FLUID DYNAMICS LABORATORY

LAB MANUAL

Subject Code	**:**	**AAEB05**
Regulations	**:**	**IARE-R18**
Class	**:**	**II Year I Semester (AE)**

Department of Aeronautical Engineering

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad

INSTITUTE OF AERONAUTICAL ENGINEERING

(AUTONOMOUS)

Dundigal, Hyderabad - 500 043

Certificate

This is to certify that it is a bonafied record of practical work done by Sri/Kum. ____________________________________ bearing the Roll No. _____________________ of ___________ class _______________________________________ branch in the Engineering Physics laboratory during the academic year __________________ under our supervision.

Head of the Department **Lecture In-Charge**

External Examiner **Internal Examiner**

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FLUID DYNAMICS LABORATORY

OBJECTIVE:

Theobjectiveofthislabistoteach students,the knowledge of various flow meters and the concept of fluid mechanics. This lab helps to gain knowledge on working of centrifugal pumps, positive displacement pumps,hydraulic turbines. Students will compare the performance of various machines at different operating points.

OUTCOMES:

After completing this course the student must demonstrate the knowledge and abilityto:

1. Analyze the flow discharge through venturimeter and orifcemeter.
2. Understand the effects of friction for various pipe flows.
3. Explain the pipe flow losses in various pipes.
4. Understand the application of Bernoulli's theorem.
5. Understand the concepts od dimensionless numbers in fluid flows.
6. Observe the transition of flow under various circumstances.
7. Understand the impact of jet on different vanes and its applications on impellers.
8. Analyze the power efficiency of a centrifugal pump.
9. Analyze the power efficiency of a reciprocating pump.
10. Differentiate the flow properties around centrifugal pump and reciprocating pump.
11. Analyze the power efficiency and mechanical efficiency of a Pelton wheel.
12. Analyze the power efficiency and mechanical efficiency of a Francis turbine.
13. Differentiate the flow properties and efficiencies of Pelton wheel and Francis turbine.
14. Understand the rate of discharge for flow through weirs.
15. Understand the calculation of discharge for flow through dams.
16. Analyze the flow discharges through different shapes of mouth pieces.

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PROGRAM OUTCOMES

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and researchmethods, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineeringcommunity and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of theengineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

AERONAUTICAL ENGINEERING	
PSO1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products.
PSO2	**Problem solving skills**: imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles.
PSO3	**Practical implementation and testing skills**: Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies.
PSO4	**Successful career and entrepreneurship**: To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats.

ATTAINMENT OF PROGRAM OUTCOMES &CLO’s

Expt. No.	Experiment	Program Outcomes Attained	CLO’s
1	Caliberation of venturimeter and orificemeter	PO 1	CLO 1
2	Determination of pipe flow losses in rectangular and circular pipes	PO 1	CLO 2, CLO 3
3	Verification of Bernoullis theorem	PO 2	CLO 4
4	Determination of Reynolds Number of fluid flow	PO 1, PO 2	CLO 5, CLO 6
5	Study Impact of jet on Vanes	PO 1, PO 2	CLO 7
6	Performance test on centrifugal pumps	PO 2, PO 3	CLO 8, CLO 10
7	Performance test on reciprocating pumps	PO 2, PO 3	CLO 9, CLO 10
8	Performance test on pelton wheel turbine	PO 2, PO 3	CLO 11, CLO 13
9	Performance test on Francis turbine	PO 2, PO 3	CLO 12, CLO 13
10	Rate of discharge Flow through Wires	PO 2, PO 3	CLO 14
11	Flow through rectangular and V-Notch	PO 1, PO 2	CLO 15
12	Flow analysis of different shapes of mouth pieces	PO 1, PO 2	CLO 16

EXPERIMENT- I
CALIBERATION OF VENTURIMETER AND ORIFICEMETER

AIM:

To determine the coefficient of discharge of venturi meter and orifice meter.

APPARATUS:

A pipe provided with inlet and outlet and pressure tapping and venturi in between them, Differential u-tube manometer, Collecting tank with piezometer, Stopwatch, Scale,A pipe provided with inlet and outlet and pressure tapping and Orifice in between them

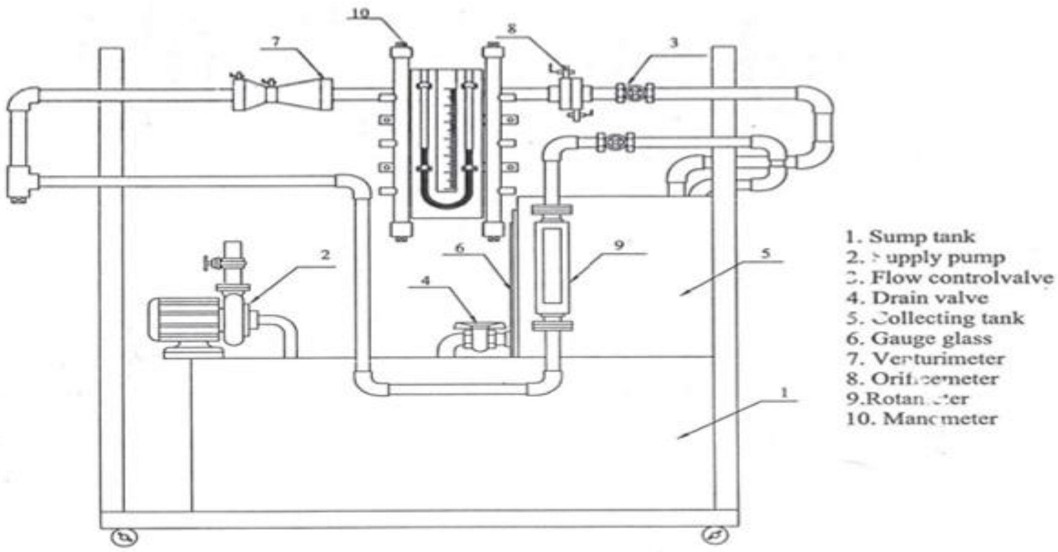
THEORY:

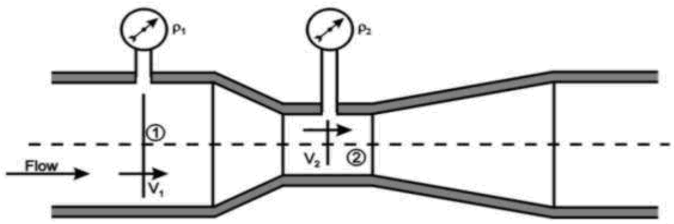
Venturi, the Italian engineer, discovered in 1791 that a pressure difference related the rate of flow could be created in pipe by deliberately reducing its area of cross-section. The modern version of the venturi meter was first developed and employed for measurement of flow of water by Clemens Herschel in 1886. Venturi meter continues to be the best and most precise instrument for measurement of all types of fluid flow in pipes. The meter consists of a short length of gradual convergence throat and a longer length of gradual divergence. The semi-angle of convergence is 8 to 10 degrees and the semi-angle of divergenceis3 to 5 degrees. By measuring the difference in fluid pressure becore and after throt the flow rate can be obtained from Bernoulli's equation.

