प्रयोगशाला मैनुअल

द्रव यांत्रिकी एवं हाइड्रोलिक मशीन प्रयोगशाला (CE334)

के लिए

(**बीटेक, पाँचवाँ सेमेस्टर. यांत्रिक** के लिए**)**

LABORATORY MANUAL

FOR

FLUID MACHANICS & HYDRAULIC MACHINES LAB. (CE-334)

(For B.Tech. V^{th} sem. Mechanical)

सिविल इंजीनियरिंग विभाग
मौलाना आज़ाद राष्ट्रीय प्रौद्योगिकी संस्थान
भोपाल (म.प्र.)

DEPARTMENT OF CIVIL ENGINEERING
MAULANA AZAD NATIONAL INSTITUTE OF TECHNOLOGY
BHOPAL (M.P.)

नाम /Name: --

स्कॉलर क्रमांक /Scholar No.:------------------------------------ बैच संख्या/ Batch No.:-----------------

अनुक्रमणिका/INDEX

क्र.सं./S.No.	प्रयोग का नाम /Name of Experiment	पृष्ठ सं/Page No.
1.	बर्नौली के प्रमेय का सत्यापन / Verification of Bernaulli's theorem	
2.	घूर्णित वेन पर बहुमुखी धारा के लिए अभिक्रिया-संवेग सिद्धांत को सत्यापित करना। Verification of Impulse momentum principle	
3.	दिए गए वेंचुरी मीटर का अंशांकन Calibration of given Venturi meter	
4.	दिए गए ओरीफिस मीटर का अंशांकन Calibration of given Orifice meter	
5.	दी गई पाइप लाइन में नुकसान को मापना और इसके घर्षण कारक पर रेयॉनल्ड्स संख्या के प्रभाव को निर्धारित करना। To measure the losses in the given pipe line and determine the effect of Reynold's number on its friction factor.	
6.	प्रवाह की व्यवस्था के निर्धारण के लिए रेनॉल्ड्स संख्या ज्ञात करना। To find Reynolds number for determination of regimes of flow.	
7.	पेल्टन व्हील की एफ्फीसिएन्सी कैरेक्टरस्टिक्स प्राप्त करना To derive efficiency characteristics of Pelton Wheel	
8.	सेन्ट्रीफ्यूगल पम्प की H-Q कैरेक्टरस्टिक्स और एफ्फीसिएन्सी कैरेक्टरस्टिक्स प्राप्त करना To derive H-Q and efficiency characteristics of Centrifugal pump	
9.	फ्रांसिस टरबाइन की एफ्फीसिएन्सी कैरेक्टरस्टिक्स प्राप्त करना To derive efficiency characteristics of Francis turbine	
10.	रेसिप्रोकेटिंग पंप में दक्षता और प्रतिशत स्लिप की गणना करना To compute the efficiency and percentage slip in reciprocating pump	
11.	केप्लान टरबाइन का अध्ययन /Study of Kaplan turbine	

प्रयोग क्रमांक. 1
Experiment no. 1

उद्देश्य: बर्नौली के प्रमेय को सत्यापित करना।
Objective: To verify Bernoulli’s theorem.

आवश्यक उपकरण:
Apparatus required:
Experimental setup for the verification of Bernoulli’s theorem consisting of inlet tank with supply, horizontal transparent pipe of varying cross-sectional area attached with piezometers at equal distance along its length, control valve, measuring tank, stop watch.

Fig.1.1 Experimental setup of Bernoulli's experiment

सिद्धांत //Theory:
The total energy associated with water consist of pressure, kinetic and potential energies and as per energy conservation law, energy remains constant. The energy per unit weight of water is known as head with linear unit 'cm or m'. Bernoulli’s theorem states that for a stream lined, steady, potential and incompressible fluid flow, the sum of pressure head, velocity head and potential head is a constant.

$$\frac{p}{\gamma}(Pressure\ head) + \frac{V^2}{2g}(Velocity\ head) + z(Potential\ head) = constant$$

Where,

p – The static pressure (N/m^2),
γ – The specific weight of water (N/m^3)
V – Linear velocity of flow (m/s),
g – Acceleration due to gravity (m/s^2)
z – Elevation from datum line (m),

उपयोग किये जाने वाले सूत्र /Formulae to be used:

