to rotate the shaft of a hydraulic machine.

8.6 Multiple Choice Questions

11. ________________is the electric power obtained from the energy of the water.
   a) Roto dynamic power
   b) Thermal power
   c) Nuclear power
   d**)** Hydro electric power

12. Which energy generated in a turbine is used to run electric power generator linked to the turbine shaft?
   a) Mechanical Energy
   b) Potential Energy
   c) Elastic Energy
   d) Kinetic Energy

8.6 Multiple Choice Questions

13. Which kind of turbines changes the pressure of the water entered through it?
    a) Reaction turbines
    b) Impulse turbines
    c) Reactive turbines
    d) Kinetic turbines

14. Which type of turbine is used to change the velocity of the water through its flow?
    a) Kinetic turbines
    b) Axial flow turbines
    c) Impulse turbines
    d) Reaction turbines

8.6 Multiple Choice Questions

15. Turgo Turbine is an impulsive turbine.
   a) True
   b) False

Explanation: In a turgo turbine, velocity of water changes with due respect. Hence it is an Impulse turbine.

16. The main function of nozzle is to __________
   a) Varying temperatures
   b) Pressure variations
   c) Load variations
   d) Heat variations

8.6 Multiple Choice Questions

17. Which kind of turbine is a Pelton Wheel turbine?
    a) Tangential flow turbine
    b) Radial flow turbine
    c) Outward flow turbine
    d) Inward flow turbine

18. In what type of turbine water enters in radial direction and leaves axial direction?
    a) Tangential flow turbine
    b) Axial flow turbine
    c) Outward flow turbine
    d) Mixed flow turbine

8.6 Multiple Choice Questions

19. The hydraulic turbine suitable for a speed range of 95 to 440 rpm is

a) Pelton wheel
b) Kaplan
c) Rankine
d) Francis

20. Head under which Kaplan turbine is operated______

a) 10-70 meters
b) 70 -100 meters
c) 100-200 meters
d) Above 200 meters

8.6 Multiple Choice Questions

21. Head under which Francis turbine is operated?
  a) 10-70 meters
  b) 70-100 meters
  c) 100-200 meters
  d) **40-600 meters**

Note: Francis turbine is operated under the head between 60-350m

- Francis turbine is also reaction turbine but pressure energy is less when compared with Kaplan turbine. Hence head is between 40 and 600 meters.

22. Under what head is Pelton turbine operated?
  a) 20-50 meters
  b) **150-2000 meters**
  c) 60-200 meters
  d) 50-500 meters

Note: Pelton turbine is operated under the head above 350m; but for low specific speed, the head may be 150m and above

- Pelton turbine is an impulse turbine only energy available is kinetic energy which is proportional to head, hence it requires high head. Theoretically there is no limit to max value of head

8.6 Multiple Choice Questions

23 Among the following which turbine has least efficiency?
a) Pelton turbine
b) Kaplan turbine
c) Francis turbine
d) Propeller turbine

24. In general, reaction turbines consist of which types of energies?
a) kinetic energy and potential energy
b) potential energy and pressure energy
c) kinetic energy and pressure energy
d) gravitational energy and potential energy

8.6 Multiple Choice Questions

25. Medium specific speed of turbine implies _______________
   a) Pelton turbine
   b) Kaplan turbine
   c) Francis turbine
   d) Propeller turbine

26. Impulse turbine and reaction turbine are classified based on?
   a) Type of energy at inlet
   b) Direction of flow through runner
   c) Head at inlet of turbine
   d) Specific speed of turbine

8.6 Multiple Choice Questions

27. To obtain maximum efficiency of pelton turbine, the blade velocity should be ….. times the inlet velocity of jet.

a) One Quarter

b) Half

c) Once

d) Twice

28. The type of centrifugal pump preferred for a specific speed of 20 rpm is

(a) Slow speed pump with radial flow at outlet

(b) Medium speed pump with radial flow at outlet

(c) High speed pump with radial flow at outlet

(d) High speed pump with axial flow at outlet

8.6 Multiple Choice Questions

29. Which component of a hydropower plant is responsible for converting the rotational energy of the turbine into electrical energy?

a) Generator

b) Penstock

c) Dam

d) Spillway

30. High specific speed of turbine implies that it is ____________
a) Francis turbine
b) Propeller turbine
c) Pelton turbine
d) Kaplan turbine