An orifice plate is a thin plate with a hole in it, which is usually placed in a pipe. When a fluid passes through the orifice, its pressure builds up slightly upstream of the orifice, but as the fluid is forced to converge to pass through the hole, the velocity increases and the fluid pressure decreases. A little downstream of the orifice the flow reaches its point of maximum convergence, afterd that, the flow expands, the velocity falls and the pressure increases. By measuring the difference in fluid pressure across tappings upstream and downstream of the plate, the flow rate can be obtained from Bernoulli's equation

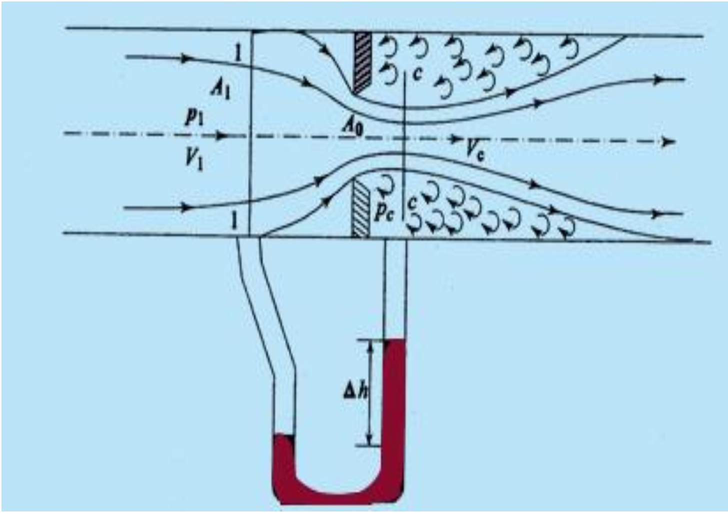
PROCEDURE:

1. The pipe is selected for conducting venturimeter experiment.
2. The motor is switched on, as a result water will flow
3. According to the flow, the ccl4 level fluctuates in the U-tube manometer
4. The reading of H1 and H2 are noted
5. The time taken for 5 cm rise of water in the collecting tank is noted
6. The experiment is repeated for various flow in the same pipe
7. The co-efficient of discharge is calculated
8. The same procedure is followed for conducting orifice experiment





Venturimeter



Orifice meter

TABULARCOLUMN:

VENTURIMETER:

S.NO	Manometric head			Time taken for h cm raise of water in tank t	Theoretical Discharge (Q_t) m^3/sec	Actual Discharge (Q_a) m^3/sec	Coefficient of discharge $C_d = Q_a/Q_t$
	h_1	h_2	h_w				

ORIFICEMETER:

S.NO	Manometric head			Time taken for h cm raise of water in tank t	Theoretical Discharge (Q_t) m^3/sec	Actual Discharge (Q_a) m^3/sec	Coefficient of discharge $C_d = Q_a/Q_t$
	h_1	h_2	h_w				

CALCULATIONS:

t = Time taken for h cm raise of water in tank

h_1= Manometric head in first limb m

h_2 = Manometric head in second limb m

h_w= Venturi head in terms of flowing liquid m

$= (h_2-h_1) \times \{\frac{\text{Specific gravity of ccl 4}}{\text{specific gravity of water}}-1\}$

Specific gravity of carbon tetra chloride (ccl_4) = 1.6

Specific gravity of water = 1

Diameter of the pipe = 4 cm

Diameter of the throat = 2.4 cm

Area of collecting tank = 50×50 cm^2

Theoretical Discharge (Qt) = K× $\sqrt{h}$ m^3/sec

$K=\frac{a1\times a2\times\sqrt{2g}}{\sqrt{a1^2-a2^2}}$

a_1=area of cross section of pipe

a_2=area of cross section of pipe at throat

Actual Discharge (Q_a) = [Volume of water collected in tank/time taken to collect water]

= [Area of tank × height of water collected in tank]/ t

Coefficient of discharge $C_d = Q_a/Q_t$

PRECAUTIONS:

RESULT:

Viva questions:

1. What is discharge?
2. What is continuity equation?
3. Write Bernoulli's equation?
4. Give formula for experimental discharge?
5. What is coefficient of discharge?
6. Derive expression for theoretical discharge?

EXPERIMENT - II
DETERMINATION OF PIPE FLOW LOSSES IN RECTANGULAR AND CIRCULAR PIPES

AIM:

To determine the Darcy's friction factor (f) of the given pipe

APPARATUS:

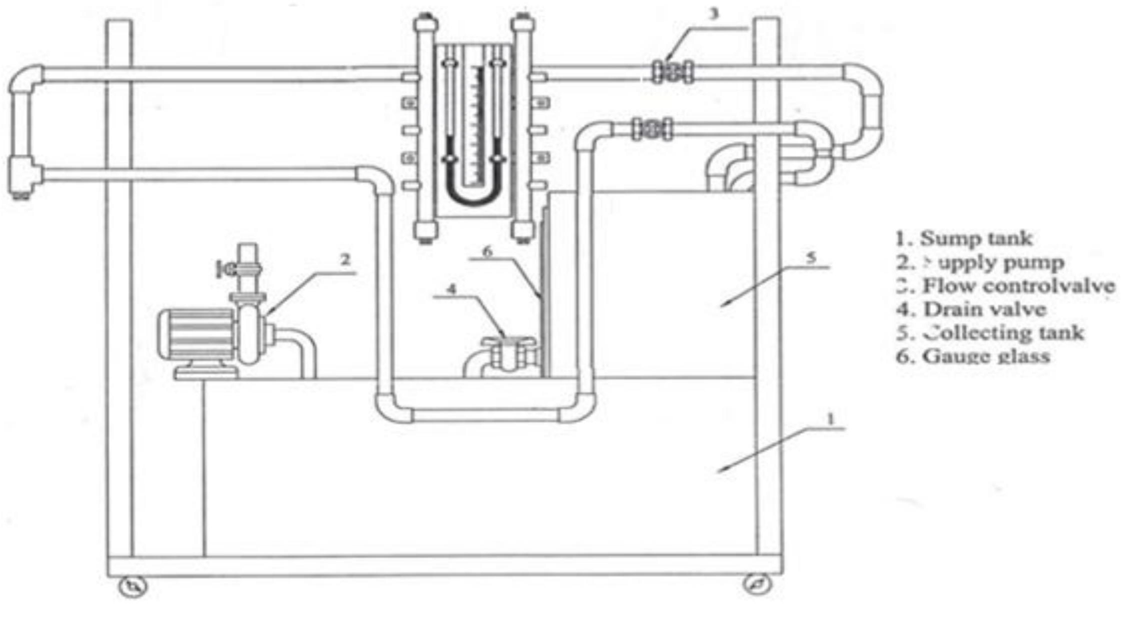
A pipe provided with inlet and outlet and pressure tapping, Differential u-tube manometer, collecting tank with piezometer, Stopwatch, Scale.

DESCRIPTION:

When the fluid flows through a pipe the viscosity of the fluid and the inner surface of the pipe offer resistance to the flow. In overcoming the resistance some energy of the flowing fluid is lost. This is called the major loss in pipe flow. Boundary roughness, which has little significance in laminar flow, plays an important role in turbulence. This, together with transverse momentum exchange of fluid particles due to the perpetual turbulent intermixing, are the main sources of tangential or shear stresses in turbulent flow. Various equations have been proposed to determine the head losses due to friction. These equations relate the friction losses to physical characteristics of the pipe and various flow parameters.

PROCEDURE:

1. The pipe is selected for doing experiments
2. The motor is switched on, as a result water will flow
3. According to the flow, the mercury level fluctuates in the U-tube manometer
4. The reading of H1 and H2 are noted
5. The time taken for 5cm rise of water in the collecting tank is noted
6. The experiment is repeated for various flow in the same pipe
7. The co-efficient of discharge is calculated



SCHEMATIC DIAGRAM

TABULARCOLUMN:

RECTANGULAR PIPE:

S.NO	Manometric head			Time taken for h cm raise of water in tank t sec	Discharge (Q) m^3/sec	Velocity (v) m/sec	Friction factor (f)
	h_1	h_2	h_f				

CIRCULAR PIPE:

S.NO	Manometric head			Time taken for h cm raise of water in tank t sec	Discharge (Q) m^3/sec	Velocity (v) m/sec	Friction factor (f)
	h_1	h_2	h_f				

CALCULATIONS:

Friction factor (f) = $\frac{2 \times g \times D \times hf}{4l \times v2}$ Where,

g = Acceleration due to gravity (m / sec^2)

$D_{\text{for circular pipe}} = 4x \frac{cross\ sectional\ area}{wetted\ perimeter} = 4x \frac{\pi r^2}{\pi d} = d$

d= Diameter of the pipe = 2cm

$D_{\text{for squarer pipe}} = 4x \frac{cross\ sectional\ area}{wetted\ perimeter} = 4x \left[\frac{w x h}{2x(w+h)}\right]$

w= 2cm ,width of pipe, h= 2cm , height of pipe(for a square)

l = Length of the pipe = 200cm

v = Velocity of liquid following in the pipe (m / s)

h_f = Loss of head due to friction (m)

= $(h_2-h_1) \times \{\frac{\text{Specific gravity of Hg}}{\text{specific gravity of water}} - 1\}$ Where

h_1 = Manometric head in the first limbs

h_2 = Manometric head in the second limbs

Actual Discharge $Q = \frac{A \times h}{t}$ (m^3 / sec)

Where

A = Area of the collecting tank (m^2)

h = Rise of water for 5 cm (m)

t = Time taken for 5 cm rise (sec)

Also

Q=Velocity in the pipe X Area of the pipe

= v X a

V = Q/a

PRECAUTIONS:

RESULT:

Viva questions:

1. Derive Darcy's equation?
2. Draw and explain pipe friction apparatus with neat sketch?
3. Write a formula for minor loses and major loses of pipe?
4. Write a formula for pressure head H?
5. What is area of wetted perimeter?