Area of tank	‘A’ = Length × Breadth (cm^2)
Volume of water in tank	‘V’ = ‘A’ × ‘h’ (cm^3)
Discharge through pipe	‘Q’ = ‘V’/‘t’ (cm^3/s)
Velocity at any section ‘i’	‘v_i’ = ‘Q’/‘a_i’ (cm/s)
Velocity head at section	‘Hv_i’ = ‘v_i^2’/2g (cm)

Where,
t - time of collection of water in measuring tank (sec).
h - rise in water level in measuring water tank (cm)
a_i - area of pipe at section ‘i’ (cm^2)

प्रयोग विधि /Procedure:

1. इनलेट टैंक आपूर्ति वाल्व को आवश्यक ऊंचाई तक भरने के लिए खोला जाता है।
2. पानी को उसके आउटलेट पर नियंत्रण वाल्व खोलकर पारदर्शी पाइप के माध्यम से बहने दिया जाता है।
3. इनलेट वाल्व को इस तरह समायोजित किया गया कि इनलेट टैंक में पाइप का पानी स्थिर रहे।
4. विभिन्न पीजोमीटर में जल स्तर की ऊंचाई यानी दबाव शीर्ष 'एचपीआई' नोट की जाती है।
5. पानी को मापने वाले टैंक में एक अवधि (न्यूनतम 40 सेकंड) के लिए एकत्र किया जाता है और टैंक में जल स्तर में वृद्धि दर्ज की जाती है।
6. पाइप के माध्यम से प्रवाह को अलग-अलग करने के लिए वाल्व नियंत्रण वाल्व के उद्घाटन को बदलें और चरण 3 से चरण 5 को दोहराएं।
7. रीडिंग के 2 सेटों के लिए चरण 3 से चरण 6 तक दोहराएं।

1. The inlet tank supply valve is opened to fill up to required height.
2. The water is allowed to flow through transparent pipe by opening the control valve at its outlet.
3. The inlet valve adjusted such that pipe water in inlet tank remain constant.
4. The height of water levels i.e., pressure head 'H_{pi}' in different piezometers are noted.
5. The water is collected in measuring tank for a period (minimum 40 seconds) and rise of water level in tank is recorded.
6. Change the valve control valve opening to vary the flow through pipe and repeat step 3 to step 5.
7. Repeat step 3 to step 6 for 2 sets of reading.

अवलोकन /Observations:

स्थिरांक /Constants:

1. Measuring tank size =
2. Measuring tank area=
3. Assume datum elevation 'z' = 0.0 (cm)

वेरिएबल्स /Variables:

SET-1: Time of water collection 't' = Rise of water in measuring tank 'h' =

Volume of water 'V' = Discharge through pipe 'Q' =

Section No.	Area (cm^2)	V (cm/s)	H_{vi} (cm)	H_{pi} (cm)	Total head (cm)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

SET- 2: Time of water collection 't' =
Rise of water in measuring tank 'h' =
Volume of water 'V' =
Discharge through pipe 'Q' =

अवलोकन तालिका/OBSERVATION TABLE

Section No.	Area (cm^2)	V (cm/s)	H_{vi} (cm)	H_{pi} (cm)	Total head (cm)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					

परिणाम की प्रस्तुति /Presentation of result:

- Plot the position of piezometer tubes on (x-axis) and piezometric head (Hp+z) on Y axis. Join all ordinates to get hydraulic gradient line.
- Add Velocity head (Hv) over piezometric head. Join the points and draw total energy line.
- Draw a horizontal line from section 1. Difference between the horizontal line and total head at last section will give loss of head.

टिप्पणियाँ/Comments:

प्रयोग क्रमांक. 2

Experiment no.2

उद्देश्य - घूर्णित वेन पर बहुमुखी धारा के लिए अभिक्रिया-संवेग सिद्धांत को सत्यापित करना।

Objective: To verify impulse momentum principle for flow over curved vane.

