SHREE RAMCHANDRA EDUCATION SOCIETY'S

SHREE RAMCHANDRA COLLEGE OF ENGINEERING,

LONIKAND, PUNE – 412 216

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

TURBO MACHINES(TM) **TE (ME) Semester-VI**

Prepared by

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List of Experiments (S.P.UNIPUNE SYLLABUS)

Note: - 1.Eight experiments from above list should be performed; out of which at least four trials should be conducted.

2. Data from any trial performed should be analyzed by using any suitable software

Sr. No	Name of Experiment
1	Verification of impulse momentum principle
2	Study and trial on pelton wheel and plotting of main / operating characteristics
3	Study and trial on any one Reaction turbine and plotting of main/operating characteristic
4	Study and trial on centrifugal pump and plotting of operating characteristics
5	Trial on centrifugal air compressor
6	Visit to hydro/steam turbine power plant
7	Design of pumping system installation using manufacturers catalogue
8	Study of different types of nozzles
9	Study of axial flow compressors/ centrifugal air blower
10	Study of multi staging of steam turbines
11	Visit to pumping station

INDEX

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	SHREE RAMCHANDRA COLLEGE OF ENGG. LONIKAND	LABORATORY MANUAL
	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: **Verification of impulse momentum principle**	
DEPARTMENT OF ELECTRICAL ENGINEERING		
EXPERIMENT NO. : SRCOE/MECH/TE/TM/	SEMESTER : VI (TE)	PAGE:

EXPERIMENT NO-01

1. **Title :** Verification of impulse momentum principle using flat & curved vanes.
2. **Aim :** To conduct an experiment on the Jet on Vane apparatus and determine the vane efficiency.
3. **Equipment :** Impact of Jet Appratus

Theory:

The study of impact of a jet of water is essential to understand the principle of an impulse turbine such as Pelton Wheel Turbine. When high pressure water from a source such as a dam flows through a nozzle in the form of a jet, the entire pressure energy of the water is converted into kinetic energy at the nozzle. When this jet of water hits a vane positioned in front of it, the vane deflects the jet and due to the change in the momentum of the water jet, a force is imparted to the vane by the water.

Experimental Setup:

The equipment consists of a high efficiency gun metal nozzle fitted to a 25mm. diameter pipe supply line with a gate valve. Vertically above the nozzle, a gun metal vane is fitted to a bracket of a differential lever which balances the upward force of the jet from the nozzle, The lever is provided with an adjustable no load screw mechanism. The force due to the jet on the lever is counter balanced by metric weights placed on a hanger. Different types of vanes can be fitted to the bracket.

The complete assembly is enclosed is a framed structure housing with a transparent window for visual observation. The water deflected by the vane is collected in the collecting tank.

For experimental purposes, a brass nozzles with 6 mm nozzle diameter and two

Gun metal vanes of the following shape are provided i) Semi-circular vane (180 deg. angle of deflection) ii) Horizontal flat vane (90 deg. angle of deflection)

4. Experimental Procedure:

i) Fit the required vane on the lever.

ii) Measure the differential lever arms and calculate ratio of lever arms(2.2 in this case). iii) Balance the lever systems by means of counter weight for no load.

iv) Place a weight on the hanger.

v) Open the gate valve and adjust the jet, so that the weight arm is balanced. vi) Collect water in the collecting tank.

vii) Note : (a) The pressure gauge reading - P. (b) The weight placed - W.

(c) Time for 10cm. rise in the collecting tank -t. viii) Calculate the discharge by weight.

ix) Calculate the vertical force.

5. Diagram

6. Specification:

1. Area of collecting tank A = 0.3 x 0.3 sq.m

2. Rise in water level R = 0.1 m (say)

3. Time taken = t seconds

4. Actual flow rate Q = AR/t cu.m/sec

   = 0.009/t cu.m/sec

5. Actual mass flow rate M = 1000 Q kg/sec

6 Nozzle diameter d = 0.006 m

7 Nozzle area a = $3.14 \times d^2/4$ sq.m

   = 2.83×10^{-5} sq.m

8 Jet velocity V = Q/ a m/sec

9 Angle of deflection of the vane to the jet = $T_l - T_2$ deg

10. Mass flow rate of water = M kg/sec

11 The lifting force (F) = Change in momentum per second in vertical direction.

$$F = M \times V \times (\sin T_l - \sin T_2)/g$$

For Horizontal flat vane, T_1 = 90 deg and T_2 =0 deg.

$$\mathbf{F} = (M \times V)/ g$$

For Semi-circular vane,

T_1 = 90 deg and T_2 = -90 deg.