EXPERIMENT-III

VERIFICATION OF BERNOULIS THEOREM

AIM:

To verify the Bernoulli's theorem.

APPARATUS:

A supply tank of water, a tapered inclined pipe fitted with no. of piezometer tubes point, measuring tank, scale, and stop watch.

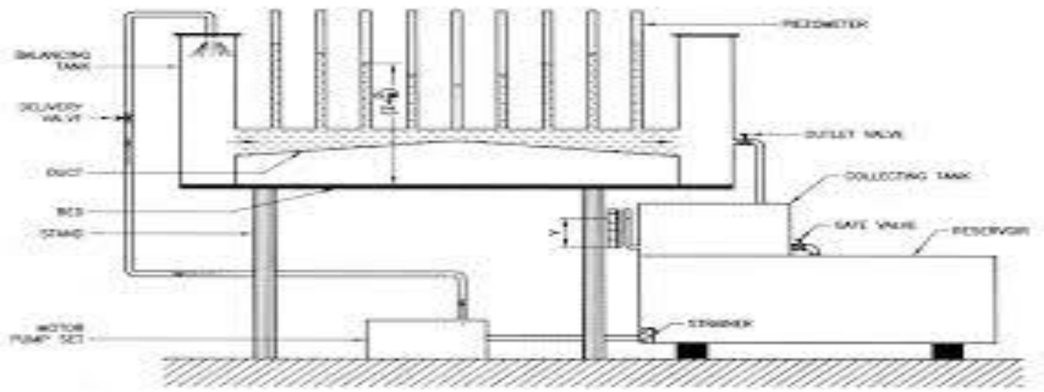
THEORY:

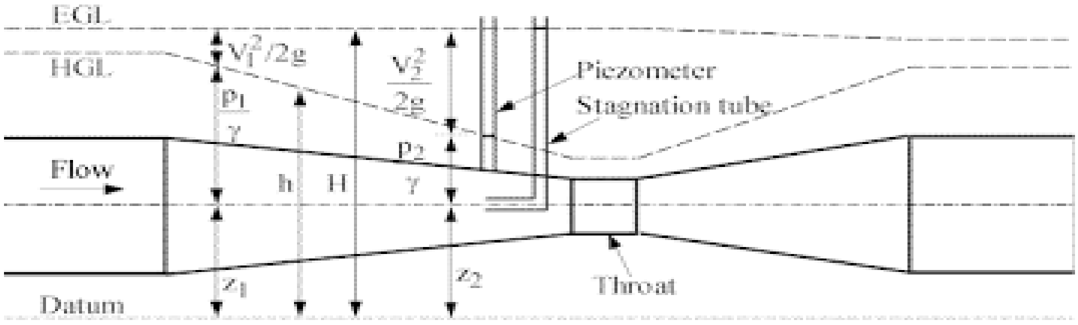
Bernoulli's theorem states that when there is a continues connection between the particle of flowing mass liquid, the total energy of any sector of flow will remain same provided there is no reduction or addition at any point. I.e. sum of pressure head and velocity head is constant.

PROCEDURE:

1. Open the inlet valve slowly and allow the water to flow from the supply tank.
2. Now adjust the flow to get a constant head in the supply tank to make flow in and outflow equal.
3. Under this condition the pressure head will become constant in the piezometer tubes. Note down piezometer readings.
4. Note down the quantity of water collected in the measuring tank for a given interval of time.
5. Compute the area of cross-section under the piezometer tube.
6. Compute the values of velocity head and pressure head.
7. Change the inlet and outlet supply and note the reading.
8. Take at least three readings as described in the above steps.

SCHEMATIC DIAGRAM





Throat

TABULARCOLUMN:

S.NO	**Pizeometer Reading**	**time for 5cm rise**	**Discharge Q**m^3/sec	**Pressure Head** m	**Velocity Head** m	**Datum head** m	**Total Head**

S.NO	**Pizeometer Reading**	**time for 5cm rise**	**Discharge Q**m^3/sec	**Pressure Head** m	**Velocity Head** m	**Datum head** m	**Total Head**

S.NO	Pizeometer Reading	time for 5cm rise	Discharge Qm^3/sec	Pressure Head m	Velocity Head m	Datum head m	Total Head

CALCULATIONS:

Pressure head = $\frac{P}{\rho g}$ m

Velocity head = $\frac{v2}{2g}$ m

Datum head = Z = 0 m (for this experiment)

Velocity of water flow = v

Q (Discharge) = [Volume of water collected in tank/time taken to collect water]

= [Area of tank × height of water collected in tank]/ t m^3/sec

Also

Q= velocity of water in pipe × area of cross section = v × A_x m^3/sec

Area of cross section (A_x) = A_t + [$\frac{(Ai-At)\times Ln}{L}$] m^2

A_t = Area of Throt

A_i = Area of Inlet

Dia of throt = 25mm

Dia of inlet = 50mm

L_n= distance between throt and corresponding pizeometer

L=length of the diverging duct or converging duct = 300mm

Distance between each piezometer = 75mm

Total Head = $\frac{P}{\rho g} + \frac{v2}{2g} + Z$

PRECAUTIONS:

RESULT:

Viva questions:

1. Write Bernoulli's equation?
2. What are assumptions of Bernoulli's equation?
3. Write Euler's equation?
4. Explain about a C.D nozzle?
5. What is pitot static tube, and peizometer?

EXPERIMENT-IV
DETERMINATION OF REYNOLDS NUMBER OF FLUID FLOW

AIM:-To find critical Reynolds number for a pipe flow.

APPARATUS :- Flow condition inlet supply, elliptical belt type arrangement for colouredfluid with regulating valve, collecting tank.

FORMULA :- Reynolds No = Inertia force/Viscous force

Reynolds Number:- It is defined as ratio of inertia force of a flowing fluid and the viscous force of the fluid. The expression for

Reynolds number is obtained as:-

Inertia force (Fi) = mass . acceleration of flowing

= δ. Volume. Velocity/ time
= δ. ±5*3L4 27L4 Velocity

= δ.area .Velocity . Velocity
= $\delta.A\ .V^2$

Viscous force (Fv) = Shear stress . area

= τ. A

= μ. du/dy . A

= VA/τ

By definition Reynolds number:-

Re= Fi/Fu

= δAV2/μ/t.A

= V.L /μ/s

= V.L /v { v = μ/ ρis kinematics viscosity of the fluid } In case of pipe flow, the lineardimension L is taken as dia (d) hence Reynolds number for pipe flow is :-

Re = V .d /v or

Re = ρVd /v

PROCEDURE:-

1. Fill the supply tank some times before the experiment.
2. The calculated fluid is filled as container.
3. Now set the discharge by using the valve of that particular flow can be obtained.
4. The type of flow of rate is glass tube is made to be known by opening the valve of dye container.
5. Take the reading of discharge for particular flow.

Using the formula set the Reynolds no. for that particular flow, aspect the above procedure for all remaining flow

OBSERVATION:-

Type	Time	Discharge				$Q=m^3/3$	$R_e=4Q/\pi\Delta V$
		initial	Final	Difference	Volume		

PRECAUTIONS:-

1. Take reading of discharge accurately.
2. Set the discharge value accurately for each flow.

RESULT:-

Viva questions

1. Reynolds number importance?
2. Describe the Reynolds number experiments to demonstrate the two type of flow?
3. Define laminar flow, transition flow and turbulent flow?

EXPERIMENT-V

IMPACT OFJETSONVANES

AIM: To find the coefficient ofimpact of jet onvanes.

