SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

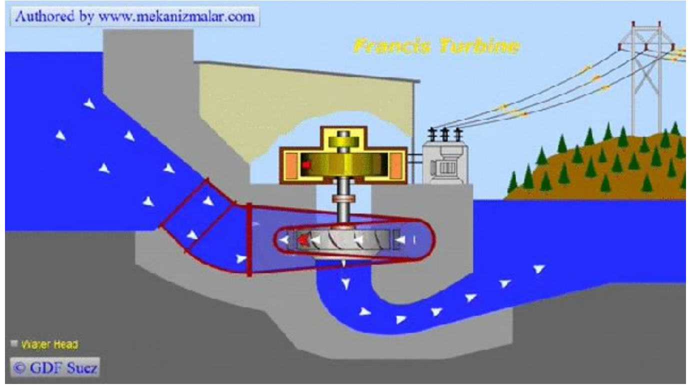
DEPARTMENT OF AGRICULTURE ENGINEERING

19MEB201 – FLUID MECHANICS AND MACHINERY

II YEAR III SEM

UNIT 5– TURBINES

TOPIC 6 – FRANCIS TURBINE

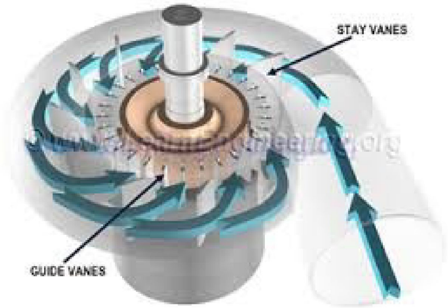


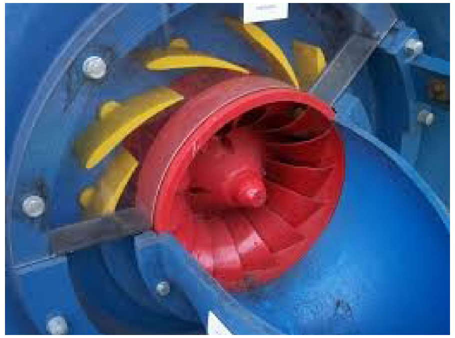
CONTENT

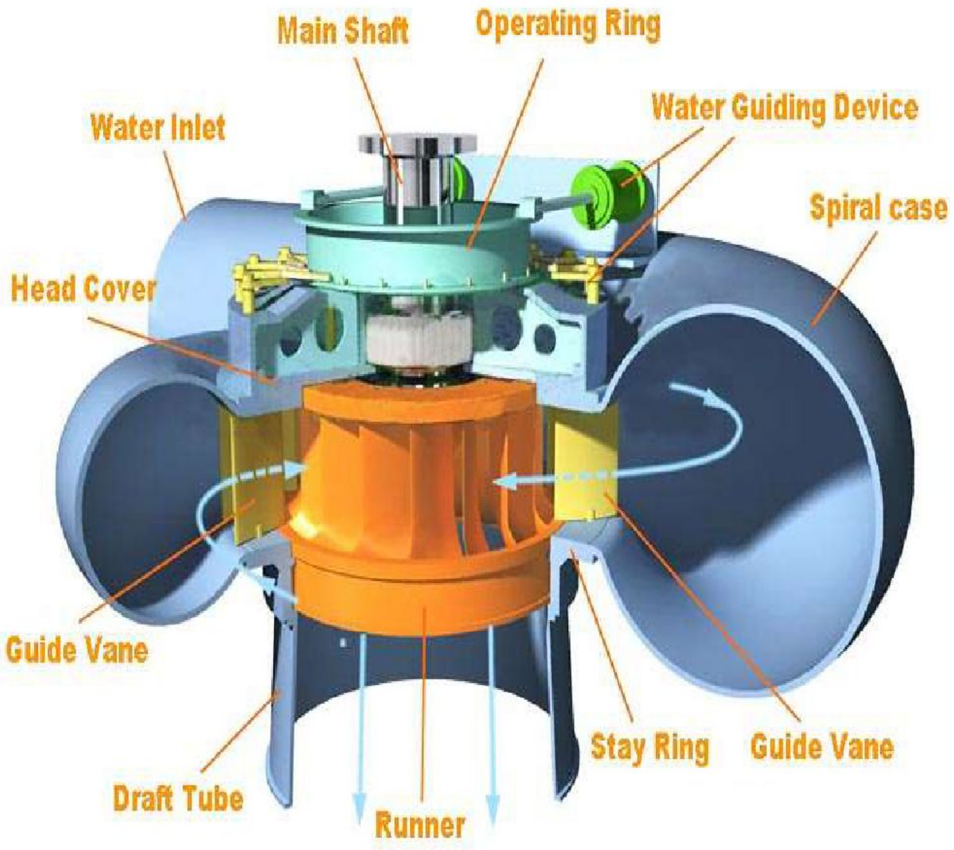
FRANCIS TURBINE

- The Francis turbine is a type of water turbine that was developed by James B.Franceis and are used for medium head (45-400m) and medium discharge (10-700 m^3/s)
- The Francis turbine is a type of reaction turbine, a category of turbine in which the working fluid comes to the turbine under immense pressure and the energy is extracted by the turbine blades from the working fluid
- The turbine's exit tube is shaped to help decelerate the water flow and recover the pressure
