SRINIVASAN ENGINEERING COLLEGE

(Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai)

PERAMBALUR – 621 212.

DEPARTMENT OF AERONAUTICAL ENGINEERING

CE 6461 Fluid Mechanics and Machinery Laboratory

MANUAL NOTE BOOK

Name :………………………………………………………………….

Register Number :………………………………………………………………….

Semester :………………………………………………………………….

Academic Year :………………………………………………………………….

CONTENTS

Sl. No.	Date	Name of the Experiment	Page	Marks	Sign

Completed / Not Completed

Average Marks	

Signature of Staff in Charge

CE6461 FLUID MECHANICS AND MACHINERY LABORATORY

L	T	P	C
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OBJECTIVES:

Upon Completion of this subject, the students can able to have hands on experience in flow measurements using different devices and also perform calculation related to losses in pipes and also perform characteristic study of pumps, turbines etc.,

LIST OF EXPERIMENTS

1. Determination of the Coefficient of discharge of given Orifice meter.
2. Determination of the Coefficient of discharge of given Venturi meter.
3. Calculation of the rate of flow using Rota meter.
4. Determination of friction factor for a given set of pipes.
5. Conducting experiments and drawing the characteristic curves of centrifugal pump/ submergible pump.
6. Conducting experiments and drawing the characteristic curves of reciprocating pump.
7. Conducting experiments and drawing the characteristic curves of Gear pump.
8. Conducting experiments and drawing the characteristic curves of Pelton wheel.
9. Conducting experiments and drawing the characteristics curves of Francis turbine.
10. Conducting experiments and drawing the characteristic curves of Kaplan turbine.

TOTAL: 45 PERIODS

OUTCOMES:

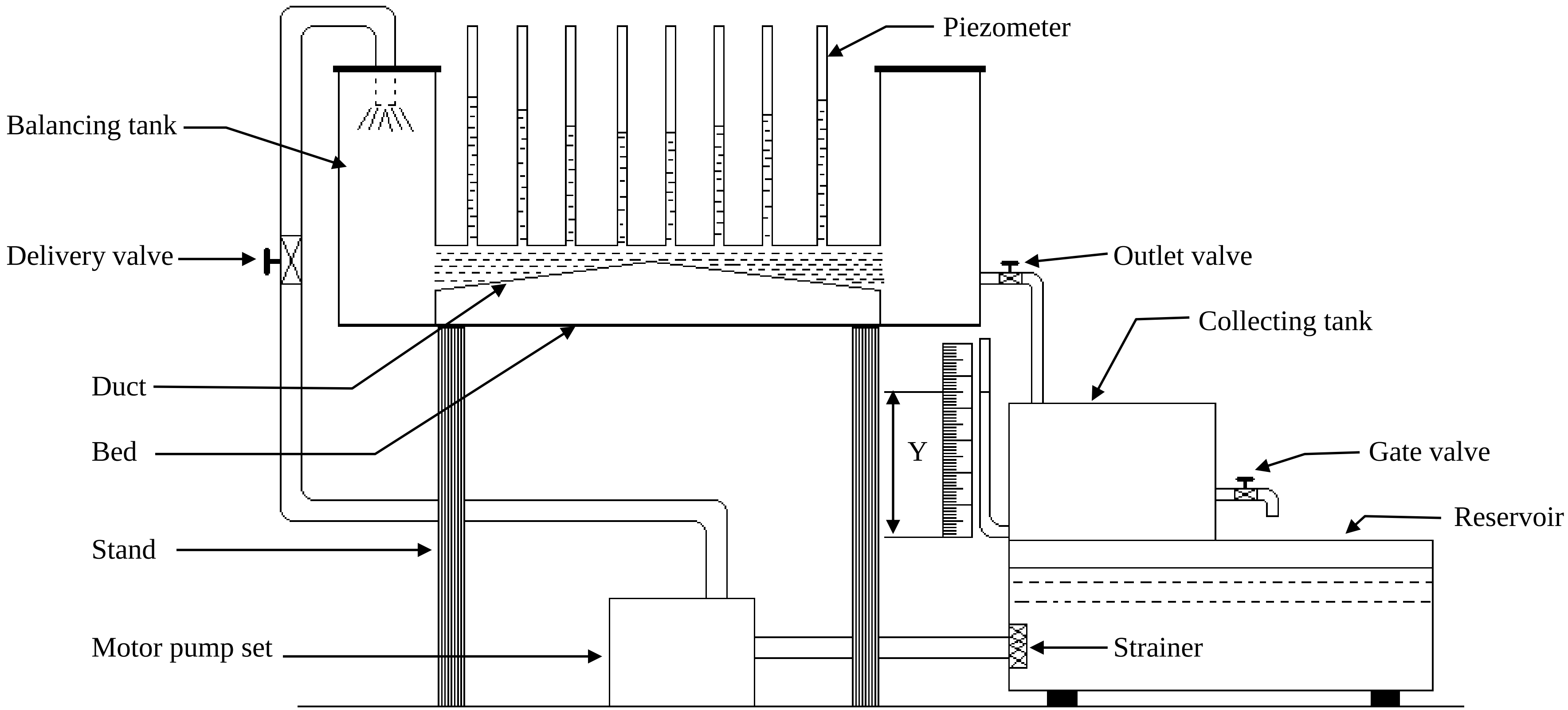
- ✈ Ability to use the measurement equipment for flow measurement.
- ✈ Ability to do performance test on different fluid machinery.

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

Sl No	Name of the Equipment	Qty
1	Orifice meter setup	1
2	Venturi meter setup	1
3	Rotameter setup	1
4	Pipe Flow analysis setup	1
5	Centrifugal pump/submergible pump setup	1
6	Reciprocating pump setup	1
7	Gear pump setup	1
8	Pelton wheel setup	1
9	Francis turbine setup	1
10	Kaplan turbine setup	1

EXPERIMENTS

BERNOULLI'S APPARATUS



Exercise No:	BERNOULLI'S EXPERIMENT
Date:	

AIM

To verify the Bernoulli's theorem experimentally.

APPARATUS REQUIRED

1. Bernoulli's apparatus
2. Piezometers
3. Collecting tank
4. Meter scale
5. Stop watch

EXPERIMENTAL SET UP

A typical experimental set up is shown in figure.

Bernoulli's apparatus consists of a glass duct of varying depth. Width of the duct remains constant throughout the duct. Number of piezometers is fitted at different points as shown.

A pump is used to lift water from reservoir to Bernoulli's apparatus. It is driven by an electric motor.

A collecting tank is used to collect water from outlet pipe. It is fitted with a gate valve which returns water to reservoir.

PROCEDURE

1. Measure the cross section of the duct at the respective piezometers by using meter scale.
2. Measure the inner plan dimensions of collecting tank by using meter scale.
3. Keeping the delivery valve closed, switch on the pump.
4. Open the delivery valve and allow water into the duct.
5. Open the outlet valve. Remove air bubbles (if any) in the piezometers.
6. Adjust the outlet valve to maintain constant head in balancing tank.
7. Take bed as datum. Measure water level in each piezometers. This reading gives the sum of datum head and pressure head [Z+p/w].

   [OR]

   For convenience, take top surface of duct as datum. Measure water level in each piezometer. This reading gives pressure head [p/w]. We select first case.

