Government college of Engineering

Department of Mechanical Engineering

LAB Manual

Fluid Mechanics and Hydraulic Machines

Mechanical 3rd Semester

PME3I102

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INSTRUCTIONS TO STUDENTS

1. Be prompt in arriving to the laboratory and always come well prepared for the experiment.
2. Be careful while working on the equipment's operated with high voltage power supply.
3. Work quietly and carefully. Give equal opportunity to all your fellow students to work on the instruments.
4. Every student should have his/her individual copy of the Mechanisms & Machines Practical Book.
5. Every student has to prepare the notebooks specifically reserved for the Mechanisms & Machines Practical work "Mechanisms & Machines laboratory Book".
6. Every student has to necessarily bring his/her Mechanisms & Machines Practical Book and laboratory book when he/she comes to the laboratory to perform the experiment.
7. Record your observations honestly. Never makeup reading or to doctor them to get a better fit on the graph or to produce the correct result. Display all your observations on the graph (If applicable).
8. All the observations have to be neatly recorded in the Mechanisms & Machines laboratory Book and verified by the instructor before leaving the laboratory.
9. If some of the readings appear to be wrong then repeat the set of observations carefully.
10. After verification of the recorded observations, do the calculation in the Mechanisms & Machines laboratory Book and produce the desired results and get them verified by the instructor.
11. Never forget to mention the units of the observed quantities in the observation table. After calculations, represent the results with appropriate units.
12. Calculate the percentage error in the results obtained by you if the standard results are available and also try to point out the sources of errors in the experiment
13. Do not forget to get the information of your next allotment (the experiment which is to be performed by you in the next laboratory session) before leaving the laboratory from the Technical Assistant.
14. Calculate the percentage in the results obtained by you if the standard results are available and also try to point out the sources of errors in the experiment.
15. Finally record the verified observations along with the calculation and results in the Mechanisms & Machines Practical Book.
16. Do not forget to get the information of your next allotment (the experiment which is to be performed by you in the next laboratory session) before leaving the laboratory from the Technical Assistant.
17. The grades for the Mechanisms & Machines course work will be awarded based on your performance in the laboratory, regularity, recording of experiments in the Mechanisms & Machines Practical Book. lab quiz, regular viva-voce and end-term examination.

CERTIFICATE

This is to certify that

Mr./Ms...wit h enrollment no. .... during the academic year ....

Date of Submission: ....

Staff In charge: ....

Head of Department: ....

TABLE OF CONTENT

EXPERIMENT NO:1

IMPACT OF JET ON VANES

Aim: To determine the co-efficient of impact on vanes

Theory:

The liquid comes out in the form of a jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid is flowing under pressure. If some plate, which may be fixed or moving, is placed in the path of the jet, the jet on the plate exerts a force. This force is obtained from Newton's second law of motion or from impulse momentum equation. Thus impact of jet means the force excited by the jet on a plate, which may be stationary or moving.

a) Force exerted by the jet on a stationary plate is when,
   i) Plate is vertical to jet ii) plate is inclined to jet
   iii)Plate is curved.
b) Force exerted by the jet on a moving plate is when
   i) Plate is vertical to jet ii) plate is inclined to jet.
   iii) Plate is curved

Apparatus used:

1. Vanes (flat, inclined with $\theta = 60^0$ and hemispherical), experimental setup comprising rotameter, nozzles of different diameter, steady supply of water using pump.

Procedure:

1. Fix the required diameter of nozzle and the vane of the required shape in position.
2. Bring the force indicator position to zero.
3. Keep the delivery valve closed and switch on the pump.
4. Close the front transparent glass tightly.
5. Open the delivery valve and adjust the flow rate.
6. Observe the force as indicated on the force indicator.
7. Note down the diameter of the pipe of the jet and shape of the vane and the discharge is calculated.

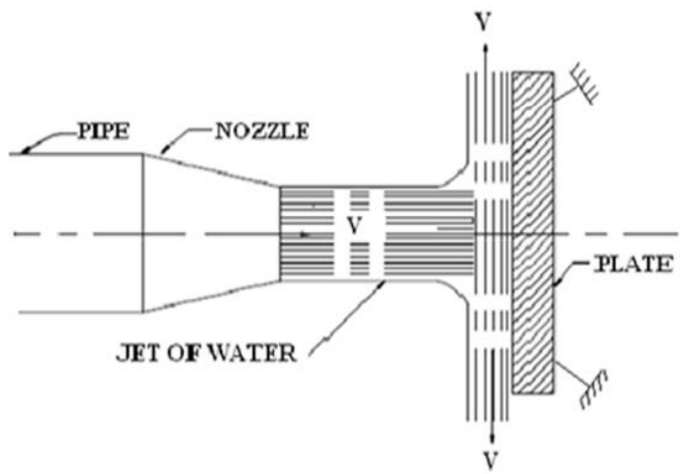


Figure 1

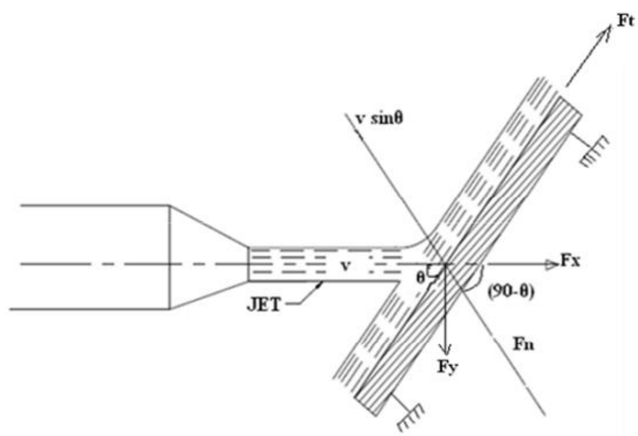


Figure.2.