उपकरण आवश्यक/Apparatus required:

1. Experimental setup consisting of nozzle fitted upward at end of vertical supply pipe enclosed in a glass cylinder with control valve, a curved vane attached to rod, lever arrangement.
2. A measuring tanks
3. A stopwatch
4. Brass weights

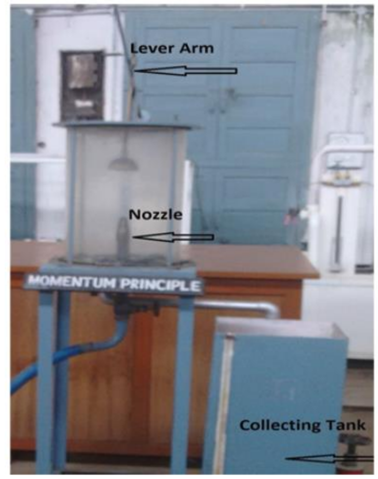

Fig.2.1 Experimental setup of Impulse momentum principle

सिद्धांत /Theory:

Some problems cannot be easily solved by consideration of energy Principle (Bernoulli's Theorem) alone due to complicated geometry of flow in some situations. Examples of such flows are in pumps, turbines, pipe bends and enlargements etc. In such cases impulse momentum principle can be conveniently used. It states that the impulse i.e., product of the force and time for which force acts is equal to the change in momentum of the body i.e. product of the mass and velocity of the body. When water strikes a solid object, it imparts dynamic force on that object. If a vertical jet of water with velocity 'U' strike a curved plate, then dynamic force F_x and F_y directions are given by:

$$F_x = \frac{Q \times \gamma}{g}(U_{2x} - U_{1x}) \quad F_y = \frac{Q \times \gamma}{g}(U_{2y} - U_{1y}) \quad F = \sqrt{F_x^2 - F_y^2}$$

Where,

Ux - Velocity component in X-direction (m/s)

Uy - Velocity component in Y-direction (m/s)

γ - Specific weight of water (N/m^3)

g - Acceleration due to gravity (m/s^2)

Subscripts 1 and 2 denote velocity values at inlet and exit of curve plate.

उपयोग किये जाने वाले सूत्र /Formulae to be used:

Discharge from nozzle
$$Q = \frac{A \times Y}{T}$$

Jet velocity
$$V = \frac{Q}{a}$$

Theoretical dynamic force
$$F_T = \rho QV(1 + \cos\Theta)$$

Actual dynamic force
$$F_T = \frac{W \times L_2}{L_1}$$

Force coefficient
$$C_F = \frac{F_A}{F_T}$$

Where,

A - Area of measuring tank (cm^2),
Y - Rise of water level in measuring tank (cm),
T- Time of water collection (sec),
a - Area of nozzle (cm^2),
ρ – Density of water ($1gm/cm^3$),
θ - Outlet angle of curve vane (15^o),
L_1 - Length from fulcrum to weight hanger (cm),
L_2 - Length from fulcrum to rod attached to curved vane (cm)

प्रयोग विधि /PROCEDURE:

1. एक हेंगर को लीवर आर्म के अंत में लगाएं और उसे समतल स्थिति में रखने के लिए बैलेंसिंग वेट को लीवर आर्म पर स्थानांतरित करके उसकी लंबाई 'L1' और 'L2' को नापें। 'L1' फलक्रम से हेंगर तक और 'L2' में जुड़े रॉड तक।
2. पैन पर वजन 'W' रखें और नियंत्रण वाल्व को धीरे-धीरे खोलें ताकि नोजल से पानी का जेट निकले। वाल्व के खोलने को समायोजित करें ताकि लीवर आर्म फिर से समतल स्थिति में आ जाए।
3. मापने वाले टैंक में स्तर को नोट करें और फिर निर्दिष्ट समय (कम से कम 40 सेकंड) के लिए पानी को मापने वाले टैंक में एकत्र करें और फिर से पानी के स्तर को नोट करें।
4. विभिन्न वजन लेते हुए कम से कम 4 बार चरण 2 और 3 को दोहराएं।

1. Put a hangar at the end of the lever arm and balance it horizontally positions by adjusting the location of the balancing weight on the lever arm. Measure the lengths 'L1' and 'L2' from the fulcrum to the hanger and rod attached to the curved vane respectively.
2. Put the weight say 'W' on the pan and open the control valve slowly to issue jet of water from the nozzle. Adjust the valve opening such that the lever arm comes again to horizontal position.
3. Note the level in the measuring tank and then collect water in the measuring tank for fixed time (Min.40 seconds) and again note the water level.
4. Repeat step 2 and 3 for least 4 times taking different weights.