OBSERVATION

1. Inner plan dimensions of collecting tank,
   Length, l = = m
   Breadth, b = = m
2. Rise of water level, Y = = m

Duct Section Number	Time taken 'Y'm rise T [sec]	Discharge Q=(AY)/T [m^3/sec]	Duct area = Width x Depth a [m^2]	Velocity V = Q / a [m / sec]	Velocity head V^2 / 2g [m]	Datum head + Pressure head Z + (p / w) [m]	Total head = [Z+(p/w)]+(V^2/2g) [m]
01							
02							
03							
04							
05							
06							
07							

1. Close the gate valve of collecting tank tightly.
2. Note the time taken 'T' for 'Y'm rise of water level in collecting tank by using stop watch.
3. Repeat the experiment by changing the flow with the help of outlet valve and observe corresponding readings. After experiment is over, switch off the pump.
4. Tabulate the readings.

FORMULAE USED

Discharge, $Q = (AY) / T$ m^3/sec

Where,

A → Area of collecting tank in m^2.

Y → Rise of water level in collecting tank in m.

T → Time taken in sec.

Velocity, $V = Q/a$ m/sec

Where,

a → Area of duct in m^2.

Bernoulli's equation is,

Total head at any section $= Z + (p/w) + (V^2/2g)$ m

Where,

Z → Datum head in m.

p/w → Pressure head in m.

$V^2/2g$ → Velocity head in m.

MODEL CALCULATION

Area of collecting tank, A = l x b

=

= m^2

Discharge, Q = (AY) / T

=

= m^3/sec

Section Number

Velocity, V = Q/a

=

= m/sec

Velocity Head, $V^2/2g$ = [g = 9.81 m/ sec^2]

= m

Sum of datum head and pressure head = Z + (p/w)

= m

∴ Total head = Z + (p/w) + ($V^2/2g$)

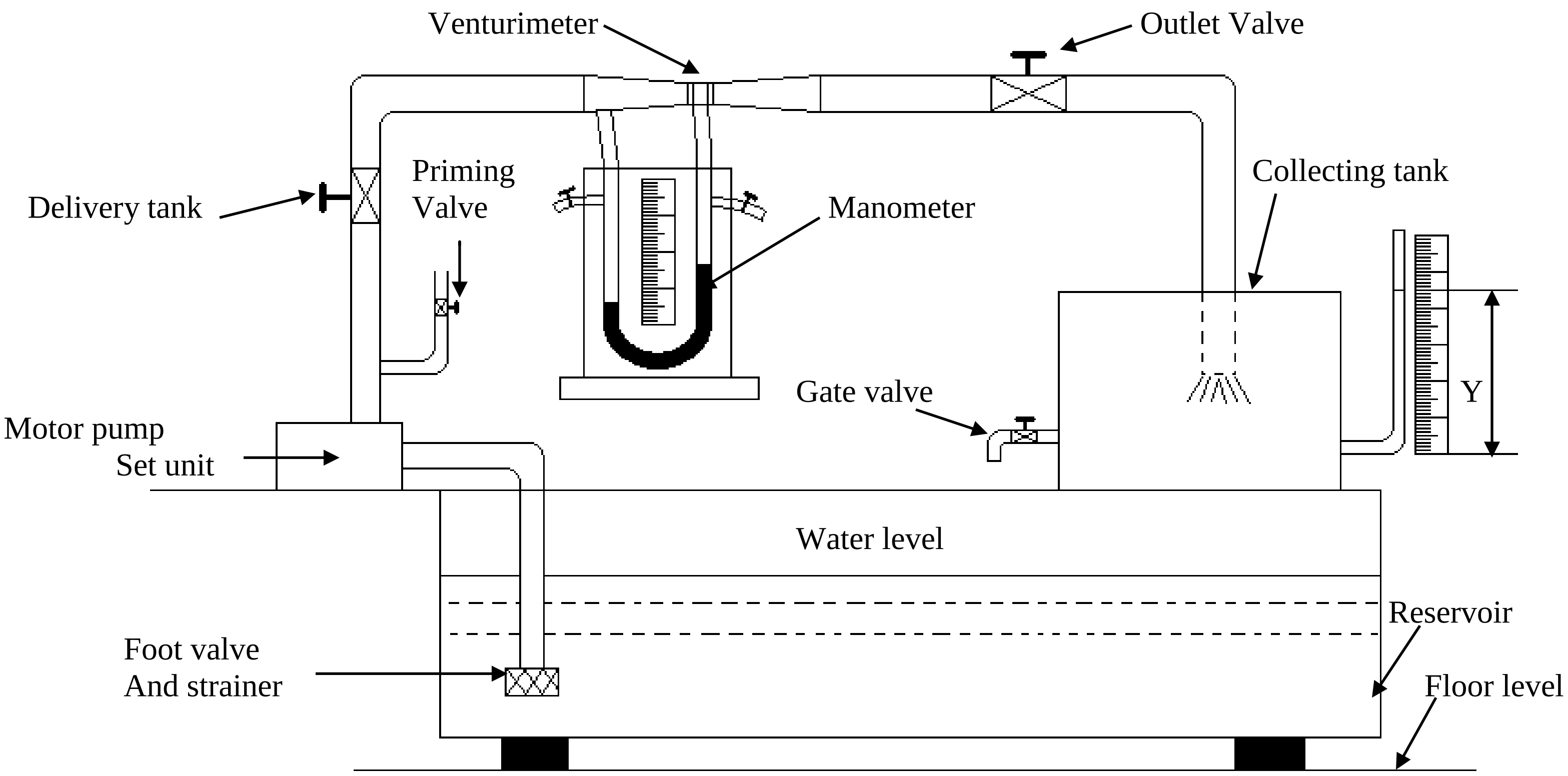
=

= m

RESULT

Total head at all duct sections are same. So, Bernoulli's theorem is verified.

VENTURIMETER APPARATUS



Exercise No: 02	VENTURIMETER
Date:	

AIM

To determine the coefficient of the given venturimeter.

APPARATUS REQUIRED

1. Venturimeter apparatus
2. Differential U tube manometer
3. Collecting tank
4. Piezometer
5. Meter scale
6. Stop watch

EXPERIMENTAL SET UP

A typical experimental setup is shown in figure.

Venturimeter consists of three parts.

- Convergent cone
- Cylindrical throat
- Divergent cone.

Nipples are provided at inlet and throat for manometer connection.

A pump is used to lift water from reservoir to venturimeter apparatus. It is driven by an electric motor.

A collecting tank is used to collect water falling from outlet pipe. It is fitted with a gate valve which returns water to reservoir.

PROCEDURE

1. Note the inlet diameter and throat diameter of venturimeter.
2. Measure the inner plan dimensions of the collecting tank by using meter scale.
3. Connect the manometer to the pressure tapping cocks of the venturimeter.
4. Keeping the delivery valve closed, switch on the pump.
5. Open the delivery valve and allow water into the venturimeter.
6. Open the outlet valve slightly.
7. Remove air bubbles (if any) from the manometer.
8. Note the mercury levels in both limbs [h_1 and h_2].
9. Close the gate valve of collecting tank tightly.
10. Note the time 'T' for 'Y'm rise of water level in collecting tank by using stop watch.

OBSERVATION

1. Inlet diameter, d_1 = = m
2. Throat diameter, d_2 = = m
3. Inner plan dimensions of collecting tank,
   Length, l = = m
   Breadth, b = = m
4. Rise of water level, Y = = m

Reading Number	Manometer Reading		Difference $h=(h_1-h2)/1000$ [m]	Venturi Head H=h x 12.6 [m]	Time taken for 'Y'm rise T [sec]	Actual discharge $Q_a = (AY) / T$ [m^3/sec]	Theoritical discharge, $Q_t = C\sqrt{H}$ [m^3/sec]	Coefficient of meter, $K = Q_a / Q_t$ [no unit]	$\sqrt{H}$ [For Graph]
	h1 [mm]	h2 [mm]							

Average value of K =

11. Repeat the above procedure by gradually increasing the flow and observe corresponding readings. After experiment is over, switch off the pump.
12. Tabulate the readings.