- Water flow is radial from exterior to interior

FRANCIS TURBINE







APPLICATIONS

- Francis type units cover a head range from 40 to 600 m (130 to 2,000 ft).
- Its efficiency decreases as flow decreases.
- They may also be used for pumped storage,
- where a reservoir is filled by the turbine (acting as a pump) driven by the generator acting as a large electrical motor during periods of low power demand.

Question: Differentiate Francis with Pelton wrt. application.

FRANCIS TURBINE – MAIN COMPONENTS

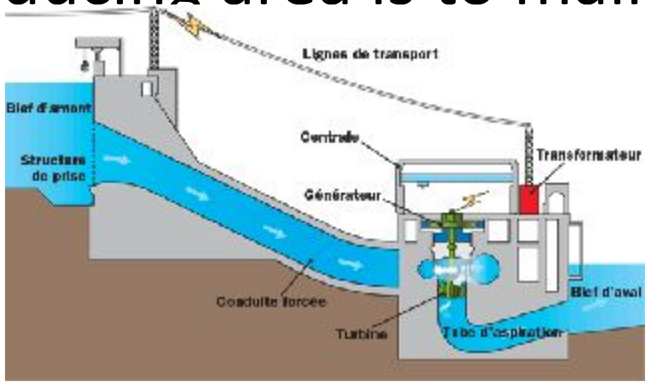
1) Scroll Casing

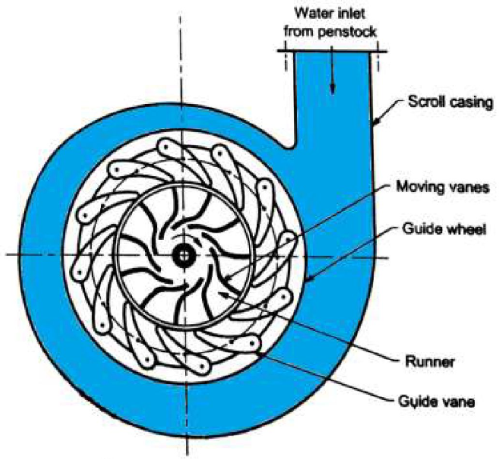
a) It is surrounding to the runner, guide vanes and moving vanes.

b) It is always full with water.

c) Shape is spiral.

d) Reducing area is to maintain velocity of water at constant.