APPARATUS: Impactofjetonvanesexperimentaltest rig,Flatvane,curvedvane,Dead weights,stop watch.

THEORY:A jet of fluid emerging from a nozzle has somevelocityand henceitpossesses acertainamountof kinetic energy.If thejet strikes an obstruction placed in its path, it will exert forceon obstruction. This impressed forceis known as impact of jet and it is designated as hydrodynamic force, in order to distinguish itfrom the forcedueto hydrostaticpressure. sinceadynamic forceis exerted byvirtueof fluid motion, it always involves a changeof momentum, unlikeaforcedueto hydrostaticpressurethat implies no motion.

PRINCIPLE: Theimpulse momentumprinciplemaybeutilized to evaluatethehydrodynamic force exerted on abodybya fluid jet.

(1)When jet strikes a stationaryFlat vane

In this casethe flat vaneis stationaryand jet strikes on it at the middle and then splits in two parts leaves the corners tangentiallyso

$F=\rho av^2(1+\cos\theta)$

The forceofImpact will be maximum if the angleof declination is $\theta=90°$

ForFlat vane $\frac{\rho av2}{g}$ For

curved vane=

$\frac{\rho av2}{g}(1+cos\theta)$

PROCEDURE:

1. Fixthe vaneto be tested insidethe testing chamberbyopeningthen transparent door provided.Close the door and tighten thelock.

2. Notethe initial readingon the scale.

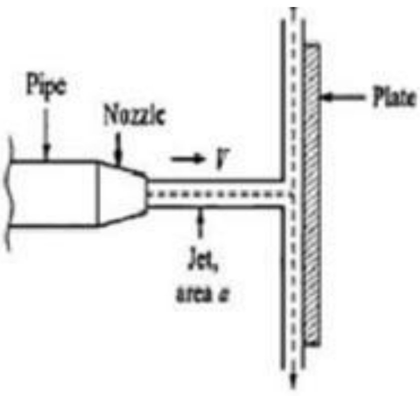
3. Open the inlet water.Thewater jet from thenozzle strikes on vanegetsdeflectedand drains backto collectingtank.

4 .Close the collectingtank drain valve and notedown thetime taken for2cm rise in waterlevel in the collectingtank. Open thedrain valve.

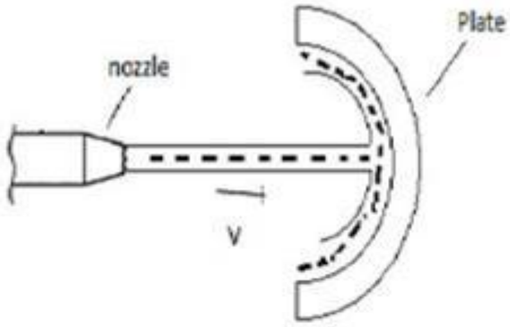
5. Add dead weight to bringthepointer back to theinitial readingon the scale. Note down the dead weights.

6. Repeat the experimentfordifferent flowrates byadjustingthe position of theinlet valves and for different vanes.

SCHEMATIC DIAGRAM:



Flat plate



Hemispherical plate

OBSERVATIONANDCALCAULATIONTABULAR COLUMN:

(i) Flatvane:

S.NO	Weight (grams)	F_a(Actual force) N	Ft(Theoretical force(N)	Velocity (m/s)	t (Time taken forh cmrise of waterin the tank	Q= $\frac{A \times h}{t}$ m^3/s	K
1	100						
2	150						
3	200						
4	250						

(ii)curvedvane:

S.NO	Weight (grams)	F_a(Actual force) N	Ft(Theoretical force(N)	Velocity (m/s)	t (Time taken forh cmrise of waterin the tank	Q= m^3/s	K
1	100						
2	150						
3	200						
4	250						

Calculations:

Theoretical force (N):$F_t=\rho a v^2(1+\cos\theta)$ ForFlat vane(θ=90)=$\frac{\rho a v2}{g}$

For curved vane=$\frac{\rho a v2}{g}(1+cos\theta)$

Wherediameterof nozzle=1cm

Areaof collectingtank= $\frac{AR}{t}$ m^3/s

WhereA=Areaof collectingtankm^2

R=risein waterlevel.m

Coefficient of impact on vanes= $\frac{Fth}{Fa}$

PRECAUTIONS:

1. Flow should besteadyand uniform.
2. Readings on thescale should takenwithouterror.
3. Weight should be kept in the hanger slowly

RESULT:

The coefficient of impact of jet on vanes forFlatvaneis .

The coefficient of impact of jet on vanes forCurved vaneis .

Viva questions:

1. Define the terms impact of jet and jet propulsion?
2. Find the expression for efficiency of a series of moving curved vane when a jet of water strikes the vanes at one of its tips?

EXPERIMENT-VI

PERFORMANCETEST ON CENTRIFUGAL PUMP

AIM : To find the efficiencyand draw theperformance curves ofcentrifugal pump.

APPARATUS: Centrifugal pump test rig, energymeter to measurethe input electricalenergy, pressure gauges (Suction and delivery), stop watch.

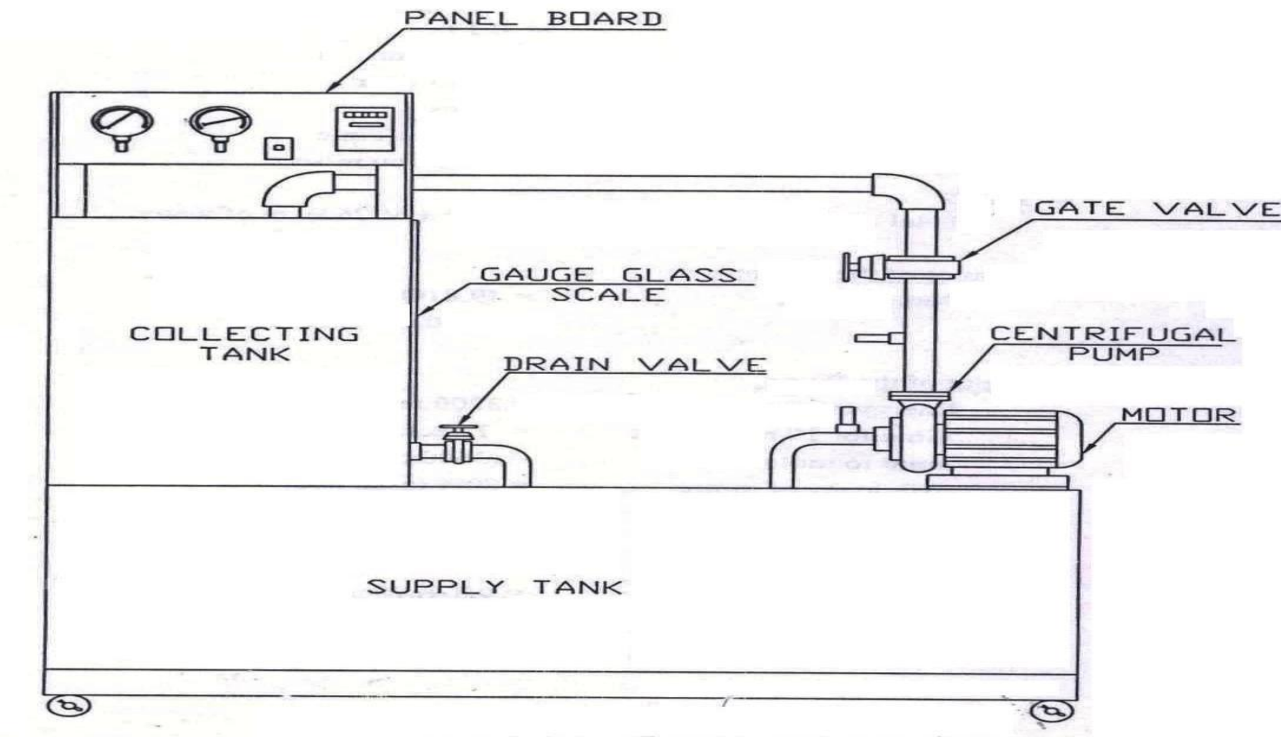
THEORY:

Thepump which raiseswaterfrom lowerlevel to higher level bythe action centrifugal forceis known as centrifugal pump. Thepump lifts waterbecause ofatmosphericpressureactingon the surfaceof thewater. A centrifugal pump is rotodynamicpump that usesa rotatingimpeller to increasethepressureofthefluid.It works byrotational kinetic energy, typicallyfroman electricmotorto an increasethe staticfluid pressure. Theyare commonlyusedto moveliquid through apipingsystem.