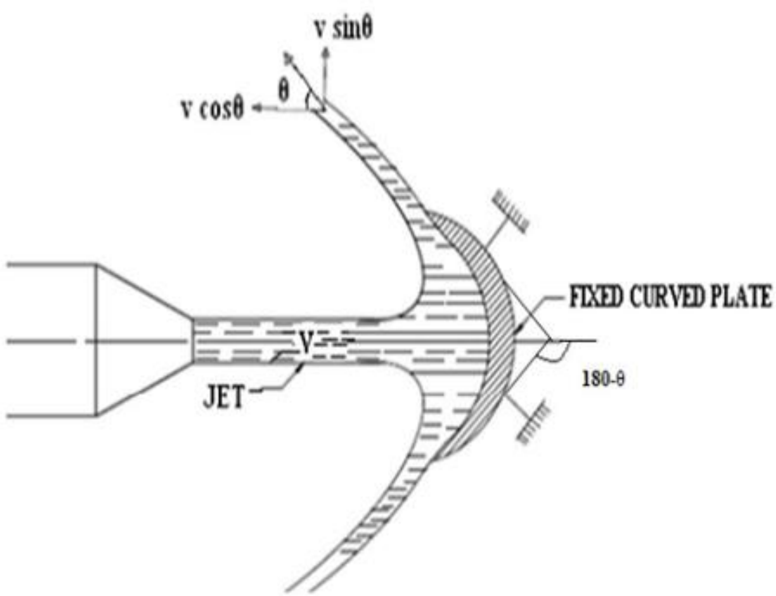


Figure.3.

Table of readings:

Type of Vane	Dia of Jet, D(m)	Q	Force indicator (F_{act})	
		m^3/s	Kgf	N
Hemispherical				
Flat				
Inclined				

Observation and Calculation:

Cross section area of jet $a = \pi d^2/4\ m^2$

Where, d is diameter of the jet in m

Velocity of jet, $V = Q/a$ m/s Where Q is discharge in m^3/s

Theoretical force,

Fthe = $\rho a V^2$ **N** [flat plate]

Fthe = $2\rho a V^2$ **N** [Hemispherical plate]

Fthe = $2\rho a V^2 \sin^2\theta$ N [Inclined plate]

Actual force = F_{act} (observed in force indicator).

Co-efficient of impact, $k = F_{act} / F_{the}$

Table of calculations:

Type of Vane	Diameter of jet d (m)	F_{the}	$k = \frac{F_{act}}{F_{the}}$	Avg. k

Precaution:

1. Apparatus should be in leveled condition.
2. Reading must be taken in steady conditions.
3. Discharge must be varied very gradually from a higher to smaller value.

Experiment No. 02

PELTON TURBINE TEST RIG

AIM:

1) To study the working principle of Pelton (impulse) turbine
2) To understand the functional aspects of various components constituting the turbine
3) To study performance characteristics of turbine at various heads, speed and load.

INTRODUCTION:

Hydraulic (or water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce the electricity, viz., hydroelectric power.

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which impinges on the turbine runner, it is the pressure of the flowing water, which rotates the runner of the turbine. Of many types of turbines, the Pelton turbine, most commonly used, falls into the category of impulse turbine while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton turbine (impulse) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory size turbine as the limitation of the pump's availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

The experimental setup consists of Centrifugal pump set, Turbine unit, sump tank, notch tank arranged in such a way that the whole unit works as recirculation water system. The centrifugal pump set supplies the water form the sump tank to turbine through control valve situated on the pump and a sphere valve before entering the turbine. The water after passing through the Turbine unit enters the Notch tank and then flows back to sump tank through the Notch tank which is fixed with a notch plate for measurement of flow rate.

The loading of the turbine is achieved by a brake drum with rope & spring balance, provision for measurement of turbine speed (digital RPM indicator), Head on turbine (pressure gauge) are built in on the control panel.

SPECIFICATION:

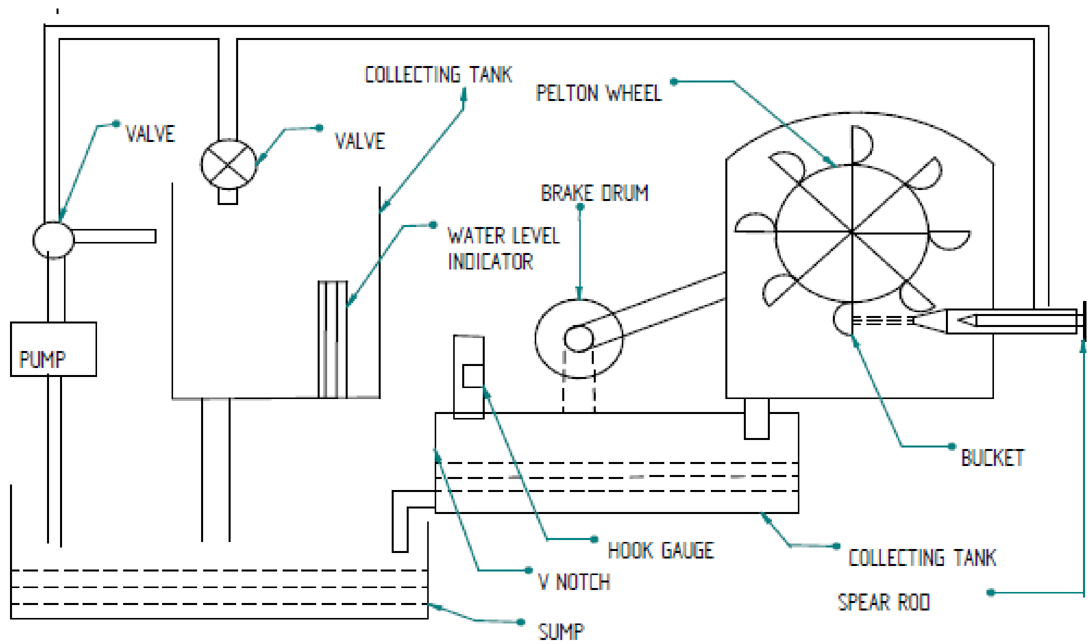
Supply pump capacity: 7.5Hp, 3ph, 440V
Turbine capacity: 1.1 kW
Run away speed: 1500 rpm
Loading: Brake drum with spring balance