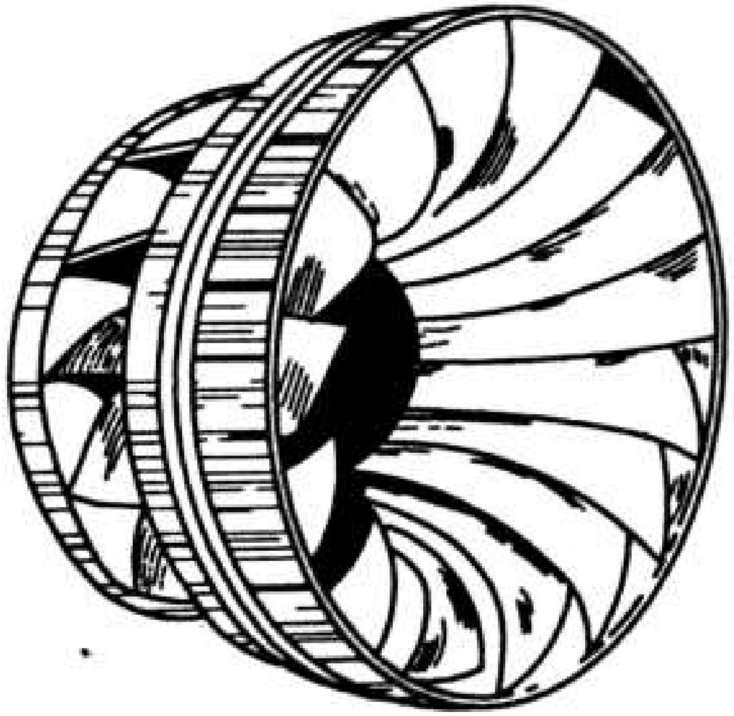
FRANCIS TURBINE – MAIN COMPONENTS

2) Runner

a) It is rotary part of turbine keyed with shaft

b) Vanes are fixed on inlet ring and outlet ring

c) Water enters radially and exit axially



FRANCIS TURBINE – MAIN COMPONENTS

3) Guide Vanes

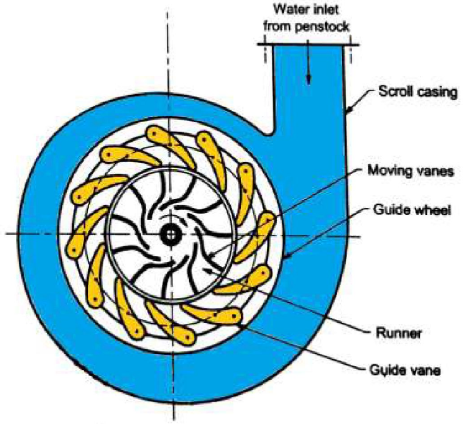
a) It is surrounding to the moving vanes.

b) Guide vanes are fixed vanes.

c) Shape is like aerofoil.

d) Guide the water from casing to runner.

FRANCIS TURBINE – MAIN COMPONENTS



4) Moving Vane

a) It is surrounding to the runner.

b) Shape is aerofoil.

c) One end is pivoted on fixed ring andanother end is pivoted on moving ring.

d) Regulating the discharge of water fromcasing to runner as per desired load.

FRANCIS TURBINE – MAIN COMPONENTS

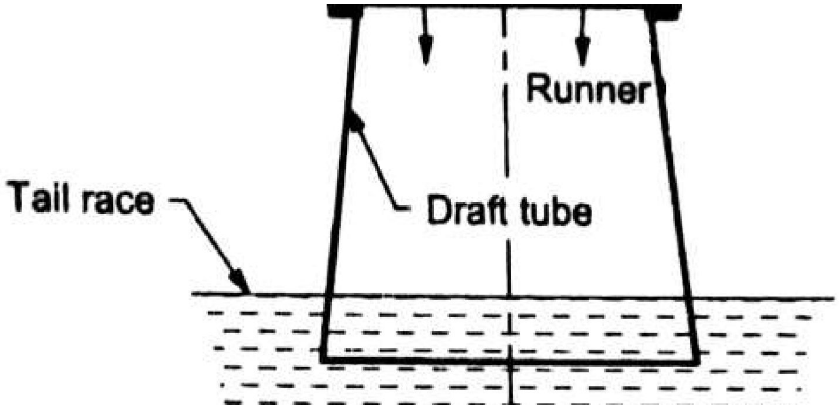
5) Draft Tube

a) It is fixed at exit of turbine to tail race.

b) Convert kinetic energy of water to pressure energy.

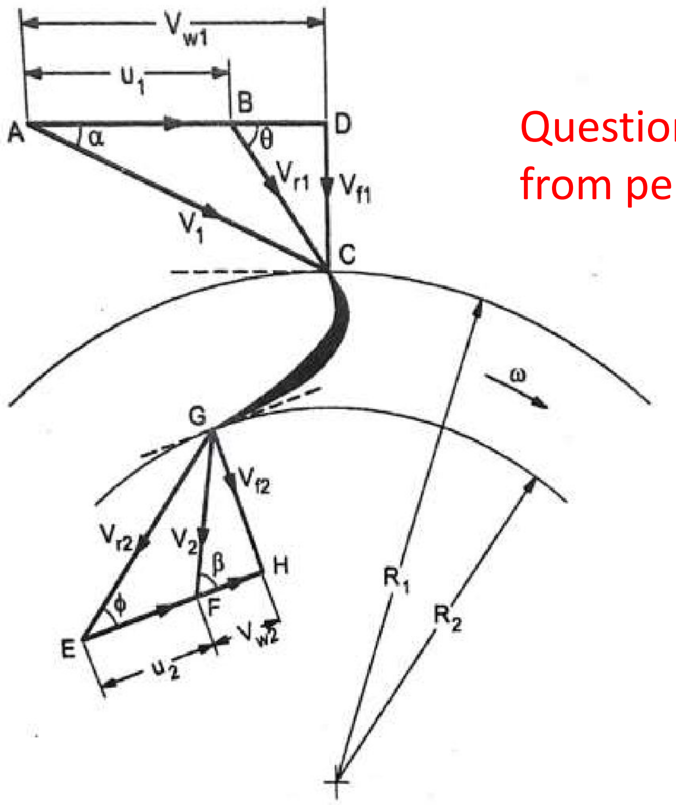
c) Increase head on turbine.

d) Improve efficiency and reduces cavitations.