Fluid enters axiallythrough the middleportion ofthe pump calltheeye,after which it encounters the rotatingblades.It acquires tagentialand radial velocitybythe momentum transferwith impellerblades and acquiresadditional radialvelocitybycentrifugal force.

PROCEDURE

1.Primethe pump, close the deliveryvalveand switch on the unit.
2.Open the deliveryvlave and maintain the requird deliveryhead.Notethereading.
3.Notethe corresponding suction head pressurereading..
4.Measuretheareaof the collectingtank.
5.Close thedrain thevalve and note down thetimetaken for 10cm rise ofthewaterlevel in the collecting tank.
6.Fordifferent deliveryheads repeat theexperiment.
7.For everyset ofreadingnote thetime taken for10 revelutions of Energymeter



OBSERVATION&CALCULATIONTABULAR COLUMN:

S.NO	Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mmof Hg(P_s)	Timefor 3 rev of Energy meter seconds (t_e)	Timefor10 cmrise in collecting tank(t) seconds	Discharge (Q) m^3/sec	Input Power Pi KW	Output Power Po KW	Efficiency%
1								
2								
3								
4								

CALCULATIONS:

Thetotal effectivehead H in meters ofWorking of centrifugal pump

Total head

$$H=H_s+H_d+Z$$

Sincethe deliverypressureis in kg/cm2and suction gaugepressureareinmmof Hgthe total head developed bythe pump to be converted in to meters ofwater column.

WhereHd=Deliveryhead

Hs =Suction head

Z= Friction loss

H_s=m

$$H_d=\frac{P_d x 9.81x10^2}{9.81x1000} m$$

Friction loss Z=2.2 m

Note: Thevelocityand thelossof head in thesuction pipe areneglected

Weknow thedischarge **Q=** $\frac{A\times h}{t}$ m^3/s

Thework donebythepump is given byKW

OutputpowerP$_o$= $\frac{\rho QgH}{1000}$ KW

Input powerP$_i$= $\frac{3600xN}{Ext_E}$ KW

E-Energymeter constant=150

t_E=time for3revolutions of Energymeter.

N-no of Revolutions.

The efficiencyof the centrifugal pump=

Ƞ=Po/Pi x100%.

GRAPHS:

1)Plot Pi and Po versusSpeed N

2) Head versus Speed N

3) Speed versus Efficiency.

4) Head vs Discharge

PRECAUTIONS:

1.Close thedeliveryvalvebeforestartingthe pump.

2.Takereadingscorrectly

RESULTS:

Theperformancecharacterstics of centrifugal pump arestudied and the maximum efficiencywas found to be .

.

Viva Questions:

1.What is a pump?
2.What is a centrifugal pump?
3.what are forces involved in impeller?
4.What is priming?

EXPERIMENT-VII

PERFORMANCETESTONRECIPROCATINGPUMP

AIM: To studythe performancecharacteristics of Reciprocatingpump and to findslip.

APPARATUS: ReciprocatingtestRig,Pressuregaugesattheinletanddeliverypipes,Energymeterto measurethe input electrical energy, stopwatch ,Tachometer.

THEORY: Reciprocating pumps are positive displacement pump as a definite volume of liquid is trapped in a chamber which is alternatively filled from the inlet and empited at a higher pressure through the discharge. The fluid enters a pumping chamber through an inlet and is pushed out through outlet valve by the action of piston. They are either single acting independent suction and delivery strokes or double acting suction and delivery both the directions. Reciprocating pumps are self priming pumps and are suitable for very high head at low flows.They deliver reliable discharge flows and is often used for metering duties because of constancy of flow rate..

DESCRIPTION: Itconsistofadoubleactionreciprocatingpumpofsize25x20mmwithaairvesselcoupledto 1HP, 1440Rpm, collectingtankwitha piezometer.

PROCEDURE:

1.Keepthedeliveryvalveopenandswitchonpumpslowly closethedelivery valveandmaintainaconstant head.
2.Notethe deliveryand suction pressuregaugereading.
3.Notethe time for10 revolutions of Energymeter.
4.Notethe time for10cmrise in waterlevelin collectingtank.
5.Notethe speed of thepump.
5.Repeat the test for4 other different head.

OBSERVATION&CALCULATION TABULAR COLUMN:

S.NO	Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mmof Hg(P_s)	Time for3 revof Energy meter (t_e)sec	Timefor 10cmrise in collecting tank (t)sec	Speed Np Rpm	Discharge (Q)m^3/sec	Input Power P_i KW	Output Power P_o KW	η %
1									
2									
3									
4									
5									

CALCULATIONS:

Strokelength of thepump (L) =0.045m
Bore(d)=0.04m
Piston area (a) =(π/4) × $(0.04)^2$

Areaof the collectingtank (A) =50 X 50cm^2
Np=speed of mortarin rpm

To findthe percentageofslip = $\frac{Qt - Qa}{Qt} \times 100$

Q_t=theoretical discharge= $\frac{2L \times a \times Np}{60}$ m/sec

Q_a=Actual discharge=Q= $\frac{A \times h}{t}$ m/sec

A =Areaof thecollectingtank
t = time for (h) risein waterlevel.

To find theoverall efficiencyof thepump = P_o/P_i

Input power P_i= $\frac{3600 \times N}{E \times te}$Kw

Wher
e
N =Number of blinks of energymeterdisc
E =Energymeter constant = 1600 (rev / Kw hr)
T =time taken for'Nr' revolutions (seconds)

Output power P_o= $\frac{\rho \times g \times Q \times H}{1000}$Kw

Where
,
ρ =Densityof water =1000 (kg/ m³)
g=Acceleration dueto gravity=9.81(m /s^2) H =Total head of water (m)
H =suction head(H_s) + deliveryHead (H_d) +Datum Head
Where H_d=deliveryhead= $\frac{P_d x 9.81 x 10^4}{\rho x g}$ m

H_s=suction head m
Z=Friction loss=2.2 m

GRAPHS:

1. Actual dischargeVs Total head
2. Actual dischargeVs Efficiency
3. Actual dischargeVsInput power
4. Actual dischargeVs Output power

RESULT: Theefficiencyofthereciprocatingpumpis.Tostudyanddrawthecharacteristics curves.

EXPERIMENT VIII

PERFORMANCE TESTON PELTON WHEEL

AIM: To draw the followingcharactersticcurvesof pelton wheel under constant head.

APPARATUS :

1. Venturimeter2. Stopwatch 3. Tachometer4. Dead weight

DESCRIPTION:

Pelton wheel turbine is an impulse turbine, which is usedto act on high loads and forgeneratingelectricity. All the available heads are classified into velocityenergy(i.e) kinetic energybymeans of spear andnozzle arrangement. Position of thejet strikes the knife-edgeof thebuckets with least relativeresistances and shocks. Whilepassingalongthe buckets thevelocityof thewateris reduced and hence an impulse forceis supplied to the cups which in turn aremovedandhenceshaft is rotated.Pelton wheel is an impulseturbine which is used to utilizehigh heads forgeneration of electricity.Itconsistsof arunner mountedon ashaft.
To this a brakedrum is attached to applybrakes over thespeed of theturbine. A casingis fixed overthe runner. Allthe availablehead is converted into velocityenergybymeans of spearand nozzle arrangement. Thespearcan bepositioned in 8 places that is, 1/8,2/8, 3/8, 4/8, 5/8 6/8, 7/8and 8/8 of nozzle opening. The jet ofwaterthen strikes the buckets of the Peltonwheel runner. Thebuckets arein shapeofdouble cups joined at middleportion. Thejet strikes the knife edgeof thebuckets with least resistance and shock. Thejet isdeflected through morethan 160˚to 170˚. Whilethe specific speed of Pelton wheel changes from 10 to100 passingalongthe buckets, thevelocityof water is reduced and hencetheimpulsive forceis supplied tothe cups whichin turn aremoved and hencethe shaft is rotated. Thesupplyofwateris arranged bymeans of centrifugal pump. Thespeed of turbine is measured with tachometer.