F = (2 x M x V)/g

12 Actual lifting force measured **(Fact)** = W x lever arm ratio kg

13 The efficiency of the Jet = Fact / F

7. Observation Table:

Vane type	Inlet Pressure P Kg/sq.cm	Time for R cm rise t seconds	Flow rate Q x 10^{-3} cu.m/sec	Mass flow rate M Kg/ sec	Jet Velocity V m/s	Input force F Kg	Counter Load W Kg	Fact Kg	Vane efficiency Fact/F
Cup									
Cup									
Flat									
Flat									

8. Calculation:

9. Result table

10. Conclusion-

Experiment No-02

PELTON TURBINE TEST RIG

OBJECTIVE:

To Study the operation of a Pelton Turbine.

AIM:

To determine the output power of pelton turbine.

To determine the efficiency of the pelton turbine.

INTRODUCTION:

A turbine is a machine which converts the fluid energy into mechanical energy which is then utilized to run the electric generator of a power plant. Fluid used can be water or steam. The Pelton wheel is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmosphere. The turbine is used for high head.

THEORY:

Pelton turbine is a impulse turbine. In an impulse turbine, all the available energy of water is converted into kinetic energy or velocity head by passing it through a

contracting nozzle provided at the end of the penstock. The water coming out of the nozzle is formed into a free jet, which strikes on a series of buckets of the runner thus causing it to revolve. The runner revolves freely in air. The water is contact with only a part of the runner at a time, and throughout its action on the runner.

DESCRIPTION:

The set up consists of centrifugal pump, turbine unit, and sump tank, arranged in such a way that the whole unit works as re-circulating water system. The centrifugal pump supplies the water from sump tank to the turbine. The loading of the turbine is achieved by rope brake drum connected with weight balance. The turbine unit can be visualize by a large circular transparent window kept at the front. A bearing pedestals rotor assembly of shaft, runner and brake drum, all mounted on suitable cast iron base plate.

UTILITIES REQUIRED:

1. Electricity Supply: Three Phase, 420 V AC, 50 Hz, 5 kW with earth connection.
2. Water supply (Initial fill).
3. Drain Required.
4. Floor Area Required: 1.5 m x 0.75 m.
5. Mercury (Hg) for manometer: 250 gms.
6. Tachometer for RPM measurement.

EXPERIMENTAL PROCEDURE

Starting Procedure:

1. Close all the valves provided.
2. Fill sump tank .th with clean water and ensure that no foreign particles are there.
3. Fill manometer fluid i.e. Hg. in manometer by opening the valves of manometer and one PU pipe from pressure measurement point of pipe.
4. Connect the PU pipe back to its position and close the valves of manometer.
5. Open the by-pass valve and ensure that there is no load on the brake drum.
6. Switch ON the pump with the help of starter.
7. Close the by-pass valve.
8. Open pressure measurement valves of the manometer.
9. Open the air release valve provided on the manometer, slowly to release the air from manometer. (This should be done very carefully)
10. When there is no air in the manometer, close the air release valves.
11. Now turbine is in operation.
12. Load the turbine with the help of hand wheel attached on the top of weight balance.
13. Note the manometer reading and pressure gauge reading.
14. Measure the load applied and RPM of the turbine.
15. Repeat the experiment at different load.
16. Repeat the experiment for different discharge by regulating the nozzle position by the hand wheel provided for same.

Closing Procedure:

1. When the experiment is over, first of all remove the load on dynamometer.
2. Open the by-pass valve.
3. Close the ball valves provided on manometer.
4. Switch OFF Pump with the help of starter.
5. Switch OFF main power supply.
6. Drain the sump tank by the drain valve provided.

