Experiment No.2

STUDY & TRIAL ON A FRANCIS TURBINE

& PLOTTING OF MAIN /OPERATING CHARACTERISTICS.

Name of the student:

Roll No:

Date of Performance :

Date of Submission

Marks Scored:

Signature of Staff

Experiment No : 02

1. Title : Study & trial on Francis turbine & plotting of main/operating characteristics.
2. Aim : To study the characteristics of a Francis turbine.
3. Equipment : FRANCIS TURBINE TEST RIG (3.7 KW-OUTPUT)

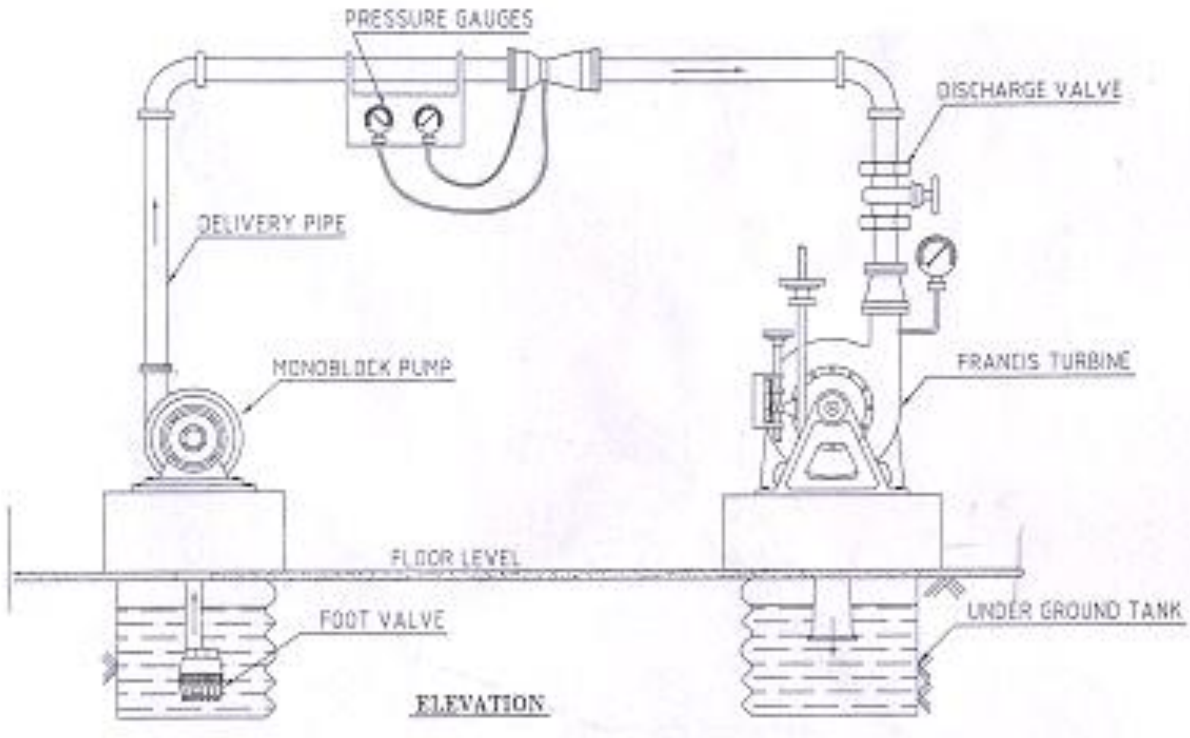
Description:

Francis turbine is a reaction type hydraulic turbine, used in dams and reservoirs of medium height to convert hydraulic energy into mechanical and electrical energy. Francis Turbine is a radial inward flow reaction turbine. This has the advantage of centrifugal forces acting against the flow, thus reducing the tendency of the turbine to over speed . Francis Turbines are best suited for medium heads, say 40m. to 300m. The specific speed ranges from 25 to 300.

The turbine test rig consists of a 3.72 KW (5 HP) turbine supplied with water from a suitable 15 HP centrifugal pump through suitable pipelines, a gate valve, and a flow measuring venturimeter. The turbine consists of a cast iron body with a volute casing and a gunmetal runner consisting of two shrouds with aerofoil shaped curve vanes in between. The runner is surrounded by a set of adjustable gunmetal guide vanes. These vanes can be rotated about their axis by a hand wheel. Their position is indicated by a pair of dummy guide vanes fixed on the outside of the turbine casing. At the outlet, a draft tube is provided to increase the net head across the turbine. The runner is attached to the output shaft with a brake drum to absorb the energy produced.

Water under pressure from pump enters through the guide vanes into the runner. While passing through the spiral casing and guide vanes, a portion of the pressure energy is converted into velocity energy. Water thus enters the runner at a high velocity and as it passes through the runner vanes, the remaining pressure energy is converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into the mechanical energy i.e., the water head is converted into mechanical energy and hence the runner rotates. The water from the runner is then discharged into the tailrace. The discharge through the runner can be regulated also by operating the guide vanes.

The flow through the pipe lines into the turbine is measured with the venturimeter fitted in the pipe line. The Venturi meter is provided with a set of pressure gauges. The net pressure difference across the turbine inlet and outlet is measured with a pressure gauge and a vacuum gauge. The turbine output torque is determined with a rope brake drum dynamometer. A tachometer is used to measure the rpm.