CONSTRUCTIONALFEATURES:

CASING:casingis fabricated from MS Plates with integralbaseis provided.
RUNNER: Runner is madeof steel and machined preciselyandfixed to horizontal shaft.Thebucket resembles to a hemispherical cup with adividing wallinits centerin the radial direction ofthe runner.The buckets are arranged uniformlyon the peripheryof therunner.The compactassembly Nickel plated toprevent corrosion and to haveasmooth finish.
NOZZLE ASSEMBLY: Nozzle assemblyconsist essentiallyofaspear, ahand wheeland the input pipe.The waterfrom the supplypump is madeto pass through the nozzle beforeitenters the turbine.shaftis madeof stainlesssteel and carriesthe runnerand brakedrum.
Brakearrangement : Brake arrangementconsist of machined and polishedbrakedrum,coolingwaterpipes internal water scoop, dischargepipe springbalance, dischargepipe,spring balance, beltarrangement supportingstand.
Baseframe: Base frame is madeis madeof MS channel forsturdyconstruction and itis an integral part of the casing.

TECHANICALSPECIFICATIONS: TURBINE:
1. Rated supplyhead-40m.
2. Discharge-660Lpm.
3. Rated speed-800 Rpm.
4. Runner outside diameter-300m.
5. No ofpelton buckets-20 No’s
6. Brakedrum diameter-300m
7. Power output-3.5

HP SUPPLY PUMP:
Centrifugal pump Multista

FLOWMEASURINGUNIT:

Venturimeter
Convergent diameter-65mm.
Throat diameter-39mm.
Pressureguage-7 kg/cm^2

PROCEDURE:

1. Graduallyopen the deliveryvalve of thepump.
2. Adjust the nozzle openingat about½ th of the openingbyoeratingthe spear valvebyHandwheel.
3. Thehead should bemade constant byoperating the deliveryvalveand thehead should bemaintainedat constant value.
4. Observethe speed of the turbineusingthetachometer.
5. Observethereadings of $h_1$and $h_2$corresponding the manometric fluid in thetwo limbs,whichare connected to the venturimeter.
6. Adjust the load on the brakedrum;notethe speedofthe turbine usingtachometer and springbalance reading.
7. Repeat the experiment fordifferent loadings

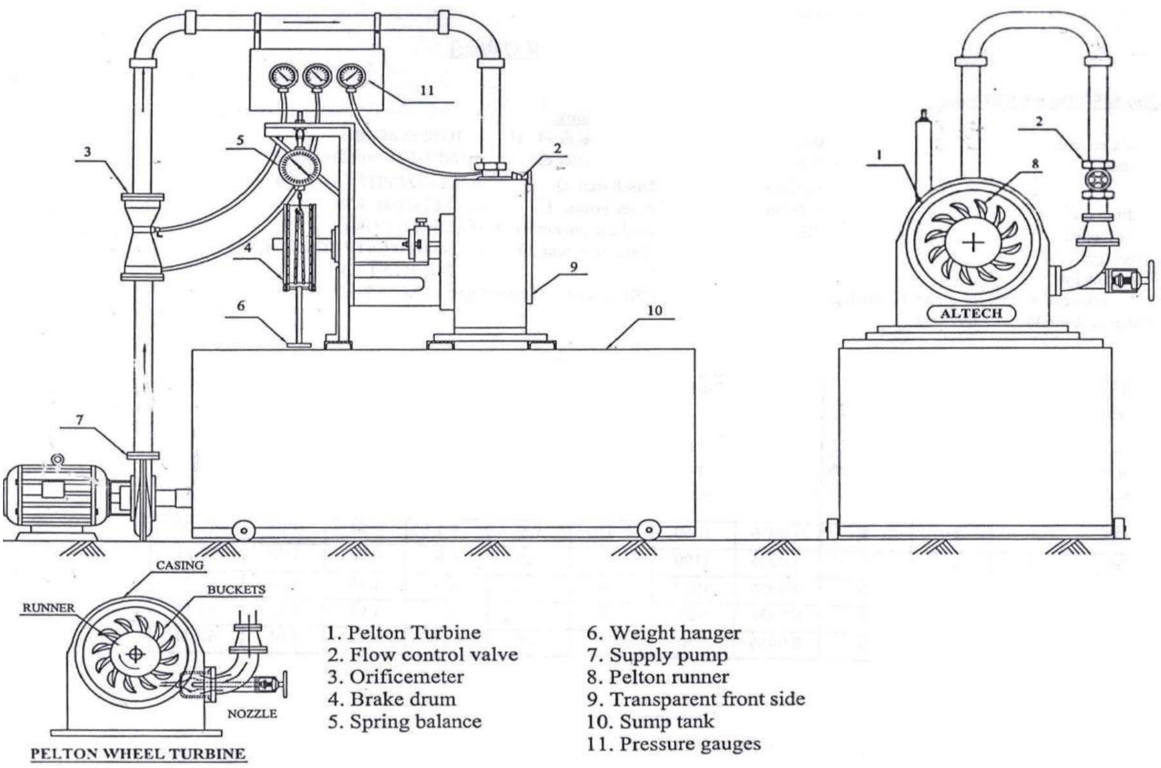
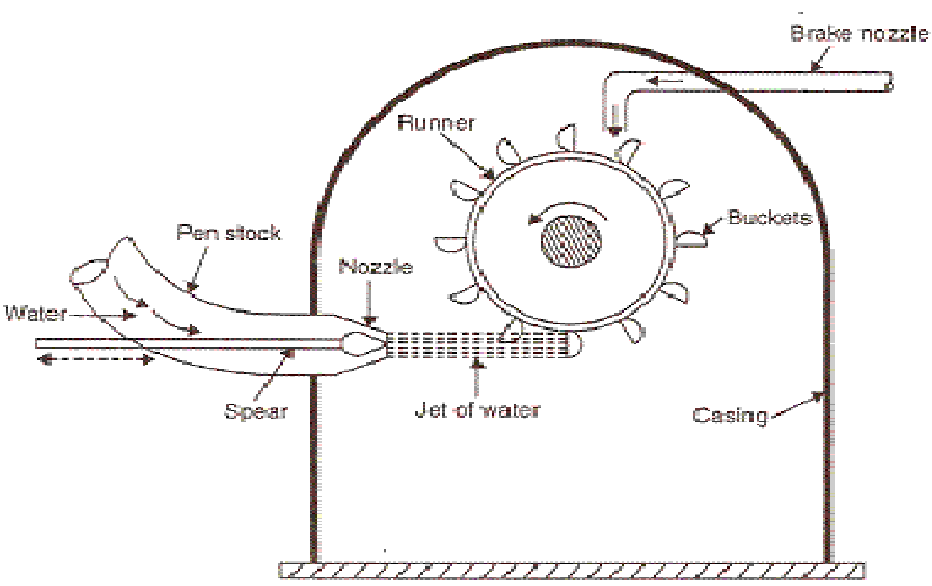


Fig: schematic representation ofPelton wheel



OBSERVATION&CALCULATIONTABULAR COLUMN(MECHANICALLOADING):

S.NO	Gate opening	Pressure Gauge (Kg/cm^2)	Vacuu m Gauge (mm of Hg)	Manometer Readin		Speed of Break drum Dynamometer 'N'(Rpm)	Spring Balance		Power Output (P (KW)	Power Input (P)(KW)	Efficiency 'η' (%)
				h_1(cm)	h_2(cm)		T_1(kg)	T_2(kg)			
1											
2											
3											
4											

S.NO	Load (KW)	Voltammeter (V)	Current (A)	Power (KW)	Speed of Break Drum Dynamometer 'N'Rpm	Efficiency 'η' (%)
1						
2						
3						
4						
5						

OBSERVATIONS:

Venturimeterinlet Diameter, d1=65 mm.

Venturimeterinlet area, a1 =.

Venturimeter throat diameter ,d2=39mm.

Venturimeterthroat area, a2 = .