Question: What is cavitation?

VELOCITY TRIANGLE



Question: How the velocity triangle differs from pelton turbine ?

FRANCIS TURBINE –WORK DONE & EFFICIENCY

1) Uniform Velocity of Inlet and Outlet Tip

$$u_1 = \frac{\pi \times D_1 \times N}{60} \qquad u_2 = \frac{\pi \times D_2 \times N}{60}$$

Where,

$D_1 = \text{Diameter of Outer Ring}$

$D_2 = \text{Diameter of Inner Ring}$

2) Work Done

$$W.D. = \frac{w \times Q}{g} \times [(v_{w1} \times u_1) \pm (v_{w2} \times u_2)]$$

Work done per second per unit weight of water

$$W.D. = \frac{[(v_{w1} \times u_1) \pm (v_{w2} \times u_2)]}{g}$$

FRANCIS TURBINE –WORK DONE & EFFICIENCY

- 3) DISCHARGE OF TURBINE

$$Q = Area\ of\ Flow\ (\pi \times D_2 \times B_2) \times Velocity\ of\ Flow (v_{f2})$$

$$Q = \pi \times D_1 \times B_1 \times v_{f1} \qquad Q = \pi \times D_2 \times B_2 \times v_{f2}$$

Where,

$D_1 = Diameter\ of\ Outer\ Ring$

$D_2 = Diameter\ of\ Inner\ Ring$

$B_1 = Width\ of\ Runner\ Blades\ at\ Inlet$

$B_2 = Width\ of\ Runner\ Blades\ at\ Outlet$

$v_{f1} = Flow\ Velocity\ at\ Inlet$

$v_{f2} = Flow\ Velocity\ at\ Outlet$

- 4) Hydraulic Efficiency

$$\eta_h = \frac{Power\ Developed\ by\ Runner\ (P)}{Input\ Power\ (P_i)}$$

$$\eta_h = \frac{\frac{w \times Q}{g} \times [(v_{w1} \times u_1) \pm (v_{w2} \times u_2)]}{w \times Q \times H}$$

$$\eta_h = \frac{[(v_{w1} \times u_1) \pm (v_{w2} \times u_2)]}{g \times H}$$

Where,

$H = Net\ Head\ Available\ on\ Turbine$

5) Mechanical Efficiency

$$\eta_m = \frac{Shaft\ Power\ (P_s)}{Power\ Developed\ by\ Runner\ (P)}$$

6) Overall Efficiency

$$\eta_o = \frac{Shaft\ Power\ (P_s)}{Input\ Power\ (P_i)}$$

7) Speed Ratio

$$k_u = \frac{u_1}{\sqrt{(2 \times g \times H)}}$$

Where,

$k_u = Speed\ Ratio\ (0.6\ to\ 0.9)$

8) Flow Ratio

$$k_f = \frac{v_{f1}}{\sqrt{(2 \times g \times H)}}$$

Where,

$k_f = Flow\ Ratio\ (0.15\ to\ 0.30)$

9) Ratio of Width to Diameter

$$n = \frac{B_1}{D_1}$$

Where, $n = Ratio\ of\ Width\ to\ Diameter\ (0.1\ to\ 0.45)$

IMPULSE VS REACTION TURBINE

Sl.No.	Impulse turbine e.g. Pelton turbine	Reaction turbine e.g. Kaplan & Francis turbines
1	In an impulse turbine all the available energy of water is converted into kinetic energy as it passes through a nozzle.	In a reaction turbine, at the entrance to the runner, only a part of the available energy of water is converted into kinetic energy and a greater part remains in the form of pressure energy.
2	The water flowing through the nozzle impinges on the buckets which are fixed on the outer periphery of the wheel.	The water is guided by the guide blades to flow over the runner vanes.

ASSESSMENT - KAHOOT

https://create.kahoot.it/share/francis-turbine/a31c8787-9944-4c58-b4
9b-2d39a02bd600

REFERENCES

TEXT BOOK REFERENCES

- Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi. 2011. 10th Edition
- Kumar. K.L., Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd., New Delhi, 2010. 8th Edison

WEB REFERENCES

- https://www.sanfoundry.com/fluid-mechanics-questions-answers-rayleighs-method/
- https://www.iith.ac.in/~ksahu/class14_FM.pdf
- https://en.wikibooks.org/wiki/Fluid_Mechanics/Dimensional_Analysis#Rayleigh_Method
- https://giphy.com/explore/turbine