FORMULAE USED

Difference in mercury levels, $h = (h_1 - h_2) / 1000$ m of mercury

Where,

h_1 → Mercury level in one limb in mm.

h_2 → Mercury level in another limb in mm.

Venturi head, $H = h [(S_m – S_w) / S_w]$

$= h [(13.6 – 1) / 1]$

$H = h \times 12.6$ m of water

We know that,

S_m → Specific gravity of mercury = 13.6

S_w → Specific gravity of water = 1

Venturimeter constant, $C = (a_1 a_2 \sqrt{2g}) / \sqrt{(a_1^2 – a_2^2)}$

Where,

a_1 → Area of inlet in m^2.

a_2 → Area of throat in m^2.

g → Acceleration due to gravity (9.81) in m/sec^2

Theoritical discharge, $Q_t = C\sqrt{H}$ m^3/sec

Where,

C → Constant of venturimeter.

Actual Discharge, $Q_a = (AY) / T$ m^3/sec

Where,

A → Area of collecting tank in m^2.

Y → Rise of water level in collecting tank in m.

T → Time taken in sec.

Coefficient of meter, $K = Q_a / Q_t$ no unit

MODEL CALCULATION

Area of inlet, a_1 $= (\pi/4) \times d_1^2$

=

= m^2

Area of throat, a_2 $= (\pi/4) \times d_2^2$

=

= m^2

Venturimeter constant, C $= (a_1\ a_2 \sqrt{2g}) / \sqrt{(a_1^2 - a_2^2)}$

=

=

Area of collecting tank, A = l x b

=

= m^2

Reading Number

h_1 = mm

h_2 = mm

$\therefore$ h $= (h_1 - h_2) / 1000$

=

= m of mercury

GRAPH

Draw a graph between Q_a (X-axis) and $\sqrt{H}$ (Y-axis).

Venturi head,	H	= h x 12.6	
		=	
		=	m of water
Thermal discharge,	Q_t	= $C\sqrt{H}$	
		=	
		=	m^3/sec
Actual discharge,	Q_a	= (AY) / T	
		=	
		=	m^3/sec
Coefficient of Venturimeter,	K	= Q_a / Q_t	
		=	
		=	no unit

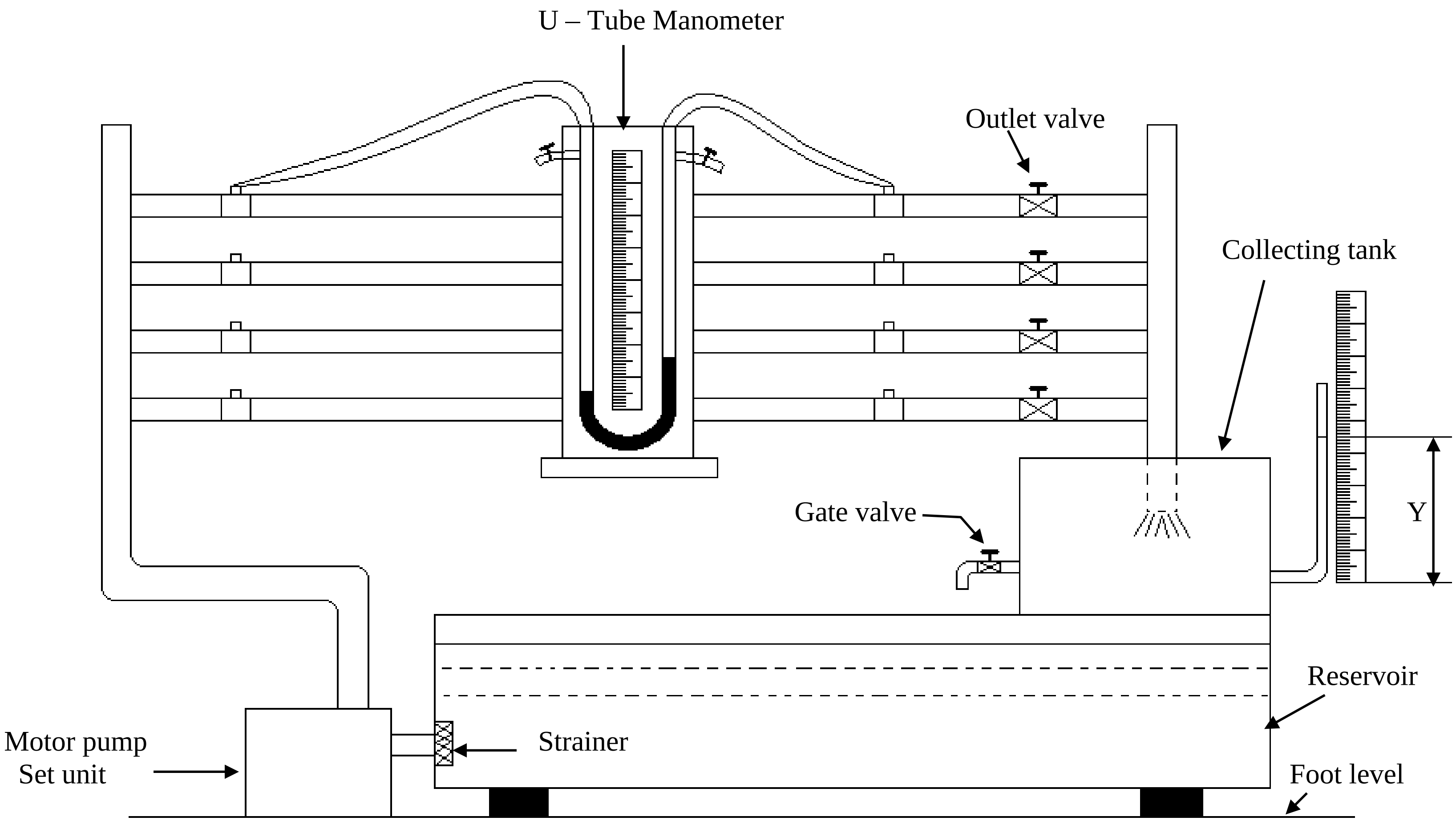
RESULT

Coefficient of given venturimeter is

i. From calculation (K) =

ii. From graph (K) =

PIPE FRICTION APPARATUS



Exercise No: 04	PIPE FRICTION
Date:	

AIM

To determine the friction factor of the given pipe.

APPARARUS REQUIRED

1. Pipe friction apparatus
2. Differential 'U' tube manometer
3. Collecting tank
4. Piezometer
5. Meter scale
6. Stop watch

EXPERIMENTAL SET UP

A typical experimental set up is shown in figure.

Pipes of different diameter but of same length are arranged with outlet valves.

Nipples are provided at certain distance on each pipe for manometer connection.

A pump is used to lift water from reservoir to pipe friction apparatus. It is driven by an electric motor.

A collecting tank is used to collect water falling from outlet pipe. It is fitted with a gate valve which returns water to reservoir.

PROCEDURE

1. Note the diameter of the selected pipe.
2. Measure the length of selected pipe between two pressure tapping cocks by using meter scale.
3. Measure the inner plan dimensions of the collecting tank by using meter scale.
4. Connect the manometer to the pressure tapping cocks of the selected pipe.
5. Keeping the outlet valve closed, switch on the pump.
6. Open the outlet valve slightly and allow water into the selected pipe.
7. Remove air bubbles (if any) from the manometer.
8. Note the mercury levels in both the limbs [h_1 and h_2].
9. Close the gate valve of collecting tank tightly.