अवलोकन /Observation table:

Size of collecting Tank =

Area of collecting tank =

Dia of nozzle =

Area of jet=

Length of lever fulcrum to vane L_1=

Length of fulcrum to hanger L_2 =

Type of Vane=

Angle of Vane =

Sr. No.	Collection time (s)	Initial level 'Y1' (cm)	Final level 'Y2' (cm)	Discharge (cm^3/s)	Velocity (cm/s)	Weight applied (gm)	Actual hydrodynamic force (dyne)	Theoretical hydrodynamic force (dyne)	Coefficient of force

नमूना गणना/Sample calculation:

ग्राफ/Graph:

1. Plot the graph between F_T (X-axis) and F_A (Y-axis) and find C_F.

टिप्पणियाँ/Comments:

प्रयोग क्रमांक. 3
Experiment no.3

उद्देश्य - दिए गए वेंचुरी मीटर का अंशांकन (वास्तविक डिस्चार्ज $Q_a = K\ H_{Hg}{}^{n}$ मानते हुए स्थिरांक K और n निर्धारित करना) और प्रवाह की विभिन्न दरों के लिए दिए गए वेंचुरी मीटर के डिस्चार्ज गुणांक (C_d) का निर्धारण करना।

Objective: To calibrate the Venturimeter (To determine the constants K and n, assuming the actual discharge $Q_a = K\ H_{Hg}{}^{n}$) and to determine the coefficient of discharge (C_d) of given Venturi meter for different rates of flow.

आवश्यक उपकरण/Instruments required:

1. A supply pipe attached with a venturimeter and control valve at the end.
2. A measuring tank
3. A stop watch
4. Differential manometer attached to pressure taping for venturimeter.

सिद्धांत/Theory:

As per Bernoulli's theorem, for constant potential energy and flow rate, increase in velocity will decrease the pressure at any point and this concept can be used for discharge measurement in pipes. The device developed based on this concept are called differential flow meter. The velocity in pipe is increased by reducing the pipe diameter. Venturi meter is a device used for measuring the rate of flow of a fluid through a pipe. It consists three parts: converging cone, throat (least dia section) and diverging cone as shown in fig.1. The amount of pressure change between throat and inlet in particular venturi meter depends on the flow rate. The actual discharge will be different than the theoretical discharge because of losses. Calibration is process to develop relationship between actual and theoretical discharge.

Fig.3.1: Experimental setup of Venturi-meter

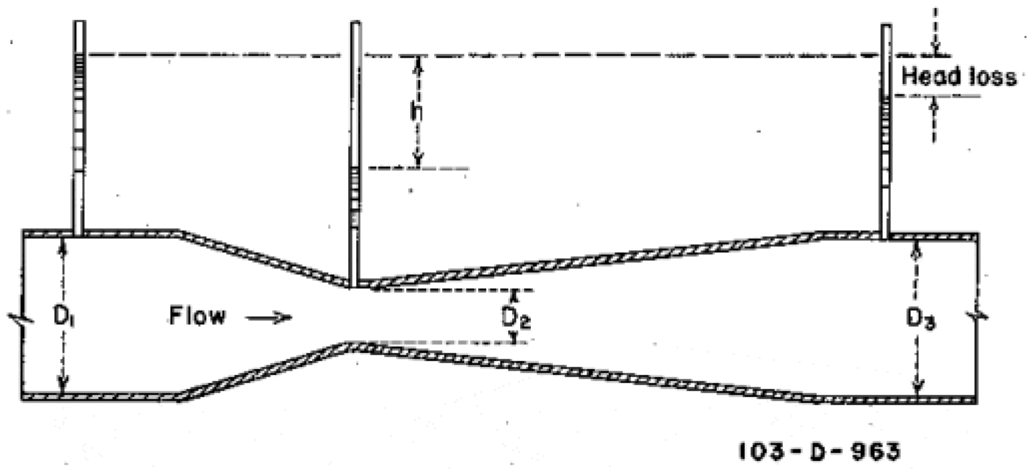

Fig.3.2: Venturi-meter

उपयोग किये जाने वाले सूत्र

Formulae to be used:

Actual discharge $$Q_A = \frac{A \times Y}{T}$$

Differential pressure head (in water column) $$H = \left(\frac{S_m}{S_w} - 1\right) \times h_m$$

Theoretical discharge $$Q_T = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

Coefficient of discharge $$C_D = \frac{Q_A}{Q_T}$$

Where,

A - Area of measuring tank in (cm^2)