OBSERVATION TABLE:

Constant Speed:

S. no	Turbine Speed 'N' rpm	Pr Gauge Reading 'P' Kg/cm^2	Head over turbine 'H' in m	Head over the Venturimeter h2-h1=h*10 in m	Sprint balance reading Kg S2-S1=S	Flow rate 'Q' m^3/s	Input power kW	Brake power BP kW	Turbine Effeciency % $\eta_{Turbine}$

EXPERIMENTAL SETUP:



EXPERIMENTAL SETUP

PROCEDURE:

1) Connect the panel to the electrical source & ascertain the direction of the pump is in order (clock wise direction from shaft end) by momentarily starting the pump.
2) Fill filtered clear water into the sump tank up to ¾th its full capacity
3) Keep the control valve situated above the pump in fully closed position, and the sphere valve in half open position.
4) Start the pump; gradually open the control valve slowly so that the turbine achieves sufficient speed.
5) Wait till the speed of the turbine maintained constant.
6) Load the turbine by turning the hand wheel situated on the load frame clock wise observing the dial spring balance to any desired minimum load
7) Allow the turbine speed to stabilize
8) Record the readings indicated on pressure gauge, dial balance RPM indicator and head over the notch plate
9) Continue loading the turbine in steps up to its full load and record the corresponding readings at each steps
10) After the experiment is over bring the turbine to no load condition by rotating the hand wheel on the load frame in anti-clock wise direction and stop the pump.
11) Tabulate all the recorded readings and calculate the input power, output power & efficiency of the Turbine.

Graphs to be plotted:

Main Characteristics Curves (constant Head)

1. Q_u Vs N_u
2. P_u Vs N_u
3. η_o Vs N_u

Operating Characteristics Curves (Constant Speed)

4. η_o Vs % full load.

S. no	Turbine Speed 'N' rpm	Pr Gauge Reading 'P' Kg/cm^2	Head over turbine 'H' in m	Head over the Venturimeter h2-h1=h*10 in m	Sprint balance reading Kg S2-S1=S	Flow rate 'Q' m^3/s	Input power kW	Brake power BP kW	Turbine Effeciency % $\eta_{Turbine}$

CALCULATIONS:

1. Head on turbine H:

H = 10 x P where P is the pressure gauge reading in Kg/cm^2

2. Flow rate of water, $\boldsymbol{Q = \frac{a_1 a_2\sqrt{2gh}}{\sqrt{a_1{}^2 - a_2{}^2}}\ m^3/s}$

g = 9.81 m/sec2
Cd = 0.9
b = Width of notch in m
h = Head over the notch in m

3. Input power = WQH / 1000 kW where W = 9810 N/m^3

4. Brake power

BP = 2πN (S_2-S_1) r x 9.81 / 60 x 1000 kW
Where r = Radius of the brake drum = 0.168 m (0.152+. 0.16)

5. Turbine efficiency

η_{turb} = BP / IP x 100

6. Unit speed, $N_u = \frac{N}{\sqrt{H}}$

7. Unit discharge, $Q_u = \frac{Q}{\sqrt{H}}$

8. Unit power, $P_u = \frac{P_{shaft}}{H^{\frac{3}{2}}}$

9. Specific speed, $N_s = \frac{N\sqrt{P_{shaft}}}{H^{\frac{5}{4}}}$

Experiment No. 03

FRANCIS TURBINE TEST RIG

AIM:

1. To study the working principle of Francis (reaction) turbine.

2. To understand the functional aspects of various components constituting the turbine. To study performance characteristics of turbine at various heads, flow rates and speeds

INTRODUCTION:

Hydraulic (water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy, which is further converted into electrical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce electricity (Hydroelectric power).

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which exerts the force on the turbine; it is the pressure of the flowing water, which rotates the Impeller of the turbine. Of many types of turbine, the Pelton wheel, most commonly used, falls into the category of impulse turbine, while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton wheel (impulse turbine) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory because of the limitation of required head & discharges. Nevertheless, an attempt has been made to study the performance characteristics within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

While the impulse turbine is discussed elsewhere in standard textbooks, Francis turbine (reaction type) which is of present concern consists of main components such as Impeller (runner), scroll casing and draft tube. Between the scroll casing and the Impeller there are guide vanes, which guides the water on to the impeller thus rotating the Impeller shaft. There are eight guide vanes, which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. When guide vane angles are varied, high efficiency can be obtained over wide range of operating conditions.