Speed(N)= __________

Diameter ofbrakedrum, D =300mm

CALCULATIONS:

Inlet Pressure, P =Kg/cm2

Vaccumgauge =mmofHg

Q=DischargeQ=C_d $\frac{a1 \times a2 \times \sqrt{2gh}}{\sqrt{a1^2 - a2^2}}$

WhereC_d-0.98

h-Manometricdifference=h_1-h_2[$\frac{s1}{s2}$-1]

wheres_1-specificgravityof mercury-13.6

s_2-specificgravityof water-1

Head, H = head available at the turbine (pressure head in terms of water column).

Outputpower(P_o)=$\frac{2\pi \times N \times T}{60}$watts

Inputpower(P_i)=($\rho \times g \times Q \times h$)W

T=(T_1-T_2)×g× radiusofbreakdrumN-m

T_1=loadappliedonBrakedrumdynamometer(Kg).

T_2=loadappliedonBrakedrumdynamometer(Kg).

RadiusOfbreakdrum=0.15m.

N=speedof BrakedrumDynamometer(Rpm). Efficiencyof theturbineη_m%=P_o/P_i

Electricalefficiency= η_e%=p_o/ P_i

p_o=electricaloutput=V× Iw.

GRAPHS:

1. Speedvs.efficiency
2. Dischargevs.powerinput
3. Inputpowervs.Speed
4. Outputpowervsspeed
5. HeadvsSpeed

PRECAUTIONS:

1.Deliveryvalveshouldclosedbeforestartof theturbinevalve.

2.Don’tapplyMechanicalloadingwhenElectricalloadingisperformed.

3.Notedownthereadingscarefully.

4.Maintainthegateopeningconstantlythroughttheexperimentfor(constantheadopenings)

RESULT:

TheEfficiencyofPeltonwheelatconstantloadis------------. Thecharacteristicscurvesaredrawn.

Viva questions:

1.Classify turbines.

2.Pelton wheel is which type of turbine.

3.what is input energy given to turbine? What are main components of Pelton turbine?

4. Draw velocity diagrams (at inlet and outlet) for Pelton blade

5. Why is Pelton turbine suitable for high heads?

EXPERIMENT- IX

PERFORMANCE TESTON FRANCIS TURBINE

AIM: To conduct load test on Francis turbine and to studythe characteristics of Francis turbine.

APPARATUS: U-tube manometer,Tachometer.

TECHANICAL SPECIFICATION:

Supplypump:Rated head-20 m,
Discharge-2000Lps.
Normal speed-1440 Rpm
Power required-11.2KW
Sizeof thepump-100x100 mm.
Pump Type: CentrifugalHigh speed singlesuction volute.
Francisturbine:Rated supplyhead-20 m.
Discharge-2000Lps.
Rated speed-1250 Rpm.
Runner diameter-150 mm.
Number ofguidevanes-8.
Brakedrum diameter-300 mm.
Flowmeasuringunit:
Manometer –U-tube differentialcolumn.
Sizeof venturimeter-100mm
Throat diameter-60mm.

DESCRIPTION:

Thewater from the penstock entersascroll casing which completelysurrounds therunner.Thepurposeof the casingis to provide an even distribution around the circumferenceof theturbine runner, maintainingan constant velocityof water.
In order to keep the velocity of water constant throught its path around the runner, the cross-sectional area of casing is gradually decreased.The casing is made up of material depending upon the pressure nto which it is subjectedFrom the scroll casing the water passes through the speed ring consist of upper and lower ringHeld together by a series of fixed vanes called stay vanes. The number of stay vanes is usually taken as half number of guide vanes.

The speed ring has two functions to perform.It directs the water to scroll casing to guide vanesFrancis turbine consists of runner mounted on a shaft and enclosed in a spiral casing with guide vanes. The cross section of flow between the guide vanes can be varied, known as gate opening. It can be adjusted ¼,½, ¾, or full gate opening. A brake drum is fixed to the turbine shaft.

By means of this drum the speed of the turbine can be varied. The discharge can be varied by operating a throttle valve on the pipe line. The water after doing work leaves the turbine through a draft tube and flows down into the tail race. A Venturimeteris fitted to the pipe for measuring discharge.

PROCEDURE:

1. Keep theguide vaneat required opening (say½th)
2. Primethe pump if necessary.
3. Close themain gatevalve and start thepump.
4. Open thegate valve for required discharge
5. Open the brakedrum coolingwatergate valve for coolingthe brakedrum.
6. Notethe Venturimeterpressuregaugereadings
7. Notethe inlet pressuregauge&outlet vacuumgauge readings
8. Notedown applied weights springbalance.
9. Measuretheturbine runner speed inrpm with tachometer.
10. Repeat the experiment fordifferent loadings**.**

OBSERVATIONS:

Venturimeterinlet
Diameter, d=100mm.
Venturimeter throat diameter d=60mm.
Speed (N)=_ Rpm
Radius ofbrakedrum, R = 0.15 m

CALCULATION:

Inlet PressureguageP =Kg/cm2
Outlet VacuumguageV =mmof Hg.
Head, H = head available at the turbine (pressure head in terms of water column)

$$Q = C_d \frac{a1 \times a2 \times \sqrt{2gh}}{\sqrt{a1^2 - a2^2}} m^3/s$$

$$Q = C_d \frac{a1 \times a2 \times \sqrt{2gh}}{\sqrt{a1^2 - a2^2}} m^3/s$$

WhereC_d-0.98

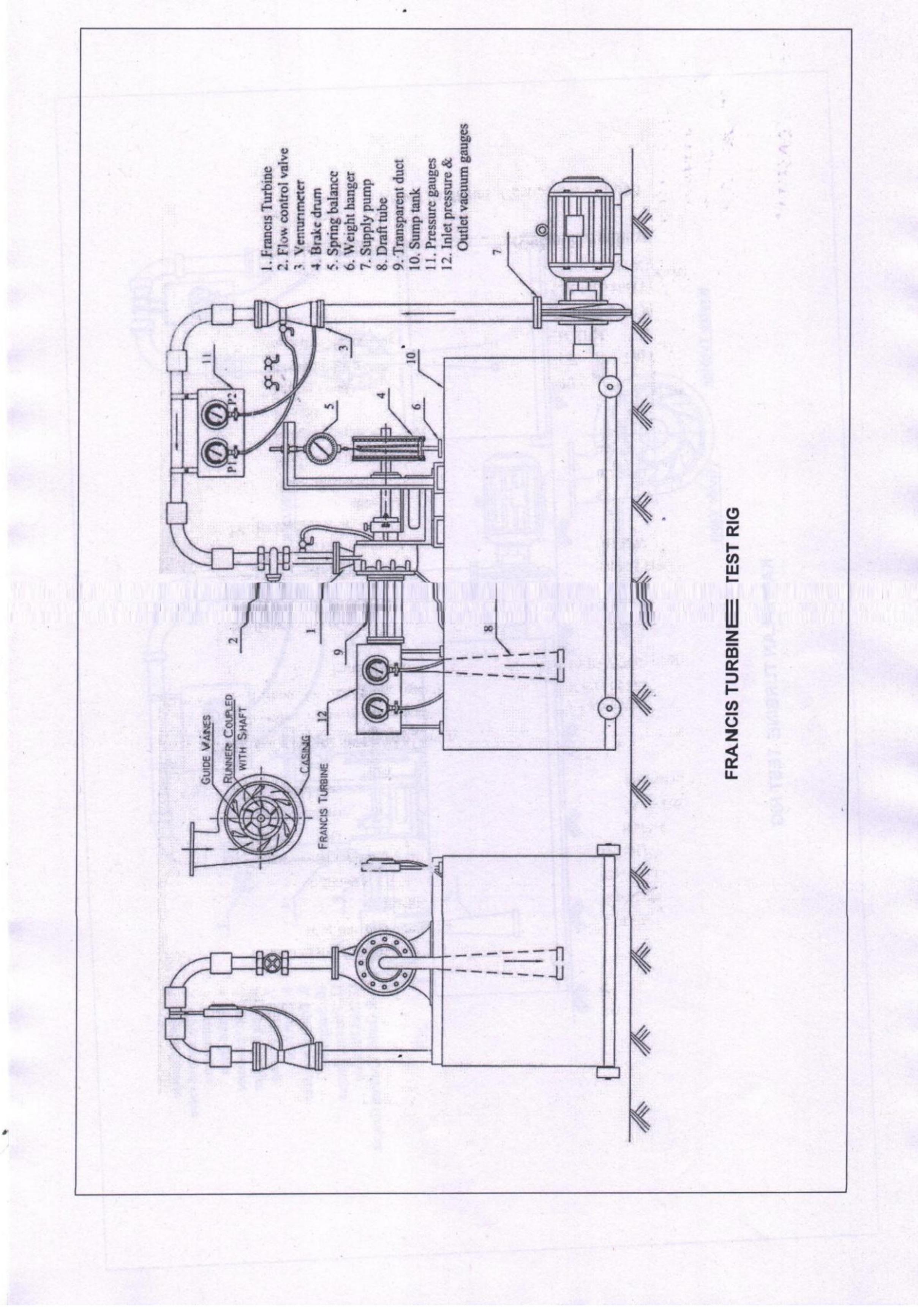
Power input $[P_i] = \frac{\rho QgH}{1000}$ KW

ρ-Densityof water 1000kg/m^3. Q- Flow rate m^3/s
g-Acceleration dueto gravity.9.81m/s
H-Total head.