8.6 Multiple Choice Questions

31. Draft tubes have __________ shafts
   a) Horizontal
   b) Vertical
   c) Circular
   d) Cross sectional

32. Efficiency of a draft tube is directly proportional to its ___________
   a) Temperature
   b) Pressure
   c) Velocity
   d) Density

8.6 Multiple Choice Questions

33. The draft tube at the exit of the nozzle increases the _______
   a) Temperature
   b) Pressure
   c) Volume of the flow
   d) Density of flow

34. Cavitation in a draft tube occurs when _______
   a) Temperature difference
   b) Pressure drop
   c) Kinetic energy difference
   d) Density of flow

8.6 Multiple Choice Questions

35. Turbine that consists of draft tubes is called as___________
   a) Impulse turbine
   b) Curtis turbine
   c) Rateau turbine
   d) Reaction turbine

36. The exit diameter for a simple elbow draft tube should be_________
   a) Large
   b) Small
   c) Very small
   d) Same

8.6 Multiple Choice Questions

37. Efficiency of a draft tube is directly proportional to its ___________
   a) Temperature
   b) Pressure
   c) Velocity
   d) Density

Explanation: The efficiency of the draft tube gives difference of the kinetic energy between the inlet and the outlet tube losses. It is directly proportional to its velocity

38. Draft tube is also called________
   a) Straight divergent tube
   b) Simple elbow tube
   c) Thermal tube
   d) Elbow tube with varying cross section

8.6 Multiple Choice Questions

39. If diameter of jet is 85mm and diameter of runner is 1.5 meter then calculate width of buckets.
a) 400mm
b) 500mm
c) 420mm
d) 425mm
   - Explanation: The expression for measuring width of buckets is 5*diameter of jet, which is 5*85=425mm
   - depth of buckets is 1.2*diameter of jet, which is 1.2*85=102mm

40. The ratio of diameter of jet to diameter of runner is _______________
a) 1:3
b) 1:6
c) 1:10
d) 3:4

8.6 Multiple Choice Questions

41. The depth of buckets of Pelton wheel ______________
   a) 1.2 times diameter of jet
   b) 1.3 times diameter of jet
   c) 1.4 times diameter of jet
   d) 1.5 times diameter of jet

42. The width of buckets of Pelton wheel is ____________________
   a) 2 times diameter of jet
   b) 3 times diameter of jet
   c) 4 times diameter of jet
   d) 5 times diameter of jet

8.6 Multiple Choice Questions

43. If diameter of jet is 85mm and diameter of runner is 1.5 meter then calculate number of buckets on Pelton wheel approximately
    a) 20
    b) 22
    c) 23
    d) 25
    - Explanation: The expression for measuring number of buckets is 15 + diameter of runner/2 time's diameter of jet, which are 15 + 1.5/2*0.085.

44. Find the diameter of runner D, if jet ratio m and diameter of jet d are given as 10 and 125mm.
    a) 1.25 meters
    b) 1.5 meters
    c) 2 meters
    d) 1.2 meters

8.6 Multiple Choice Questions

46. Calculate the total number of poles of generator for a francis turbine with synchronous speed of 461.54 rpm if f = 50 Hz

a) 12

b) 13

c) 14

d) 15

48. A turbine is to operate under a head of 25m at 200 rpm. The discharge is 9 cumecs. If efficiency =90%, determine the power generated and specific speed of turbine

a) 2662.902 HP, 54 rpm

b) 1986.525 HP, 184.62 rpm

c) 1986.525 HP, 54 rpm

d) 2662.902 HP, 184.62 rpm

8.6 Multiple Choice Questions

49. For discharge =300 cumecs, net head=5m, speed of turbine=50 rpm and efficiency =82% and specific speed =500 rpm, determine the number of Kaplan turbine need to utilize the full potential of the river.

a) 1

b) 2

c) 3

d) 4

50. Determine the number of buckets in a pelton wheel turbine with runner diameter=2m and jet diameter =0.25

a) 13

b) 17

c) 15

d) 19

8.6 Multiple Choice Questions

51. A draft tube convert helps in converting K.E. into …….

a) Electrical Energy

b) Chemical Energy

c) Pressure Energy

d) Thermal Energy

52. Which of the following is the correct equation for the electrical power generated by the hydroelectric power plant?

a) 75*0.736*wQHn Watt

b) (7.5/0.736)*wQHn Watt

c) 0.845* wQHn Watt

d) 9.81* wQHn Watt

Thank You