OBSERVATION

1. Diameter of pipe, d =

   =

   = m

2. Length of pipe between pressure tapping cocks, l =

   = m

3. Inner plan dimensions of collecting tank, length, l_t =

   = m

   breadth, b =

   = m

4. Rise of water, y =

   = m

1. Note the above 'T' for 'Y'm rise of water level in collecting tank by using stop watch.
2. Repeat the above procedure by gradually increasing the flow and observe corresponding readings. After experiment is over, switch off the pump.
3. Tabulate the readings.

FORMULAE USED

Difference in mercury levels, $h = (h_1 - h_2) / 1000$ m of mercury

Where,

h_1 → Mercury level in one limb in mm.

h_2 → Mercury level in another limb in mm.

Head lost due to fruction, $h_f = h\,[(S_m - S_w) / S_w]$

$= h\,[(13.6 - 1) / 1]$

$h_f = h \times 12.6$ m of water

We know that,

S_m → Specific gravity of mercury = 13.6

S_w → Specific gravity of water = 1

Discharge, $Q = (AY) / T$ m^3/sec

Where,

A → Area of collecting tank in m^2.

Y → Rise of water level in collecting tank in m.

T → Time taken in sec.

Velocity, $V = Q/a$ m/sec

Where,

a → Area of duct in m^2.

Darcy's formula is, $h_f = (F \times l \times V^2) / 2gd$

$\therefore\ F = (hf \times 2gd) / (l \times V^2)$

where,

F → Friction factor.

g → Acceleration due to gravity (9.81) in m/sec^2.

Reading Number	Manometer Reading		Difference $h=(h_1-h2)/1000$ [m]	Head Lost h_f=h x 12.6 [m]	Time taken for 'Y'm rise T [sec]	Discharge Q = (AY) / T [m^3/sec]	Velocity V= Q/a [m/sec]	V^2	Friction Factor $F=(h_f \times 2gd) / (l \times V^2)$
	h1 [mm]	h2 [mm]							

Average value of F =

GRAPH

Draw a graph between h_f (X-axis) and V^2 (Y-axis).

MODEL CALCULATION

Area of pipe,	a	$= (\pi/4) \times d^2$
		=
		= m^2
Area of collecting tank,	A	$= l_t \times b$
		=
		= m^2
Reading Number		
	h_1	= mm
	h_2	= mm
∴	h	$= (h_1 - h_2) / 1000$
		=
		= m of mercury
Head lost,	h_f	$= h \times 12.6$
		=
		= m of water
Discharge,	Q	$= (AY) / T$
		=
		= m^3/sec
Velocity,	V	$= Q/a$
		=
		= m/sec
Friction factor,	F	$= (h_f \times 2gd) / (l \times V^2)$
		=
		=

ii.

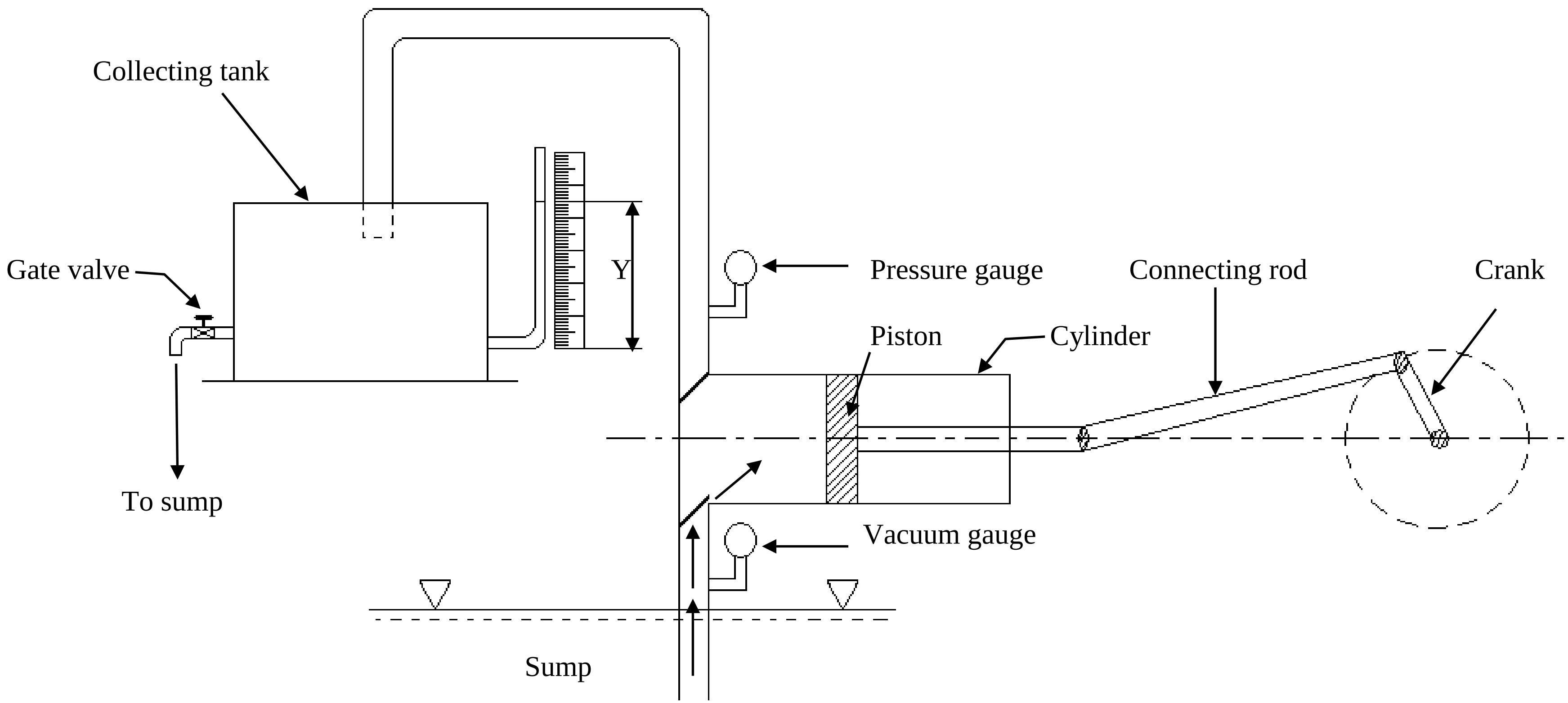
RESULT

Friction factor of given pipe is

i. From calculation (F) =

ii. From graph (F) =

RECIPROCATING PUMP



Exercise No: 06	RECIPROCATING PUMP
Date:	

AIM

To conduct the performance test and to draw the performance curves of the given reciprocating pump.

APPARATUS REQUIRED

1. Reciprocating pump
2. Collecting tank
3. Piezometer
4. Energy meter
5. Vacuum gauge
6. Pressure gauge
7. Meter scale
8. Stop watch
9. Tachometer

EXPERIMENTAL SET UP

A typical experimental set up is shown in figure.

A single acting Reciprocating pump with pipe fitting is shown.

A vacuum gauge is fitted to the suction pipe. A pressure gauge is fitted to the delivery pipe.

Pump is driven by an electric motor through a belt drive. An energy meter is connected to the input side of the motor.

A collecting tank is used to collect water falling from delivery pipe. It is fitted with a gate valve which returns water to sump.