4. Experimental Procedure:

1. Keep the guide vanes at required opening (say 3/8th).
2. Prime the pump if necessary.
3. Close the main gate valve and start the pump.
4. Open the gate valve for required discharge after the pump motor switches from star to delta mode.
5. Load the turbine by adding weights in the weight hanger. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Measure the turbine rpm with tachometer.
7. Note the pressure gauge and vacuum gauge readings:
8. Note the venturimeter pressure gauge readings.
9. Repeat the experiments for other loads.
10. For constant speed tests, the main sluice valve has to be adjusted to vary the inlet head and discharge for varying loads (at a given guide vane opening position).
11. The experiment can be repeated for other guide vane positions.

5. Specifications :

1. Venturimeter inlet diameter D = 100mm
2. Throat diameter ratio B = 0.6
3. Venturimeter discharge coefficient - Cd = 0.98
4. Venturimeter inlet area A = $\Pi / 4 \times D^2$

   $= \Pi / 4 \times (0.100)^2 = 0.00785 \, m^2$

5. Discharge Q = $Cd \times A \times B^2 \times \sqrt{(2 \times 9.81 \times dH)/(1 - B^4)}$

   $Q = 0.98 \times 0.00785 \times 0.6^2 \times \sqrt{2 \times 9.81 \times dH / (1 - 0.6^4)}$

   $Q = 0.01315 \sqrt{dH} \, m^3/sec$

4. Brake drum diameter = 0.30m.
5. Rope diameter = 0.015m.
6. Equivalent drum diameter = 0.315m
7. Hanger weight T_o = 1 Kg.

6. Observations :

I. To determine discharge:

Venturimeter line pressure gauge reading = P_1 kg /sq.cm

Venturi meter throat pressure gauge reading = P_2 kg/sq.cm

II. To determine inlet head of water:

Turbine Pressure gauge reading = P kg/sq.cm

Turbine vacuum' gauge reading = V mm of HG

Weight on Hanger = T_1 Kg.

Spring Load = T_2 Kg.

Speed of the turbine = N rpm

7. Observation Table : Constant Head Guide Vane Opening: 60%

Sr. No	Inlet pressure P kg/sq. cm	Outlet Vacuum V mm of Hg	Venturi meter Pressure gauge Readings		Speed N rpm	Weight on Hanger T_1 Kg	Weight on Spring Balance T_2 Kg
			P_1 Kg/sq.cm	P_2 Kg/sq.cm			
1							
2							
3							
4							
5							

6							
7							
8							
9							
10							

8. Calculations :

Total Head H = 10(P+V/760) m of water

Pressure difference dH = $(P_1 - P_2)$ x l0 m of water

Input Power I = 1000 QH / 75 HP

= 9.81 QH KW

Flow Rate Q = $0.01315 (dH)^{0.5} m^3/sec$

Resultant load (Net Weight) T = $(T_o + T_1 - T_2)$ kg

Output Power = (3. 14 x D x N x T) / (75 x 60) HP

= (3.14 x D x N x T) / (l02 x 60) KW

= 0.000162 NT KW

Turbine efficiency = (Turbine Output/Turbine Input) x 100 %

9. Result Table : Constant Head Guide Vane Opening: 60%

Sr. No.	Total Head H m of water	Venturimeter dH m of water	Flow rate Q cu.m/sec	Net Weight T Kg	Turbine out put O KW	Input I KW	Efficiency %
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

10. Observation Table : Constant Speed Guide Vane Opening: 60%

Sr. No.	Inlet pressure P kg/sq. cm	Outlet Vacuum V mm of Hg	Venturi meter Pressure gauge Readings		Speed N rpm	Weight on Hanger T_1 Kg	Weight on Spring Balance T_2 Kg
			P_1 Kg/sq.cm	P_2 Kg/sq.cm			
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

11. Calculations :

Total Head	H	= 10(P+V/760) m of water
Pressure difference	dH	= $(P_1 - P_2)$ x l0 m of water
Input Power	I	= 1000 QH / 75 HP
		= 9.81 QH KW
Flow Rate	Q	= 0.01315 $(dH)^{0.5} m^3/sec$
Resultant load (Net Weight)	T	= $(T_o + T_1 - T_2)$ kg
Output Power		= (3. 14 x D x N x T) / (75 x 60) HP
		= (3.14 x D x N x T) / (l02 x 60) KW
		= 0.000162 NT KW
Turbine efficiency		= (Turbine Output/Turbine Input) x l00%

12. Result Table : Constant Speed Guide Vane Opening: 60%

Sl.No	Total Head H m of water	Venturimeter dH m of water	Flow rate Q cu.m/sec	Net Weight T Kg	Turbine out put O KW	Input I KW	Efficiency %
1							
2							
3							
4							

13. Unit Quantities (From Constant head observations)

Sr. No.	Unit Discharge $Qu = Q/ H^{0.5}$	Unit Speed $Nu = N/ H^{0.5}$	Unit Power $Pu = P/ H^{1.5}$
1			
2			
3			
4			
5			

14. Characteristic Curves :

a) Main or Constant Head Characteristics

1. Unit Discharge Vs Unit Speed
2. Efficiency Vs Unit Speed
3. Unit Power Vs Unit Speed

b) Operating or Constant Speed Curve

c) Iso- Efficiency Curve

15 Conclusion :

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3.

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Signature of Staff
(Prof. A.B VERMA)