The actual experiment facility supplied consists of a sump tank, centrifugal pump set, turbine unit and Venturimeter arranged in such a way that the whole unit works on recirculating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through control valve (Gate valve). The water from the pump passes through a Venturimeter (for measurement of discharge) to the turbine unit enters the sump tank through the draft tube.

The loading of the turbine is achieved by electrical dynamometer coupled to the turbine through a V- Belt drive (V grooved pulley). The control panel is equipped with a set of heaters (electrical resistance) in steps of 200Vats each, 10 No. (200 x 10 Total 2Kw) with individual switches are provided for loading the electrical dynamometer (in turn loading the turbine). The provisions for measurement of load (by digital Voltmeter & Ammeter), turbine speed (digital RPM indicator), differential pressure across Venturimeter (Double column Mercury Manometer) & total head on turbine (pressure & vacuum gauge).

SPECIFICATION :

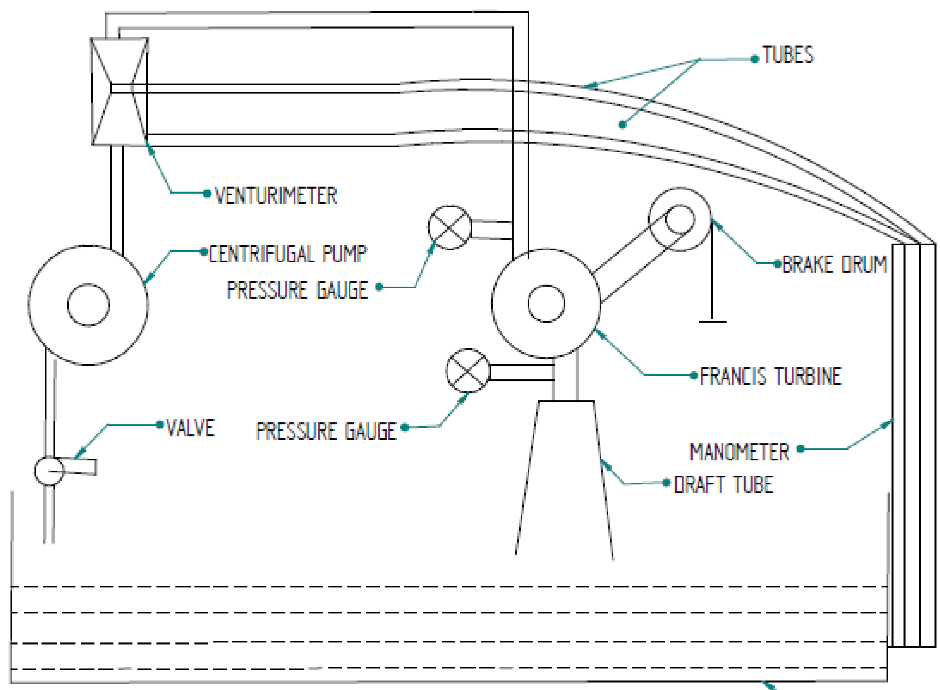
Supply pump capacity : 7.5 Kw (10 Hp) 3ph, 400V
Turbine capacity: 2.6 HP (2 Kw)
Run away speed: 2000 RPM

TABULAR COLUMN

Constant Speed:

S.no.	Pressure Gauge reading 'P' Kg/cm^2	Head over the turbine 'H' in m	Pressure Gauge reading in Kg/cm^2 Across Venturimeter		Δh	Alternator		Flow rate 'Q' m^3/s	Input Power Kw (IP)	Output Power Kw (OP)	Turbine efficiency % η_{turb}
						V Volts	I amps				

EXPERIMENTAL SETUP :



EXPERIMENTAL SETUP

PROCEDURE :

1) Install the equipment near a 3 phase 440 volts, 50 Hz, 20 amps power source & water source.
2) Connect the panel to the electrical source & ascertain the direction of the pump is in order (clock wise direction from shaft end) by momentarily starting the pump.
3) Fill filtered clear water into the sump tank up to ¾th its full capacity.
4) Keep the gate valve situated above the pump in fully closed position, turbine guide vanes in full open position.
5) Start the pump, gradually open the gate valve slowly so that the turbine achieves sufficient speed to generate 200 volts on the panel voltmeter.
6) Wait till the speed of the turbine & generated voltage maintained constant.
7) Put on the first electrical load switch and adjust the speed of Turbine to 200V on the panel Voltmeter and record the corresponding Ammeter, Pressure gauge & Head over the notch readings.
8) Continue increasing the load on the Turbine step by step by switching ON the consecutive load switches one by one, by gradually opening the Gate valve so that the Voltmeter reading shows 200V on each step. Record the corresponding readings of Ammeter, Pressure Gauge & Head over the notch.
9) Change the Turbine guide vane to any desired position (between fully open to closed conditions) by operating the hand wheel situated at the rear end of the Turbine to repeat the experiment on varied condition by following steps 7 & 8.

10) After the experiment is over bring the turbine to no load condition by switching OFF the load switches one by one and simultaneously closing the Gate valve (care must be taken to avoid sudden increase in speed / Volts while switching 'off ' the load switches) & stop the pump.

11) Tabulate all the recorded readings and calculate the input power, output power & efficiency of the Turbine.