PROCEDURE

1. Note the stroke length (L), cylinder diameter (D), type of pump and energy meter constant [N_e].
2. Measure the inner plan dimensions of the collecting tank and the difference in level between the centers of the vacuum and pressure gauge by using meter scale.
3. Keeping the delivery valve opened, switch on the pump.

OBSERVATION

1. Stroke Length, L = m

2. Cylinder diameter, D = m

3. Difference in levels between the centers of vacuum and pressure gauges,

   X = m

4. Inner plan dimensions of collecting tank, length, l =

   = m

   breadth, b =

   = m

5. Energy meter constant $[N_e]$ = revl/kWhr

6. Rise of water level in collecting tank, y = m

4. Close the delivery valve gradually. For this valve position, note the following
   - Vacuum gauge readings [H_s]
   - Pressure gauge readings [H_d]
   - Time (t) for Nr revolutions of the energy meter disc.
   - Crank speed [N].
5. Close the gate valve tightly. Note the time 'T' for 'Y'm rise of water level in collecting tank by using stop watch.
6. Close the delivery valve further. For each valve position, repeat the above procedure.
7. Tabulate the readings.
8. After experiment is over, switch off the pump.

FORMULAE USED

Actual Discharge, $Q_a = (A_t Y) / T$ m^3/sec

Where,

A_t → Area of collecting tank in m^2.
Y → Rise of water level in collecting tank in m.
T → Time taken in sec.

Theoritical discharge, $Q_t = (ALN) / 60$ m^3/sec [For single acting]

(or)

$Q_t = (2ALN) / 60$ m^3/sec [For double acting]

Where,

A → Area of cylinder in m^2.
L → Stroke length in m.
N → Crank speed in rpm.

$Slip = Q_t - Q_a$ m^3/sec

Coefficient of discharge, $C_d = Q_a / Q_t$ no unit

$\% Slip = [1 – C_d] \times 100$

Total head, $H_T = H_s + H_d + X$ m

Sl. No	Delivery valve Position	Suction Head [H_s]		Delivery Head [H_d]		Total Head $H_T=H_s+H_d+X$ [m]	Crank Speed N [rpm]	Time taken for 'Y'm rise T [sec]	Discharge		Coefficient of discharge $C_d=Q_a/Q_t$ [no unit]	% Slip= [1-C_d] x 100 [%]	Time for N_r revol. t[sec]	Output power, $P_O=wQ_aH_T$ [kW]	Input power, $P_I=(N_r/N_e)$ x (3600/t) [kW]	Efficiency $\eta=(P_O/P_I)$ x 100 [%]
			m of H_2O		m of H_2O				Actual $Q_a=(A_tY)/T$ [m^3/sec]	Theoritical Q_t = ALN/60 [m^3/sec]						
01	Full y opened															
02	Gradually close the valve [But don't close fully															
03																
04																
05																

Where,

H_s → Suction head of water in m.

H_d → Delivery head of water in m.

X → Difference in level between the centers of vacuum and pressure gauges.

Output power, $P_O = w\ Q_a\ H_T$ kW

Where,

W → Specific weight (9.81) of water in kN/m^3.

Input power, $P_I = (N_r / N_e) \times (3600 / t)$ kW

Where,

N_r → Number of revolutions of energy meter disc.

N_e → Energy meter constant in revolution per kWhr.

t → Time taken for N_r revolutions in sec.

Efficiency of pump, $\eta = (P_O / P_I) \times 100$ %

MODEL CALCULATION

Area of collecting tank, A_t = l x b

=

= m^2

Area of cylinder, A = $(\pi/4)\ D^2$

=

= m^2

Reading Number

Actual discharge, Q_a = $(A_t Y) / T$

=

= m^3/sec

Theoretical discharge, Q_t = (ALN) / 60 [For single acting]

=

= m^3/sec

(OR)

Q_t = (2ALN) / 60 [For double acting]

=

= m^3/sec

Slip = $Q_t - Q_a$

=

= m^3/sec

GRAPH

Draw the following graphs by taking H_T on X-axis

- H_T vs % Slip
- H_T vs % Efficiency
- H_T vs Q_a

Total head, $H_T = H_s + H_d + X$

Coefficient of discharge, C_d $= Q_a / Q_t$

=

= no unit

% Slip = $[1 – C_d] \times 100$

=

= %

Total Head, H_T $= H_s + H_d + X$

=

= m

Output power, P_O $= w\, Q_a\, H_T$ [$w = 9.81$ kN/ m^3]

=

= kW

Input power, P_I $= (N_r / N_e) \times (3600 / t)$

=

= kW

Efficiency of pump, η $= (P_O / P_I) \times 100$

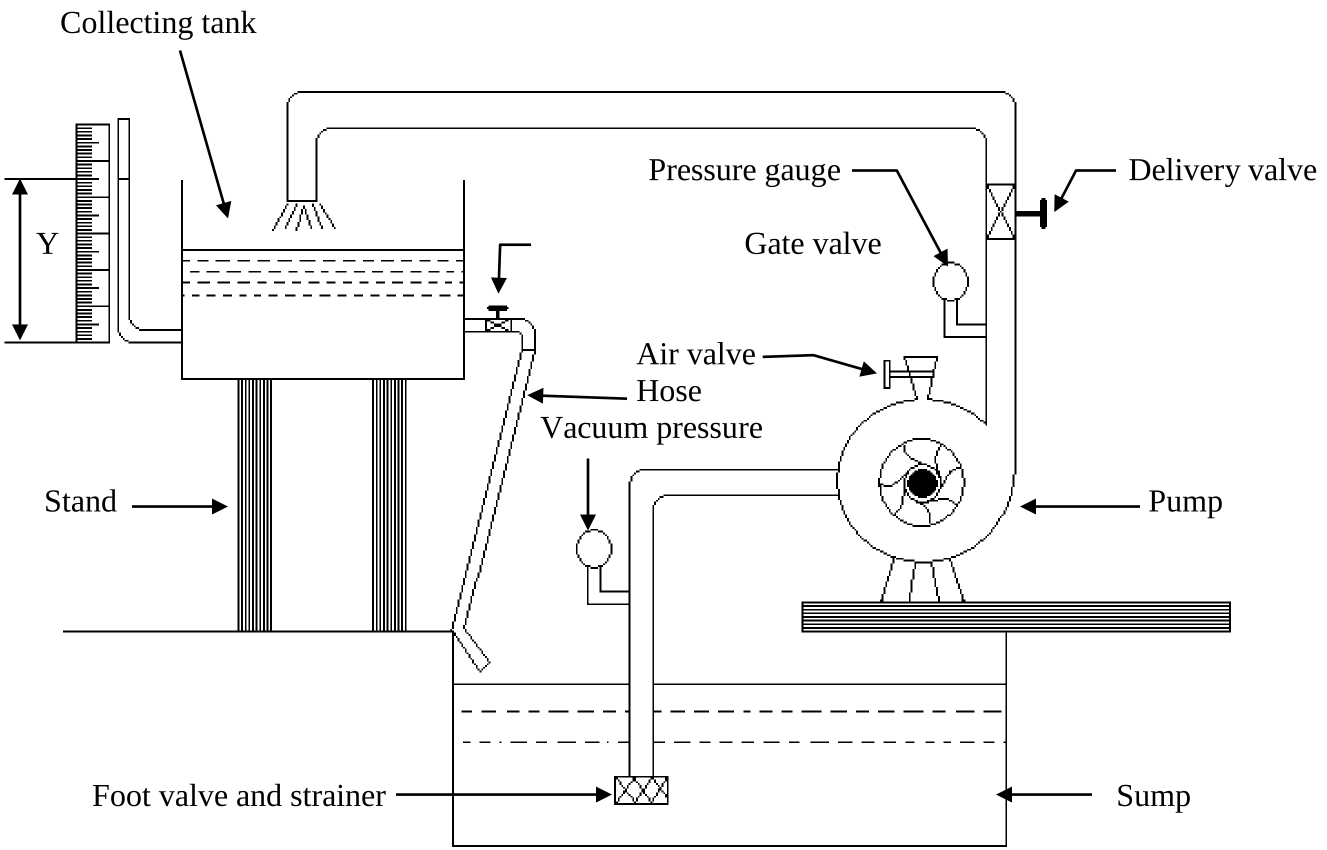
=

= %

RESULT

i.	Coefficient of discharge, C_d	=	no unit
ii.	Maximum percentage slip	=	%
iii.	Maximum percentage efficiency	=	%