T- time of collection (sec)

a_2 - cross sectional area of throat (cm^2)

S_w - specific gravity of water

a_1 - cross sectional area of inlet pipe (cm^2)

S_m - specific gravity of manometric liquid

Y – Level rise in measuring tank (Y_2-Y_1) (cm)

hm – measuring level difference between two limbs of manometer (cm)

प्रयोग विधि /Procedure:

1. टैंक के आयाम**,** पाइप और गले का व्यास मापें।
2. पाइप के माध्यम से प्रवाह की अनुमति देने के लिए नियंत्रण वाल्व को आंशिक रूप से खोलें और मैनोमीटर से जुड़े लचीले पाइप से हवा को हटा दें।
3. मापने वाले टैंक में स्तर को नोट करें और फिर निश्चित समय (न्यूनतम **40** सेकंड) के लिए मापने वाले टैंक में पानी इकट्ठा करें और फिर से पानी के स्तर को नोट करें।
4. पानी के संग्रह के दौरान अंतर मैनोमीटर के दो अंगों में मैनोमेट्रिक तरल के स्तर को भी नोट करें।
5. वाल्व के उद्घाटन को बढ़ाएं और वाल्व के कम से कम **5** उद्घाटन के लिए चरण **3** और **4** को दोहराएं।
6. प्रयोग पूरा करने के बाद मापने वाले टैंक से पानी निकाल दें।

1. Measure the tank dimensions, dia of pipe, and throat.
2. Open the control valve partly to allow flow through the pipe and remove the air from the flexible pipe connected to the manometer.
3. Note the level in the measuring tank and then collect water in the measuring tank for a fixed time (Min.40 seconds) and again note the water level.
4. Also note down the level of manometric liquid in two limbs of the differential manometer during the collection of water.
5. Increase valve openings and repeat steps 3 and 4 for at least 5 openings of the valve.
6. Drain out the water from the measuring tank after completing the experiment.

अवलोकन /OBSERVATIONS:

Size of collecting Tank =

Area of collecting tank=

Dia of inlet pipe =

Area of pipe=

Dia of throat =

Area of throat=

Specific gravity of manometric liquid=

Specific gravity of water=

Sr. No.	Collection time (s)	Initial level 'Y1' (cm)	Final level 'Y2' (cm)	Actual discharge (cm^3/s)	Level difference in manometer tubes (cm	Head difference in water column (cm)	Theoretical discharge (cm^3/s)	Coefficient of discharge

नमूना गणना:

SAMPLE CALCULATION:

ग्राफ़/GRAPHS:

1. Plot graph between Q_{th} v/s C_D.
2. Plot graph on log-log paper between H v/s Q_A and find K and n to establish equation $Q_A=KH^{n}$.

टिप्पणियाँ/COMMENTS:

प्रयोग क्रमांक. 4
Experiment no.4

दिए गए ओरीफिस मीटर का अंशांकन (वास्तविक डिस्चार्ज $Q_a = K\ H_{Hg}^{\ n}$ मानते हुए स्थिरांक K और n निर्धारित करना) और प्रवाह की विभिन्न दरों के लिए दिए गए वेंचुरी मीटर के डिस्चार्ज गुणांक (C_d) का निर्धारण करना।

Objective:

To calibrate the Orifice meter(To determine the constants Kand n, assuming the actual discharge $Q_a = K\ H_{Hg}^{\ n}$) and to determine the coefficient of discharge (C_d) of given orifice meter for different rates of flow.

Instruments required:

1. A supply pipe attached with a orifice meter and control valve at the end.
2. A measuring tank
3. A stop watch
4. Differential manometer attached to pressure taping for orifice meter.

Fig.4.1: Experimental setup of Orifice meter

सिद्धांत/Theory:

As per Bernoulli's theorem, for constant potential energy and flow rate, increase in velocity will decrease the pressure at any point and this concept can be used for discharge measurement in pipes. The device developed based on this concept are called differential flow meter. The velocity in pipe is increased by reducing the pipe diameter. Orifice meter is a device used for measuring the rate of flow of a fluid through a pipe. It consists a orifice plate (least dia section) as shown in fig.1. The amount of pressure change between throat and inlet in particular orifice meter depends on the flow rate. The actual discharge will be different than the theoretical discharge because of losses. Calibartion is process to develop relationship between actual and theoretical discharge.

