LABORATORY MANUAL
ON
FRANCIS TURBINE TEST RIG (1 kW)

Prepared

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1. **OBJECTIVE:** To study the operation of a Francis Turbine.

2. **AIM:**

    - To determine the output power of Francis Turbine.
    - To determine the efficiency of the Francis Turbine.

3. **INTRODUCTION:**

Francis Turbine, named after James Bichens Fransis, is a reaction type of turbine for medium high to medium low heads and medium small to medium large quantities of water. The reaction turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

4. **THEORY:**

Originally the Francis turbine was designed as a purely radial flow type reaction turbine but modern Francis turbine is a mixed flow type in which water enters the runner radially inwards towards the centre and discharges out axially. It operates under medium heads and requires medium quantity of water.

5. **DESCRIPTION:**

The present set-up consists of a runner. The water is fed to the turbine by means of Centrifugal Pump, radially to the runner. The runner is directly mounted on one end of a central SS shaft and other end is connected to a brake arrangement. The circular window of the turbine casing is provided with a transparent acrylic sheet for observation of flow on to the runner. This runner assembly is supported by thick cast iron pedestal. Load is applied to the turbine with the help of brake arrangement so that the efficiency of the turbine can be calculated. A draft tube is fitted on the outlet of the turbine. The set-up is complete with guide mechanism. Pressure and vacuum gauges are fitted at the inlet and outlet of the turbine to measure the total supply head on the turbine.

6. **UTILITIES REQUIRED:**

1. Electricity Supply: 3 Phase, 420 V AC, 50 H_z, 32 Amp. MCB 4 Pole with earth connection.
2. Water supply (Initial Fill.)
3. Floor Drain required.
4. Floor Area Required: 2 m x 1 m
5. Tachometer to measure RPM
6. Mercury for manometer, 250 gm.

7. **EXPERIMENTAL PROCEDURE:**

STARTING PROCEDURE:

1. Clean the apparatus and make tank free from Dust.

2. Close the drain valve provided.

3. Fill Sump tank .with Clean Water and ensure that no foreign particles are there.

4. Fill manometer fluid i.e. Hg. in manometer by opening the valves of manometer and one PU pipe from pressure measurement point of pipe.

5. Connect the PU pipe back to its position and close the valves of manometer.

6. Ensure that there is no load on the brake drum.

7. Switch ON the Pump with the help of Starter.

8. Open the Air release valve provided on the Manometer, slowly to release the air from manometer. (This should be done very carefully.)

9. When there is no air in the manometer, close the air release valves.

10. Now turbine is in operation.

11. Apply load on hanger and adjust the spring balance load by hand wheel just to release the rest position of the hanger.

12. Note the manometer reading, pressure gauge reading and vacuum gauge reading.

13. Measure the RPM of the turbine.

14. Note the applied weight and spring balance reading.

15. Repeat the same experiment for different load.

16. Regulate the discharge by regulating the guide vanes position.

17. Repeat the experiment for different discharge.

CLOSING PROCEDURE:

1. When the experiment is over, first remove load on dynamometer.

2. Close the ball valves provided on manometer.

3. Switch OFF Pump with the help of starter.

4. Switch OFF main power supply.

8. NOMENCLATURE:

A = Cross-sectional area of pipe, m^2

C_v = Co-efficient of pitot tube

D = Diameter of pipe, m

d_B = Diameter of brake drum, m

d_R = Diameter of rope, m

E_i = Input power, kW

E_o = output power, kW

g = Acceleration due to gravity, m/sec^2

H = Total head, m

h = Differential pressure of manometer, m

h_1, h_2 = Manometer reading at both points, cm

N = RPM of runner shaft

P_d = Delivery pressure, kg/cm^2

P_S = Suction pressure, mmHg

Q = Discharge, m^3/sec

R_e = Equivalent Radius, m

T = Torque/ N m

V = Velocity of water, m/s

W_1 = Applied weight, kg

W_2 = Dead weight (obtain from spring balance), kg

W_3 = Weight of hanger, kg

W_4 = Weight of rope, kg

P_w = Density of water, kg/m^3

P_m = Density of Manometer fluid i.e. Hg, kg/m^3

η_t = Turbine efficiency %

9. PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 390 volts and above 430 volts
2. To prevent clogging of moving parts, Run Pump at least once in a fortnight.
3. Always use clean water.
4. Drain the apparatus completely after experiment is over.
5. 5. Always keep apparatus free from dust.

10. **TROUBLESHOOTING:**

1. If pump does not lift the water, the revolution of the motor may be reverse.

Change the electric connection to change the revolutions.

2. If panel is not showing input, check the main supply.

11. **OBSERVATION & CALCULATION:**

DATA:

$g = 9.81\ m/sec^2$

$\rho_w = 1000\ kg/m^3$

$\rho_m = 13600\ kg/m^3$

$C_v = 0.98$

$D = 0.08\ m$

$d_B = 0.2\ m$

$d_R = 0.012\ m$

W_3 = ----- kg

W_4 = ----- kg

OBSERVATION TABLE:

S.NO.	N, RPM	$P_{d,}$ kg/cm^2	Ps, Mm Hg	$h_{1,}$ cm	$h_{2,}$ cm	W_1, kg	$W_{2,}$ kg

CALCULATIONS:

$H = 10\left(P_d + \frac{P_s}{760}\right)$ m of water = ------------------- m of water

$Q = V \times A$, m^3/sec = ----------------------- m^3/sec

$A = \frac{\pi}{4} d^2$ m2 = --------------------- m2

$h = \frac{h_1 - h_2}{100}$ m = --------------- m

$V = C_v \times \sqrt{2gh\,x\left(\frac{\rho_m}{\rho_w} - 1\right)}$ m/sec = ---------------------- m/sec

$E_i = \frac{\rho_w\, x\, g\, x\, Q\, x\, H}{1000}$ kW = ------------------- kW

$T = (W_1 + W_3 + W_4 - W_2)$ x g x R_e N m = -------------- N m

$R_e = \frac{d_B + 2d_R}{2}$ m = ------------------- m

$E_0 = \frac{2\, x\, \pi\, x\, N\, x\, T}{60\, x\, 1000}$ kW = ----------------- kW

$\eta_t = \frac{E_0}{E_i} \, x \; 100\% =$ --------------------- %

CONCLUSIONS: The experiment on Francis Turbine was performed. The input and output power of the turbine was calculated. The efficiency of the turbine was found to be ___________.