Note: Drain all the water from the sump tank, refill with fresh clean water once in a month. When the equipment is not in use for a longer duration, drain all water from the sump tank keep it clean & dry.

Graphs to be plotted:

Main Characteristics Curves (constant Head)

1. Q_u Vs N_u
2. P_u Vs N_u
3. η_o Vs N_u

Operating Characteristics Curves (Constant Speed)

4. η_o Vs % full load.

S.no.	Pressure Gauge reading 'P' Kg/cm^2	Head over the turbine 'H' in m	Pressure Gauge reading in Kg/cm^2 Across Venturimeter		Δh	Alternator		Flow rate 'Q' m^3/s	Input Power Kw (IP)	Output Power Kw (OP)	Turbine efficiency % η_{turb}
						V Volts	I amps				

CALCULATION

Output power , $\mathbf{OP} = \frac{\mathbf{V\,X\,I}}{\mathbf{1000\,X\,\eta_{Gen}}}$ P= V X I/1000 X η_Gen

η_{Gen}=0.75

Input Power , $\mathbf{IP} = \frac{\mathbf{W\,Q\,H}}{\mathbf{1000}}$ where $\mathbf{w} = \mathbf{9810}\frac{\mathbf{n}}{\mathbf{m^3}}$

$\mathbf{Q} = \mathbf{C_d K\sqrt{2ghw}}$ $\mathbf{K} = \frac{\mathbf{a_1 a_2}}{\sqrt{\mathbf{a_1}^2 - \mathbf{a_2}^2}}$

C_d=0.94

Turbine efficiency

η_{turb} = BP / IP x 100

Unit speed, $\mathbf{N_u} = \frac{N}{\sqrt{H}}$

Unit discharge, $\mathbf{Q_u} = \frac{\mathbf{Q}}{\sqrt{\mathbf{H}}}$

Unit power, $\mathbf{P_u} = \frac{\mathbf{P_{shaft}}}{\mathbf{H^{\frac{3}{2}}}}$

Specific speed, $\mathbf{N_s} = \frac{\mathbf{N\sqrt{P_{shaft}}}}{\mathbf{H^{\frac{5}{4}}}}$

EXPERIMENT NO - 04

KAPLAN TURBINE TEST RIG

AIM:

3. To study the working principle of Kaplan (reaction) turbine.
4. To understand the functional aspects of various components constituting the turbine. To study performance characteristics of turbine at various heads, flow rates and speeds

INTRODUCTION:

Hydraulic (water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy, which is further converted into electrical energy. Thus the turbine becomes the primover to run the electrical generators to produce electricity (Hydroelectric power).

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which exerts the force on the turbine; it is the pressure of the flowing water, which rotates the runner of the turbine. Of many types of turbine, the Pelton wheel, most commonly used, falls into the category of impulse turbine, while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton wheel (impulse turbine) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory because of the limitation of required head & discharges. Nevertheless, an attempt has been made to study the performance characteristics within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

While the impulse turbine is discussed elsewhere in standard textbooks, Kaplan turbine (reaction type) which is of present concern consists of main components such as propeller (runner), scroll casing and draft tube. Between the scroll casing and the runner, the water turns through right angle into axial direction and passes over the runner and thus rotating the runner shaft. The runner has four blades, which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. The runner blade angles can be varied to obtain higher efficiency over wide range of operating conditions. In other words even at part loads, when a low discharge is flowing over the runner, a high efficiency can be attained in case of Kaplan turbine. Where as this provision does not exist in Francis & Propeller turbines where the runner blade angles are fixed and integral with the hub.

The actual experimental setup consist of a centrifugal pump set, turbine unit, sump tank, arranged in such a way that the whole unit works on recirculating water system.

Specifications:

1. Supply pump capacity: 7.5 Kw (10 Hp) 3ph, 400V
2. speed : 1430 RPM
3 Dial gauge : 10 Kg
3. Runner diameter: 160 mm

CALCULATIONS:

Output power , $OP = \frac{V X I}{1000 X \eta_{Gen}}$P= V X I/1000 X η_Gen η_{Gen}=0.75

Input Power , $IP = \frac{W Q H}{1000}$ where $w = 9810 \frac{n}{m^3}$

$Q = C_d K\sqrt{2ghw}$ $K = \frac{a_1 a_2}{\sqrt{{a_1}^2 - {a_2}^2}}$

C_d=0.94

Turbine efficiency

η_{turb} = BP / IP x 100

Unit speed, $N_u = \frac{N}{\sqrt{H}}$

Unit discharge, $Q_u = \frac{Q}{\sqrt{H}}$

Unit power, $P_u = \frac{P_{shaft}}{H^{\frac{3}{2}}}$

Specific speed, $N_s = \frac{N\sqrt{P_{shaft}}}{H^{\frac{5}{4}}}$

OBSERVATION TABLE

CONSTANT SPEED:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm^2	Head over turbine 'H' in m	Manometer reading		Load		Flow rate 'Q' m^3/s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}
				L_1	L_2	Voltage V Volts	Current I Amps				
1											
2											
3											
4											
5											

CONSTANT HEAD:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm^2	Head over turbine 'H' meters	Manometer reading		Load		Flow rate 'Q' m^3/s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}
				L_1	L_2	Voltage V Volts	Current I Amps				
1											
2											
3											
4											
5											

The centrifugal pump set supplies the water from the sump tank to the turbine through control valve (Butterfly valve) and passes through and orifice meter connected to a double column mercury manometer which facilitates to obtain the quantity of water discharged form the turbine unit. Water after passing through the turbine unit enters the sump tank through the draft tube.