OBSERVATION & CALCULATIONS:

DATA:

g = 9.81 m /sec2

ρw = 1000 kg / m3

ρm = 13600 kg / m3

Cv = 0.98

D = 0.052 m

dB = 0.2 m

dR = 0.012 m

W3 = ------ kg

DAIGRAM-

OBSERVATION TABLE:

S.No.	N	P, kg/cm^2	h_1, cm	h_2, cm	W_1, kg	W_2, kg
1.						
2						
3.						

NOMENCLATURE:

A = Cross-sectional area of pipe, m2.

Cv = Co-efficient of pitot tube.

D = Diameter of pipe, m.

dB = Diameter of brake drum, m.

dR = Diameter of rope, m.

Ei = Input power, kW.

Eo = Output power, kW.

g = Acceleration due to gravity, m/sec2.

H = Total head, m.

h = Manometer difference, m.

h1,h2 = Manometer reading at both points, cm.

N = RPM of runner shaft.

P = Pressure gauge reading, kg/cm2.

Re = Equivalent Radius, m.

Q = Discharge, m3/sec.

T = Torque, N m.

V = Velocity of water, m/sec.

W_1 = Spring balance weight, kg.

W_2 = Adjustable weight, kg.

W_3 = Weight of Rope, kg.

ρ_w = Density of Water, kg/m3.

ρ_m = Density of Manometer fluid i.e. Hg, kg/m3.

η_t = Turbine efficiency.

Calculation-

Result Table-

Conclusion-

Experiment No-03

FRANCIS TURBINE TEST RIG

OBJECTIVE:

To study the operation of a Francis Turbine.

AIM:

To determine the output power of Francis Turbine.

To determine the efficiency of the Francis Turbine.

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.

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.

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 centrl 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 draught 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.

UTILITIES REQUIRED:

1. Electricity Supply: 3 Phase, 440 V AC, 50 Hz, 5 kW with earth connection.
2. Water supply (200 liters.)
3. Drain required.
4. Floor Area Required: 2 m x 1 m
5. Tachometer to measure RPM
6. Mercury for manometer, 250 gm.

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. Open the by-pass valve.
3. Close the ball valves provided on manometer.
4. Switch OFF Pump with the help of starter.

OBSERVATION & CALCULATION:

DATA:

g = 9.81 m/sec2

ρw = 1000 kg/m3

ρm = 13600 kg/m3

Cv = 0.98

D = 0.08 m

dB = 0.2 m

dR = 0.012 m

W3 = ----- kg

W4 = ----- kg

OBSERVATION TABLE:

S. No.	N, RPM	P_d, kg/cm^2	P_S, mm Hg	h_1, cm	h_2, cm	W_1, kg	W_2, kg

NOMENCLATURE:

A = Cross-sectional area of pipe, m2

Cv = Co-efficient of pitot tube

D = Diameter of pipe, m

dB = Diameter of brake drum, m

dR = Diameter of rope, m

Ei = Input power, kW

Eo = output power, kW

g = Acceleration due to gravity, m/sec2

H = Total head, m

h = Differential pressure of manometer, m

h1,h2 = Manometer reading at both points, cm

N = RPM of runner shaft

Pd = Delivery pressure, kg/cm2

V = Velocity of water, m/s

W1 = Applied weight, kg

W2 = Dead weight (obtain from spring balance), kg

W3 = Weight of hanger, kg

W4 = Weight of rope, kg

ρw = Density of water, kg/m3

ρm = Density of Manometer fluid i.e. Hg, kg/m3

ηt = Turbine efficiency

CALCULATIONS-

RESULT TABLE-

CONCLUSION-

Experiment No-04

CENTRIFUGAL PUMP TEST RIG

AIM-Study of centrifugal pump characteristics.