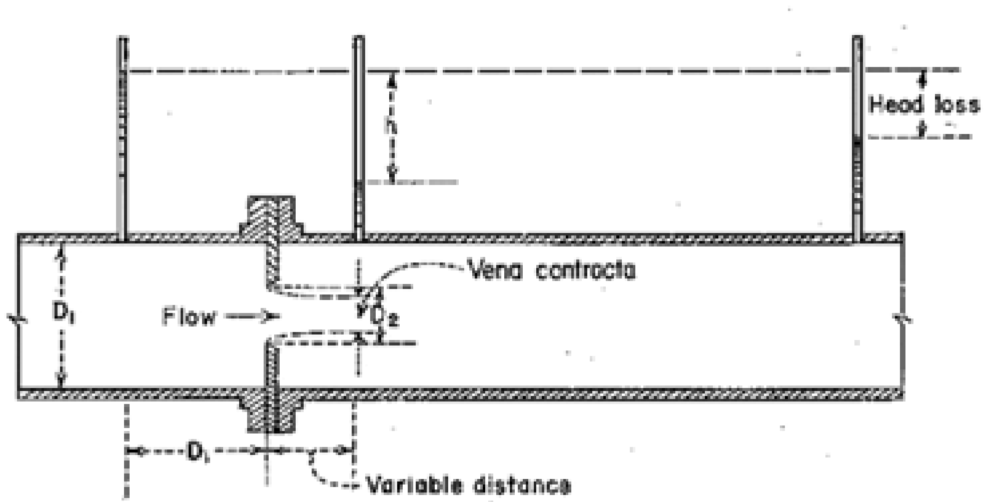

Fig.4.2: Orifice meter

उपयोग किये जाने वाले सूत्र:
Formulae to be used:

Actual discharge
$$Q_A = \frac{A \times Y}{T}$$

Differential pressure head (in water column)
$$H = \left(\frac{S_m}{S_w} - 1\right) \times h_m$$

Theoretical discharge
$$Q_T = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gH}$$

Coefficient of discharge
$$C_D = \frac{Q_A}{Q_T}$$

Where,

A - Area of measuring tank in (cm^2)

T- time of collection (sec)

a_2 - cross sectional area of orifice (cm^2)

Y – Level rise in measuring tank (Y_2-Y_1) (cm)

hm – measuring level difference between two limbs of manometer (cm)

S_w - specific gravity of water

a_1 - cross sectional area of inlet pipe (cm^2)

S_m - specific gravity of manometric liquid

प्रयोग विधि /Procedure:

1. टैंक के आयाम, पाइप के व्यास और गला मापें।
2. नियंत्रण वाल्व को आंशिक रूप से खोलें ताकि पाइप के माध्यम से प्रवाह हो सके और मैनोमीटर से जुड़े लचीले पाइप से हवा निकालें।
3. मापने वाले टैंक में स्तर को नोट करें और फिर निर्दिष्ट समय (कम से कम 40 सेकंड) के लिए पानी को मापने वाले टैंक में एकत्र करें और फिर से पानी के स्तर को नोट करें।
4. पानी के संग्रहण के दौरान डिफरेंशियल मैनोमीटर के दोनों पंजों में मैनोमेट्रिक तरल का स्तर भी नोट करें।
5. वाल्व के खुलने को बढ़ाएं और चरण 3 और 4 को कम से कम 5 बार दोहराएं।
6. प्रयोग समाप्त होने के बाद मापने वाले टैंक से पानी निकाल दें।

1. Measure the tank dimensions, dia of pipe and throat.
2. Open the control valve partly to allow flow through pipe and remove the air from the flexible pipe connected to manometer.
3. Note the level in measuring tank and then collect water in measuring tank for fixed time (Min.40 seconds) and again note the water level.
4. Also note down the level of manometric liquid in two limbs of differential manometer during the collection of water.
5. Increase valve openings and repeat step 3 and 4 for at least 5 openings of valve.
6. Drain out the water from measuring tank after completing the experiment.