CENTRIFUGAL PUMP



Exercise No: 05	CENTRIFUGAL PUMP
Date:	

AIM

To conduct a performance test on centrifugal pump and to draw its characteristic curves.

APPARATUS REQUIRED

1. Centrifugal pump
2. Collecting tank
3. Piezometers
4. Energy meter
5. Vacuum gauge
6. Pressure gauge
7. Meter scale
8. Stop watch

EXPERIMENTAL SET UP

A typical experiment set up is shown in figure.

Sump is covered with a platform. The pump to be tested is mounted on the platform. A vacuum gauge is fitted to the suction pipe. A pressure gauge is fitted to the delivery pipe.

Pump is driven by an electric motor. An energy meter is connected to the input side of the motor.

A collecting tank is used to collect water falling from delivery pipe. It is fitted with a gate valve which returns water to sump.

PROCEDURE

1. Note the speed of pump and energy meter constant [N_e].
2. Measure the inner plan dimensions of collecting tank and the difference in level between the centers of the vacuum and pressure gauge by using meter scale.
3. Prime the pump.
4. Keeping the delivery valve closed, switch on the pump.
5. Note the following
   - Vacuum gauge reading [H_s]
   - Pressure gauge reading [H_d]
   - Time (t) for N_r revolutions of the energy meter disc.

OBSERVATION

1. Speed of pump = rpm

2. Energy meter constant [N_e] = revl/kWhr

3. Inner plan dimensions of collecting tank, length, l =

   = m

   breadth, b =

   = m

4. Difference in levels between the centers of vacuum and pressure gauges,

   X = m

5. Rise of water level in collecting tank, Y = m

6. Close the gate valve tightly. Note the time 'T' for 'Y'm rise of water level in collecting tank by using stop watch.
7. Open the delivery valve gradually. For each valve position, repeat the above procedure.
8. Tabulate the readings.
9. After experiment is over switch off the pump.

FORMULAE USED

Discharge, $Q = (AY) / T$ m^3/sec

Where,

A → Area of collecting tank in m^2.
Y → Rise of water level in collecting tank in m.
T → Time taken in sec.

Total head, $H_T = H_s + H_d + X$ m

Where,

H_s → Suction head of water in m.
H_d → Delivery head of water in m.
X → Difference in level between the centers of vacuum and pressure gauges.

Output power, $P_O = w\ Q\ H_T$ kW

Where,

W → Specific weight (9.81) of water in kN/m^3.

Input power, $P_I = (N_r / N_e) \times (3600 / t)$ kW

Where,

N_r → Number of revolutions of energy meter disc.
N_e → Energy meter constant in revolution per kWhr.
t → Time taken for N_r revolutions in sec.

Efficiency of pump, $\eta = (P_O / P_I) \times 100$ %

Sl. No	Delivery valve Position	Suction Head [H_s]		Delivery Head [H_d]		Total Head $H_T=H_s+H_d+X$ [m]	Time taken for 'Y'm rise T [sec]	Discharge Q=(AY)/T [m^3/sec]	Time for N_r revol. t[sec]	Output power, $P_O=wQH_T$ [kW]	Input power, $P_I=(N_r/N_e)$ x (3600/t) [kW]	Efficiency $\eta=(P_O/P_I)$ x 100 [%]
			m of H_2O		m of H_2O							
01	Full y Closed											
02	Gradually Opened											
03												
04												
05	Fully Opened											

GRAPH

Draw the following graphs by taking Q on X-axis.

- Q vs H_T
- Q vs P_O
- Q vs η

MODEL CALCULATION

Area of collecting tank,	A	= l x b	
		=	
		=	m^2

Reading Number

Discharge,	Q	= (AY) / T	
		=	
		=	m^3/sec
Total Head,	H_T	= $H_s + H_d + X$	
		=	
		=	m
Output power,	P_O	= w Q H_T	[w = 9.81 kN/ m^3]
		=	
		=	kW
Input power,	P_I	= (N_r / N_e) x (3600 / t)	
		=	
		=	kW
Efficiency of pump,	η	= (P_O / P_I) x 100	
		=	
		=	%