The loading of the turbine is achieved by electrical dynamometer coupled to the turbine through a V- Belt drive (V grooved pulley). A set of heaters (electrical resistance) in steps of 200 Watts each, 10 no. (Total 2Kw) with individual switches provided for loading the electrical dynamometer (in turn loading the turbine). The provisions for measurement of turbine speed (digital RPM indicator), head on turbine (pressure gauge) are built-in on the control panel.

OPERATING PROCEDURE:

Install the equipment near a 3 phase 440 volts, 50 Hz, 20 amps power source &water source.

1. Connect the panel to the electrical source & ascertain the direction of the pump is in order (clock wise direction from shaft end) by momentarily starting the pump.
2. Fill filtered clear water into the sump tank &discharge tank upto the flow channel level.
3. Keep the butterfly valve situated above the pump in partially closed position & turbine runner blade in full open position.
4. Start the pump, gradually open / close the butterfly valve so that the turbine achieves sufficient speed to generate 220volts on the panel voltmeter
5. Wait till the speed of the turbine & generated voltage maintained constant.
6. Open all the valves provided on the manometer fully and the valves across the orifice meter partially to release the air trapped in the manometer and observe water flowing through the air vent tubes.
7. Close both the air vent valves simultaneously and read the difference of mercury level in the manometer limbs to obtain the discharge.
8. Switch “ON” the first two electrical load switches and adjust the speed of Turbine to 220V on the panel Voltmeter by adjusting the flow control valve and record the corresponding Ammeter, Pressure gauge and manometer readings.
9. Continue increasing the load on the Turbine step by step by switching “ON” the consecutive load switches in sets of two and maintain the panel voltmeter reading at 220V by adjusting the flow control valve accordingly.
10. Record the relative voltmeter, ammeter, pressure gauge and manometer readings on each step.
11. Bring the Turbine to no load condition by switching OFF the load switches in steps.
12. Change the Turbine Runner position by operating the hand wheel situated at the rear end of the Turbine & repeat the experiment following the steps 10 to 12.
13. After the experiment is over bring the turbine to no load condition & stop the pump.
14. Tabulate all the recorded readings and calculate the output power, input power & efficiency of the Turbine.

EXPERIMENT NO: 05

LOSSES IN FLOW THROUGH PIPES

Aim: 1. To determine the Co-efficient of friction in flow through pipes of various sizes

2. To determine various minor losses of energy in flow through pipes

Theory:

When a fluid flows through a pipe, certain resistance is offered to the flowing fluid, which results in causing a loss of energy. The various energy losses in pipes may be classified as:

(i) Major losses.

(ii) Minor losses.

The major loss of energy as a fluid flows through a pipe, is caused by friction. It may be computed mainly by Darcy-Weisbach equation. The loss of energy due to friction is classified as a major loss because in case of long pipelines. It is usually much more than the loss of energy incurred by other causes.

The minor losses of energy are those, which are caused on account of the change in the velocity of flowing fluid (either in magnitude or direction). In case of long pipes these losses are usually quite small as compared with the loss of energy due to friction and hence these are termed 'minor losses' which my even be neglected without serious error. However, in short pipes these losses may sometimes outweigh the friction loss. Some of the losses of energy that may be caused due to the change of velocity are indicated below

The loss of energy due to :

1. Major energy loss: this is due to friction and it is calculated by the following formulae:

a) Darcy-Weisbach Formula $h_f = 4fLV^2 / D \times 2g$

Where f = coefficient of friction

L= length of pipe

V = velocity of fluid in the pipe

D = Diameter of pipe

$f = 16 / Re$ if $Re < 4000$

$= 0.079 / Re^{0.25}$ if $Re > 4000$

b) Chezy's formula

$V = C (m\ i)^{0.5}$

Where m = A/P which is Hydraulic radius

i = slope of H.G.L. = h_f / L

Procedure:

1. Switch on the pump and open the delivery valve.
2. Open the corresponding ball valve of pipe under consideration.
3. Keep the ball valve of other pipeline closed.
4. Note down the differential head readings in the manometer. (Expel if any air is present by opening the drain cocks provided to the manometer).

5. Close the butterfly valve and note down the time taken for known water level rise.
where h_f is loss of head.

$$h_f = H\,[S_{HG} / S_w - 1]$$

Where H = Manometer reading in m of Hg

6. Change the flow rate and take the corresponding reading
7. Repeat the experiment for different diameter of pipelines.

Table of calculations:

Type	**Difference in Mercury level**			**H= h_1-h_2 in m**	**Rise of water in m**	**Time taken in sec**	**Discharge Q (m^3/s)**	**Velocity V (m/s)**	**Loss of head in m**
	h 1		**h 2**						

Calculations:

Area of Tank, A = 0.125 m^2

Discharge Q = AR /t m^3/s

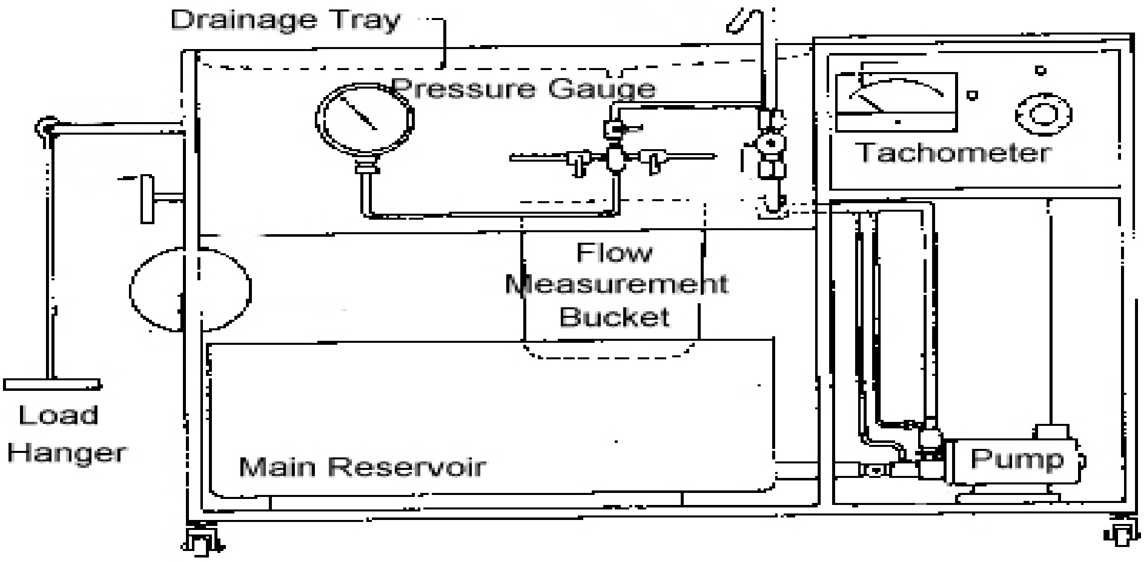
Where R = Rise in water level in collecting tank. (In m)

t = time in seconds

Velocity of flow, V = Q/a m/s

Cross sectional area of pipe a = $\pi d^2/4$ m^2

where'd' is inner diameter of pipe.



1. The loss of energy due to Minor losses :

(a) Loss of energy due to sudden enlargement.

$h_L = (V_1 - V_2)^2 / 2g$

(b) Loss of energy due to sudden contraction

$h_L = 0.5\ V^2 / 2g$

(c) Loss of energy at 90^0 Elbow

$h_L = KV^2/ 2g$

EXPERIMENT NO: 06

PERFORMANCE ANALYSIS OF CENTRIFUGAL PUMP

AIM: To conduct performance test on a Single stage Centrifugal pump test rig.

INTRODUCTION:

A pump may be defined as mechanical device when interposed in a pipe line, converts the mechanical energy supplied to it from an external source into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most engineers and technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, axial flow, reciprocating, air jet, and diaphram and turbine pumps. Most of these pumps fall into the main class namely Rotodynamic, Reciprocating (positive displacement) and Fluid operated pumps.

THEORY:

The principle of operation of a single stage centrifugal pump is covered under Rotodynamic pump category. In this pump, the liquid is made to rotate in a closed volute chamber. Thus creating the centrifugal action, which gradually builds the pressure gradient towards outlet resulting in a continuous flow.

These pumps are of simple construction can be directly coupled to electric motor and more suitable for handling clear, semi viscous, as well as turbid liquids. The hydraulic head per stage at low flow rates is limited and hence not suitable for high heads, in case of single stage centrifugal pumps. But as the pump in this case in a multi stage construction the pressure gradually builds up in successive stages almost equally in each stage. Thus achieving considerably higher heads. The multi stage centrifugal pump test rig allows the students to understand and study the various characteristics and pressure build up pattern in individual stages.

DESCRIPTION:

The single stage Centrifugal pump test rig mainly consists of:

a) Single stage Centrifugal pump

b) AC Drive motor of suitable capacity coupled to pump by stepped pulley arrangement.

c) SS sump tank and measuring tank with a piezometer

d) G. I. Pipe connections with necessary control valve etc… mounted on a neatly painted M.S. structure. The panel board is equipped with an energy meter for measurement of power input to the motor, a digital RPM indicator to indicate the speed of the pump/motor, a Vacuum gauge to measure suction head, & pressure gauge for measurement of delivery head, a starter of suitable capacity, indicating lamps and fuse etc.

Experimental Procedures:

1. Clean the apparatus and make all tanksfree from dust
2. Close the drain valve provided
3. Open flow control valve given on the water discharge
4. now switch on the main power supply 220 V AC , 50 Hz.
5. Operate the flow control valveto regulate the flow of water.
6. Set the desired RPM of motor/ Pump
7. Operate the control valve to regulate the suction of pump
8. Record discharge pressure by means of pressure gauge
9. Record suction pressure by means of suction gauge.
10. Measure the discharge by measuring tank by using stop watch.
11. Repeat the same procedure for different speed.

SPECIFICATIONS:

Pump 1.02HP/0.8KW, 2900 RPM, Single phase
Pressure gauge Bourden type
Water circulation by Pump
Stop watch Electronic

OBSERVATIONS:

1 kg / cm^2 = 760 mm of Hg
Density of water = 1000 Kg / m^3
Area of collecting tank = 0.1 m^2

Discharge rate " Q " in m^3 / s

$Q = A \times h / t$

where 'h' is height of water collected in measuring tank for a time interval of 't' sec.