1. Power input
2. Shaft output
3. Total head
4. Pump Output
5. Overall efficiency
6. Pump efficiency

❖ To plot the following performance characteristics:

1. Head Vs Discharge
2. Pump efficiency Vs Discharge

INTRODUCTION:

The hydraulic machines, which convert the mechanical energy into hydraulic energy,are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump. The centrifugal pump acts as a reversed of an inward radial flow reaction turbine. This means that the flow in centrifugal pumps is in the radial outward directions. The centrifugal pump works on the principle of forced vortex flow, which means that an external torque rotates a certain mass of liquid, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of (i.e. rise in pressure head radius is more, the rise in pressure head will be more and the liquid will be discharged Centrifugal Pump Test Rig (Variable Speed) 1/2g) the liquid at that point. Thus at the outlet of the impeller where 2r at the outlet with a high- pressure head. Due to this high-pressure head, the liquid can be lifted to a high level. Centrifugal Pump is a mechanical device, which consists of a body, impeller and a rotating mean i.e. motor, engine etc. Impeller rotates in a stationary body and sucks the fluid through its axes and delivers through its periphery. Impeller has an inlet angle, outlet angle and peripheral speed, which affect the head and discharge. Impeller is rotated by motor or i.e. engine or any other device.

DESCRIPTION:

Centrifugal Pump Test Rig consists of a sump, a centrifugal pump, a DC motor and measuring tank. To measure the head, pressure and vacuum gauges are provided. To measure the discharge, a measuring tank is provided. Flow diversion system is provided to divert flow from sump tank to measuring tank and from measuring tank to sump tank. A valve is provided in pipeline to change the rate of flow.

UTILITIES REQUIRED:

Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15amp socket with earth Drain required. Bench Area Required: 1.5 m x 0.75 m

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Clean the apparatus and make tanks free from dust.

2. Close the drain valves provided.

3. Fill sump tank 3⁄4 with clean water and ensure that no foreign particles are there.

4. Open flow control valve given on the water discharge line and control valve given

5. Ensure that all ON/OFF switches given on the panel are at OFF position.

6. Set the desired RPM of motor / pump with the speed control knob provided at the control panel.

7. Operate the flow control valve to regulate the flow of water discharged by the pump.

8. Operate the control valve to regulate the suction of the pump.

9. Record discharge pressure by means of pressure gauge, provided on discharge line.

10. Record suction pressure by means of vacuum gauge, provided at suction of the pump.

11. Record the power consumption by means of energy meter, provided in panel with the help of stop watch.

12. Measure the discharged by using measuring tank and stop watch.

13. Repeat the same procedure for different speeds of pump.

14. Repeat the same procedure for different discharge with constant speed.

CLOSING PROCEDURE:

1. When experiment is over, open gate valve properly provided on the discharge line.

2. Reduce the RPM of the pump with the help of DC drive.

3. Switch OFF the pump first.

4. Switch OFF power supply to panel.

OBSERVATION TABLE:

DATA:

EMC = 3200 Pulses/kW hr

A = 0.128 m^2

ρ = 1000 kg/m^3

η_m = 0.8 (assumed)

g = 9.81 m/s^2

h_{pg} = 1 m

OBSERVATION TABLE:

S. No.	N, RPM	P_d, kg/cm^2	P_S, mmHg	R_1, cm	R_2, cm	t, sec	t_p, sec

To plot head vs. discharge & Pump efficiency vs. Discharge

NOMENCLATURE:

A	=	Area of measuring tank, m^2
EMC	=	Energy meter constant, Pulses/kW hr
E_i	=	Pump input, kW
E_S	=	Shaft output, kW
E_o	=	Pump output, kW
g	=	Acceleration due to gravity, m/s^2
H	=	Total Head, m
h_{pg}	=	Height of pressure gauge from vacuum gaug
N	=	Speed of Pump, r.p.m.
P	=	Pulses of energy meter
P_d	=	Delivery pressure, kg/cm^2
P_S	=	Suction pressure, mmHg
Q	=	Discharge, m^3/s
R	=	Rise of water level in measuring tank, m
R_1	=	Final level of water in measuring tank, cm
R_2	=	Initial level of water in measuring tank, cm
t	=	Time taken by R, sec
t_p	=	Time taken by P, sec
ρ	=	Density of fluid, kg/m^3
η_p	=	Pump efficiency %
η_o	=	Overall efficiency %
η_m	=	Motor efficiency %

Calculation-

Result-

Conclusion-