RESULT

Characteristic curves are drawn.
Maximum efficiency (from curve) =

At the point of max efficiency the best working conditions of the pump are,

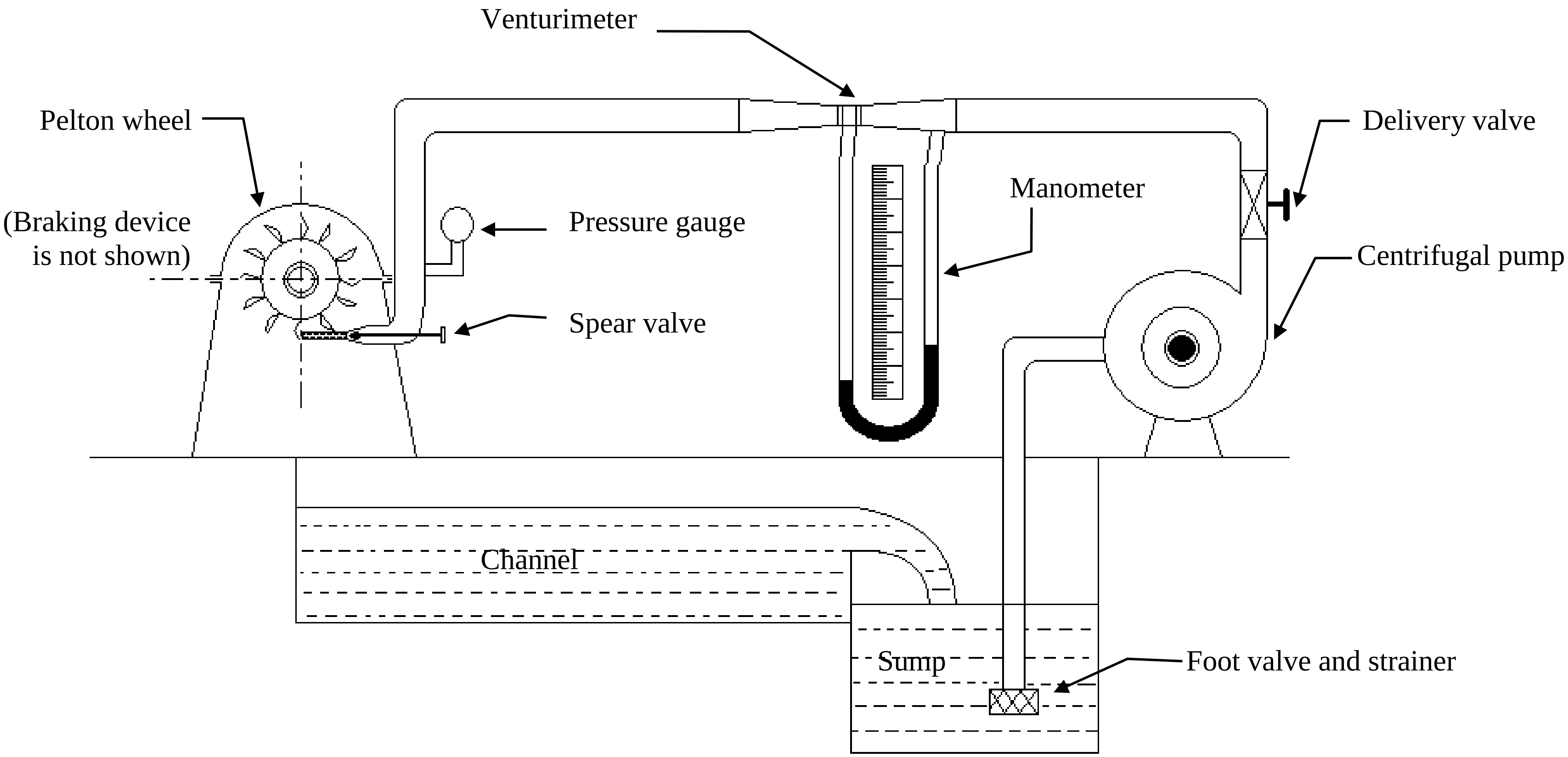
i. Discharge (Q) = m^3/sec

ii. Head (H_T) = m

iii. Output power (Po) = kW

iv. Efficiency (η) = %

TEST SETUP FOR PELTON TURBINE



Exercise No: 08	IMPULSE TURBINE [PELTON WHEEL]
Date:	

AIM

To conduct a performance test at constant pressure head and to determine maximum efficiency of the given impulse turbine. [Pelton turbine]

APPARATUS REQUIRED

1. Pelton turbine
2. Centrifugal pump
3. Venturimeter
4. Differential manometer
5. Pressure gauge
6. Tachometer
7. Braking device
8. Measuring device

TEST SET UP

It is shown in figure. Centrifugal pump is driven by an electric motor. It is used to supply water from sump to the turbine.

A Venturimeter is fitted to the unit to measure the rate of flow. A manometer is fitted to the Venturimeter.

A pressure gauge is fitted to the turbine inlet to measure the supply head.

A braking device [not shown] is coupled with the pelton wheel to measure the output.

PROCEDURE

1. Measure the circumference of brake drum and thickness of rope by using tape.
2. Note the Venturimeter constant and coefficient. Operate the spear valve to set nozzle for full opening.
3. Prime the centrifugal pump.
4. Keeping the delivery valve closed, switch on the pump.
5. Open the delivery valve. Adjust the delivery valve to maintain constant supply head.
6. Apply load on brake drum.
7. Measure the speed of turbine by using tachometer.
8. Note the manometer readings.
9. Repeat the above procedure by changing the load but by keeping constant supply head.
10. Tabulate the readings.

OBSERVATION

1. Circumference of brake drum, $2\pi R$ =

   = m

2. Thickness of rope, t =

   = m

3. Venturimeter constant, C =

4. Venturimeter coefficient, K =

5. Constant supply head, H_s = m of water

6. Dead weight, W_d = kg

7. To find R_e

   $2\pi R$ =

   R =…………../2π

   =

   $\therefore R$ = m

   Then, R_e = R+ (t/2)

   =

   = m

FORMULAE USED

Difference in mercury levels, $h = (h_1 - h_2) / 1000$ m of mercury

Where,

h_1 → Mercury level in one limb in mm.

h_2 → Mercury level in another limb in mm.

Venturi head, $H = h [(S_m – S_w) / S_w]$

$= h [(13.6 – 1) / 1]$

$H = h \times 12.6$ m of water

We know that,

S_m → Specific gravity of mercury = 13.6

S_w → Specific gravity of water = 1

Discharge through Venturimeter, $Q = KC\sqrt{H}$ m^3/sec

Where,

K → Coefficient of Venturimeter.

C → Constant of Venturimeter.

Input power, $P_I = w\ Q\ H_s$ kW

Where,

W → Specific weight (9.81) of water in kN/m^3.

H_s → Supply head of water in m.

Output power, $P_O = (2\pi N W_e R_e) / 60$ kW

Where,

N → Speed of brake drum in rpm.

W_e → Effective load on brake drum in kN.

R_e → Effective radius in m.

Efficiency of turbine, $\eta = (P_O / P_I) \times 100$ %

Sl. No	Manometer Reading		$h=(h_1 - h_2) / 1000$ [m]	Venturi head $H=h \times 12.6$ [m of water]	Load		Effective Load $W_e=((W_d + W_1 - W_2) \times 9.81) / 1000$ [kN]	Speed N [rpm]	Discharge $Q=KC\sqrt{H}$ [m^3/sec]	In put power, $P_I=wQH_s$ [kW]	Output power, $P_O=(2\pi N W_e R_e) / 60$ [kW]	Efficiency $\eta=(P_O/P_I) \times 100$ [%]
	h_1 [mm]	h_2 [mm]			W_1 [Kg]	W_2 [Kg]						
01												
02												
03												
04												
05												