Total head " H " in m

H =10(Delivery Pressure + Vacuum head)
=10(P + Pv)

where P is pressure in kg / cm^2 , Pv is the Vacuum in mm of Hg

p=(1.032+ pressure reading) Pv=(1.032- (suction pressure reading x 1.33 x 10^{-3})

Data: Energy meter constant E.M.C. = 6400 pulses/kw-h

CALCULATIONS:

1. Electrical input = P X 3600 X 1000 / EMC X t X 746 Horse power

2. HP. OUTPUT = Efficiency x H.P. INPUT
3. Discharge Q = A*R / t
4. Total head = 10*[P_d + P_s / 760] +1

5. Pump output = ρQH / 75

6. Overall efficiency = H.P. Output / H.P. Input

Table of calculations

Speed N (rpm)	Delivery pressure p (kgf/cm^2)	Suction pressure P_v mm of Hg	Time taken for 10 Impulse of energy meter (t_e) s	Water level rise in tank R		Discharge time t (s)
				mm	m	

Precautions and Maintanance instructions

1. Do not run the pump at low voltage
2. Never fully close the drain line and bypass line valve simultaneosly

3. Always keep apparatus free from dust

4. Frequently grease/oil the rotating parts

5. Always use clean water.

EXPERIMENT NO: 07

PERFORMANCE ANALYSIS OF RECIPROCATING PUMP

AIM:

To study the performance and characteristics of reciprocating pump and to determine the efficiency of the pump

INTRODUCTION:

In general, a pump may be defined as mechanical device when connected in a pipe line, can convert the mechanical energy into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most engineers and technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, axial flow (stage pumps), reciprocating, air jet, and diaphram and turbine pumps. These pumps fall mainly into a category of rotodynamic, reciprocating (positive displacement) and fluid operated pumps.

THEORY:

Reciprocating pump is a positive displacement pump. It mainly consists of a piston reciprocating inside a cylinder thus performing suction and delivery strokes. The cylinder is alternately filled and emptied by forcing and drawing the liquid by mechanical motion. This type is called positive type. Delivery and suction pipes are connected to a cylinder. Each of the two pipes is provided with a non-return valve. The function of which is to ensure unidirectional flow of liquid. It generally operates at low speed and is therefore to be coupled to a motor with V-belt. It is stable for small discharge and high heads. Generally these pumps are used for feeding small boilers, for lifting water to a higher heads & for pumping light oil. The present test rig allows the students to understand and draw the operating characteristics at various heads, flow rates and speeds.

DISCRIPTION:

The Reciprocating pump test rig mainly consists of:

a) Double stroke Reciprocating pump

b) AC Drive motor of suitable capacity coupled with a belt drive Variable speed stepped cone pully.

c) SS sump tank, SS measuring tank with a piezometer

d) G. I. Pipe connections with necessary control valve etc… mounted on a neatly painted M.S. structure.

e) The panel board is equipped with an energy meter for measurement of power input to the motor, a digital RPM indicator to indicate the speed of the pump, a Vacuum gauge to measure suction head , a pressure gauges for measurement of delivery head. a three phase starter of suitable capacity, main indicating lamps and fuses.

Experimental Procedures:

1. Clean the apparatus and make all tanksfree from dust
2. Close the drain valve provided
3. Fill sump tank 3/4 with clean waterand ensure that no foriegn matter are there.
4. Open flow control valve given on the water discharge
5. now switch on the main power supply 220 V AC , 50 Hz.
6. Operate the flow control valveto regulate the flow of water.
7. Set the desired RPM of motor/ Pump
8. Operate the control valve to regulate the suction of pump
9. Record discharge pressure by means of pressure gauge
10. Record suction pressure by means of suction gauge.
11. Measure the discharge by measuring tank by using stop watch.
12. Repeat the same procedure for different speed.

SPECIFICATIONS:

Pump 1.02HP/0.8KW, 2900 RPM, Single phase
Pressure gauge Bourden type
Water circulation by Pump
Stop watch Electronic

NOMENCLATURE:

A = area of collecting tank
EMC = Energy meter constant
N= Speed of pump in RPM
H = Total Head
P = Pulses of energy meter
Q = Discharge
R = Rise of height in collecting tank
t = Time taken by R, Sec
ρ = Density of water

Procedure:

1. Connect the power cable to three phase, 440 volts, 10 Amps with earth connection
2. Fill water in air vessel.
3. Keep the delivery valve fully open.
4. Fill the sump tank with clean soft water.
5. Select the desired speed by adjusting the step cone pulley - motor base handle.
6. Switch on the mains, the mains on indicators glow, now switch on the pump, water starts flowing to the measuring tank.
7. Note down the pressure gauge, vacuum gauge reading and time for number of revolutions of energy meter disc at full opening of delivery valve.

8. Operate the butterfly valve to note down the collecting tank reading against the known time, and keep it open when the readings are not taken.
9. Repeat the experiment for different openings of delivery valve and note down the readings as above
10. Repeat the experiment for different speeds and repeat the steps from 5 to 8.
11. Tabulate the readings.
12. After the experiment is over switch off the mains and keep the delivery valves fully open.
13. Calculate the efficiency of the pump.

OBSERVATIONS:

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Density of water = $1000\ Kg / m^3$

Area of collecting tank = $0.1\ m^2$

Discharge rate " Q " in m^3 / s

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Total head " H " in m

I =10(Delivery Pressure + Vacuum head)

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Data: Energy meter constant E.M.C. = 6400 pulses/kw-h

CALCULATIONS:

7. Electrical input = P X 3600 X 1000 / EMC X t X 746 Horse power
8. HP. OUTPUT = Efficiency x H.P. INPUT
9. Discharge Q = A*R / t
10. Total head = 10*[$P_d + P_s / 760$] +1
11. Pump output = ρQH / 75
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Table of calculations

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