Power output $[P_o] = \frac{2\Pi NT}{60 \times 1000}$ KW

N-speed of Brakedrum dynamometer. Mechanical load
$T = (T_1 - T_2) \times 9.81 \times 0.15$ N-m.

Efficiencyη= $\frac{\text{power output}}{\text{Power input}}$



FRANCIS TURBINE TEST RIG

Observation & Calculation Tabular Column (Mechanical Loading):

S.NO	Gate opening	Pressure Gauge (Kg/cm^2)	Vacuum Gauge (mm of Hg)	Manometer Reading		Speed of Break drum Dynamometer 'N'(Rpm)	Spring Balance		Power Output (P) (KW)	Power Input (P)(KW)	Efficiency 'η' %
				h_1(cm)	h2(cm)		T_1(kg)	T_2(kg)			
1											
2											
3											
4											

PRECAUTIONS:

1. Thegate valveshould be closed beforestarting the turbine.
2. Thegate valveshould be½ openingonly.
3. Mechanicalloadingshould be at consequitiveintervals.

RESULT: The efficiencyoffrancisturbine=%.

MODEL GRAPHS:

1. speedvs.efficiency
2. Dischargevs.powerinput
3. Inputpowervs.Speed
4. Outputpowervsspeed

Viva Question:

1**.**What is a reaction turbine**?**
2.what is difference between impulse and reaction turbine?
3.Specify the flow of the francis turbine.
4.what head francis turbine used?
5.what is purpose of draft tube in reaction turbine?
6.What is cavitation?

EXPERIMENT-X
FLOW THROUGH NOTCHES

AIM:

To determine the flow through notches.

APPARATUS:

Hydraulic bench, stop watch & Notch of different shape (Rectangular and Triangular)

DESCRIPTION:

In layman's terms, a Notch is defined as an obstruction. Notches are plates with sharp edged openings. They are primarily used for flow measurement. Flow of liquid occurs over these Notches. Notches are used for measuring the flow rate of a liquid from reservoirs or tanks. There are different types of notches, but for practical purposes most commonly used notches are usually rectangular, Triangular or Trapezoidal in shape. The sheet of water discharged by a notch is called Nappe or Vein. An attempt has been made to show the working principle and the calibration techniques adopted in developing the notches.

PROCEDURE:

1. Fix the plate having rectangular notch in the water passage of Hydraulic bench.
2. Turn the hydraulic bench on; water will accumulate in the channel.
3. When the water level reaches the Crest or sill of notch stop the inflow and note the reading, and design it as H1.
4. Restart the bench and note the volume and time of water that accumulates in the volumetric tank of bench, from this find the discharge, and also note the height of water at this point.
5. Find H = H2 – H1 This will give you the head over the notch.
6. Find the width of the notch.
7. Take different readings by changing the discharge head over the notch, using the above procedure.
8. Plot a graph between Log10H and Log10Q and find K from graph equation.

Find Cd from the following formula. $Cd = 2 / 3 \times k / \sqrt{2g} \times b$

$b = 3$ cm

DIAGRAM:

TABULAR COLUMNS:

S.NO	Initial (cm)	Final (cm)	Diff. (H) (cm)	Actual Discharge Q_a	Theoritical Discharge Q_{th}	C_d

RECTANGULAR NOTCH

S.NO	Initial (cm)	Final (cm)	Diff. (H) (cm)	Actual Discharge Q_a	Theoritical Discharge Q_{th}	C_d

CALCULATIONS:

PRECAUTIONS:

RESULT:

Viva questions:

1. Derive expression for theoretical discharge?
2. Sketch and explain flow through notch apparatus?
3. What are the applications of square notch?
4. What is the application of flow through notch?
5. What are the units of discharge?

EXPERIMENT-XII

DETERMINATION OF CO-EFFICIENT OF DISCHARGE FORAN EXTERNAL MOUTH PIECE BY VARIABLE HEADMETHOD

Aim: To determine the coefficient of discharge of mouth pieces.

Apparatus Required:

1. collecting tank 2.Sump Tank 3.piezometer 4.Butterfly Valve 5.scale.

Introduction:

All openings cannot be considered as an mouth piece unless the water level on the upstream side is above the opening .The purpose of the mouth piece is to measure the discharge. When the water comes out through the mouth piece , the water particles contracts to the minimum area called as the vena contracta. The diameter of the vena contracta is approximately considered as the half the diameter of the mouth piece .However, to view the vena contracta the head should be very high and due limitations an attempt has been made to study the process.

It should be borne in mind that the results are analyzed qualitatively and quantitatively

Description of Apparatus:

1)Water from the sump tank is sucked by the pump and is delivered through the delivery pipe to the collecting pipe

2) Over flow arrangement is provided to the collecting and over head tanks
3) Butterfly Valve is provided in measuring tank for instant close and release
4) the section and delivery can be controlled by means of control valves

5)Piezo meter with vinyl sticker scale is provided to measure the height of the water collected in measuring tank

6) The Equipment comes with accessories orifice and Mouthpieces each and no of different varieties

Procedure:

1. Fill the sump tank with water to the specified level.
2. Place the mouth piece of study in the overhead tank.
3. Set the head by opening the required valve in the overhead tank
4. Close the main control valve and give necessary electrical connections
5. Switch on the supply pump starter after confirming the mains on indicator is glowing.
6. Open the main control valve slowly and steadily such that the required constant head is maintained
7. Measure the discharge in the collecting tank by closing the butterfly valve and taking the time for R cm raise
8. Open the butterfly valve after taking the readings
9. Repeat above steps for different orifices and heads.
10. Calculate the discharge, velocity and contraction coefficient using given formulae.
11. After finishing the experiment close the main control valve and switch off the pump starter and disconnect the electrical connections.
12. Repeat the above step

OBSERVATIONS

For Head = ____________ m

S No	External mouth piece diameter	Head Position	Time for R cm rise of water (in s)	Cd

CALCULATIONS

Cross Sectional Area of the jet

a = $\frac{\pi}{4}d^2$ m^2

where,

d = diameter of orifice

π = Constant = 3.14

Actual Discharge Q_a

$Q_a = \frac{A\ R}{100\ t}$ m^3/s

Where,

A = Cross sectional area of the tank (in m^2)

R = Raise in Water level of the collecting tank (in cm) t = time for R cm Raise in Water (in s)

Theoretical Discharge (Q_{th})

$Q_{th} = a\sqrt{2gH}$ m^3/s

Where,

g = acceleration due to gravity (in m/s^2) H = Head above the orifice (in m)

a = cross sectional Area of jet

Note: for mouth piece the diameter to calculate the area should be taken at the outlet.

Coefficient of Discharge (C_d)

PRECAUTIONS

1. Do not run the pump dry
2. Clean the tank regularly
3. Do not run the equipment if the voltage is below 180 Volts
4. Check all the electrical connections before running
5. Before starting and after finishing the experiment the main control valve should be inclosed position
6. Do not attempt to alter the equipment as this may cause damage to the whole system

9.RESULT:

Co-efficient of discharge (C_d) =

Viva questions:

1. Define Orifice?
2. Define Mouth piece?
3. Define vena contracta?
4. Define co efficient of velocity?