GRAPHS

- Speed vs Efficiency
- Speed vs Output power
- Speed vs Discharge

MODEL CALCULATION

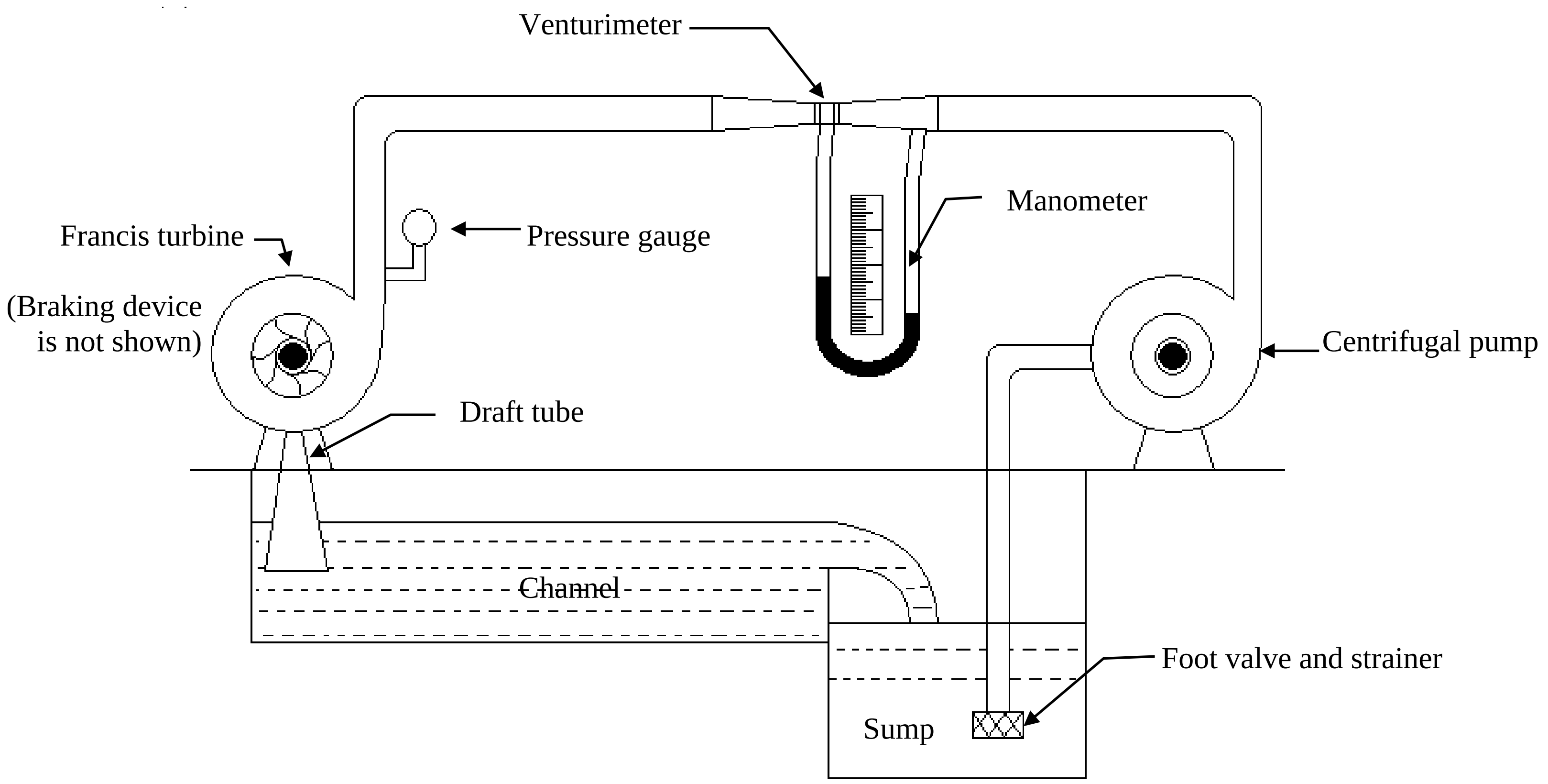
Reading Number

Difference in mercury levels,	h	$= (h_1 - h_2) / 1000$	
		=	
		=	m of mercury
Venturi head,	H	= h x 12.6	
		=	
		=	m of water
Discharge through Venturimeter,	Q	$= KC\sqrt{H}$	
		=	
		=	m^3/sec
Input power,	P_I	$= w\,Q\,H_s$	[w = 9.81 kN/ m^3]
		=	
		=	kW
Output power,	P_O	$= (2\pi N W_e R_e) / 60$	
		=	
		=	kW
Efficiency of turbine,	η	$= (P_O / P_I) \times 100$	
		=	
		=	%

RESULT

Maximum efficiency of the given pelton turbine = %

TEST SETUP FOR FRANCIS TURBINE



Exercise No: 09	REACTION TURBINE [FRANCIS TURBINE]
Date:	

AIM

To conduct a performance test and to draw the performance curves of the given reaction turbine [Francis turbine].

APPARATUS REQUIRED

1. Francis turbine
2. Centrifugal pump
3. Venturimeter
4. Differential manometer
5. Pressure gauge
6. Vacuum gauge
7. Braking device
8. Tachometer
9. Measuring tape

TEST SET UP

It is shown in figure. Centrifugal pump is driven by an electric motor. It is used to supply water from sump to the turbine.

A Venturimeter is fitted to the unit to measure the rate of flow. A manometer is fitted to the Venturimeter.

A pressure gauge is fitted to the turbine inlet to measure the supply head.

A vacuum gauge (not shown) is fitted to the inlet of draft tube to measure the vacuum head.

A braking device (not shown) is coupled with the runner of turbine to measure the output.

PROCEDURE

1. Measure the circumference of brake drum and thickness of rope by using tape.
2. Note the Venturimeter constant and coefficient. Operate the handle to set guide vane for full opening.
3. Prime the centrifugal pump.
4. Keeping the delivery valve closed, switch on the pump.
5. Open the delivery valve. Allow turbine to run for some times.

OBSERVATION

1. Circumference of brake drum, $2\pi R$ =

   = m

2. Thickness of rope, t =

   = m

3. Venturimeter constant, C =

4. Venturimeter coefficient, K =

5. Dead weight, W_d = kg

6. To find R_e

   $2\pi R$ =

   R =…………../2π

   =

   $\therefore R$ = m

   Then, R_e = R+ (t/2)

   =

   = m

7. Difference in levels between the centers of vacuum and pressure gauges, X = m

6. Apply load on brake drum.
7. Measure the speed of turbine by using tachometer.
8. Note the manometer reading.
9. Note the pressure gauge reading.
10. Note the vacuum gauge reading.
11. Repeat the above procedure by changing the load.
12. After experiment is over, switch off the pump.
13. Tabulate the readings.

FORMULAE USED

Difference in mercury levels, $h = (h_1 - h_2) / 1000$ m of mercury

Where,

h_1 → Mercury level in one limb in mm.

h_2 → Mercury level in another limb in mm.

Venturi head, $H = h [(S_m – S_w) / S_w]$

$= h [(13.6 – 1) / 1]$

$H = h \times 12.6$ m of water

We know that,

S_m → Specific gravity of mercury = 13.6

S_w → Specific gravity of water = 1

Discharge through Venturimeter, $Q = KC\sqrt{H}$ m^3/sec

Where,

K → Coefficient of Venturimeter.

C → Constant of Venturimeter.

Net supply head, $H_s = H_{gauge} + H_{vac} + X$ m

Input power, $P_I = w\, Q\, H_s$ kW

Where,

w → Specific weight (9.81) of water in kN/m^3.

H_s → Supply head of water in m.

Sl. No	Manometer Reading		$h=(h_1 - h_2)$ / 1000 [m]	Venturi head H=h x 12.6 [m of water]	Load		Effective Load $W_e=((W_d+W_1-W_2)$ x 9.81) / 1000 [kN]	Speed N [rpm]	Discharge $Q=KC\sqrt{H}$ [m^3/sec]	Pressure gauge Reading H_{gauge} [m]	Vacuum gauge Reading H_{vac} [m]	Net Supply Head $H_s= H_{gauge}+ H_{vac}+X$	In put power, $P_I=wQH_s$ [kW]	Output power, $P_O=(2\pi NW_e R_e) / 60$ [kW]	Efficiency $\eta=(P_O/P_I)$ x 100 [%]
	h_1 [mm]	h_2 [mm]			W_1 [Kg]	W_2 [Kg]									
01															
02															
03															
04															
05															

Output power, kW

Where,

N → Speed of brake drum in rpm.
W_e → Effective load on brake drum in kN.
R_e → Effective radius in m.

Efficiency of turbine, $\eta = (P_O / P_I) \times 100$ %

GRAPHS

- Speed vs Efficiency
- Speed vs Output power
- Speed vs Discharge

MODEL CALCULATION

Reading Number

Difference in mercury levels,	h	$= (h_1-h_2) / 1000$	
		=	
		=	m of mercury
Venturi head,	H	= h x 12.6	
		=	
		=	m of water
Discharge through Venturimeter,	Q	$= KC\sqrt{H}$	
		=	
		=	m^3/sec
Net supply head,	H_s	$= H_{gauge} + H_{vac} + X$	
		=	
		=	m
Input power,	P_I	$= w\ Q\ H_s$	[w = 9.81 kN/ m^3]
		=	
		=	kW
Output power,	P_O	$= (2\pi N W_e R_e) / 60$	
		=	
		=	kW
Efficiency of turbine,	η	$= (P_O / P_I) \times 100$	
		=	
		=	%

RESULT

Performance test is conducted and the performance curves of the given reaction turbine is drawn.