अवलोकन /Observations:

Size of collecting Tank =

Area of collecting tank =

Dia of inlet pipe =

Area of pipe=

Dia of orifice =

Area of orifice=

Specific gravity of manometric liquid=

Specific gravity of water=

Sr. No.	Collection time (s)	Initial level 'Y1' (cm)	Final level 'Y2' (cm)	Actual discharge (cm^3/s)	Level difference in manometer tubes (cm	Head difference in water column (cm)	Theoretical discharge (cm3/s)	Coefficient of discharge

नमूना गणना:
Sample calculation:

रेखांकन:
Graphs:

1. Plot graph between Q_{TH} v/s C_D.
2. Plot graph on log-log paper between H v/s Q_A and find K and n to establish equation $Q_A=KH^n$.

टिप्पणियाँ/Comments:

प्रयोग क्रमांक. 5
Experiment no.5

उद्देश्य- दी गई पाइप लाइन में नुकसान को मापना और इसके घर्षण कारक पर रेयॉनल्ड्स संख्या के प्रभाव को निर्धारित करना।

Objective- To measure the losses in the given pipe line and determine the effect of Reynold’s number on its friction factor.

आवश्यक उपकरण:

Apparatus required

i. overhead tank supplying water in which the level is maintained constant.

ii. pipeline with bends valves etc, fitted with inverted U-tube manometer to measure head loss.

iii. A collecting tank and stop watch to measure the rate of flow.

Fig.5.1 Experimental setup pipe frictions experiment

सिद्धांत /Theory

Losses of head (energy per unit wt.of fluid, expressed in meters of fluid)occurs in any fluid flow. The loss is caused by

(i)fluid friction in pipe or conduit-major losses

(ii)changes in velocity or direction of flow-minor losses

Fluid pipe friction loss is a continuous loss of head, h_f assumed to occur at a uniform rate along the pipe as long as the size and roughness of the pipe remain constant and is commonly referred to as the loss of head due to friction.

For turbulent flow in pipes, the major loss (h_f) is normally taken as

$$h_f = \frac{f\,l\,v^2}{2gd}$$

Where,

f – Friction factor which is dependent upon the material, surface finish,
l - Length of pipe line in which the losses occur
d - Diameter of pipe line
v - Velocity of flow in the pipeline

प्रयोग विधि /Procedure

1. पाइप के मैनोमीटर टैपिंग्स के बीच के व्यास (**d)** और लंबाई (**l)** को नोट करें।

2. मैनोमीटर से हवा निकालने के लिए एयर कॉक खोलें।

3. पानी को पाइप के माध्यम से बहने देने के लिए वाल्व खोलें।

4. मापने वाले टैंक में एक लीटर पानी एकत्र करें और संग्रहण में लगा समय नोट करें।

5. मैनोमीटर के कॉलमों में स्तरों के अंतर को नोट करें।

6. वाल्व का खुलना बदलें और चरण **4** और **5** को दोहराएं।

7. प्रयोगशाला में उपलब्ध तालिका से 'काइनेमैटिक विस्कोसिटी' '**ν**' प्राप्त करने के लिए पानी का तापमान नोट करें।

8. परिणामों को सारणीबद्ध करें।

1. Note the diameter (d) and length(l) of the pipe between manometers tappings.
2. Open the air cocks to remove the air from manometer
3. Open the valve to allow water to flow through the pipe.
4. Collect one litre of water in measuring tank and note down the time taken for the collection.
5. Note down the difference in levels in the columns of the manometers.
6. Change the valve opening and repeat the steps 4 and 5.
7. Note down the temperature of water for getting kinematic viscosity 'ע' from the table available in laboratory.
8. Tabulate the results.

अवलोकन टेबल /Observation Table

Length of pipe =

Diameter of Pipe=

S.N.	Reading of left limb of manometer(cm)	Reading of right limb of manometer (cm)	Difference (cm)	Time(secs) for collection of 1 liter of water

गणना/Calculations

Head loss 'h_f' over a length of pipe or in any fitting is given by the manometers connected between the two toppings of pipe line.

Calculate the friction factor by using the equation

$$h_f = \frac{flv^2}{2gd}$$

Note the temperature of water and find the kinematic viscosity of water by using physical table

Calculated the Reynolds No.

$$\mathrm{Re} = \frac{Vd}{\nu}$$

for each reading at a discharge.

परिणाम की प्रस्तुति/Presentation of Results

Plot friction factor 'f ' vs Re on a semi log graph and compare with the standard Moody's chart.

चर्चा/Discussion

प्रयोग क्रमांक. 6
Experiment no.6

उद्देश्य: प्रवाह की व्यवस्था के निर्धारण के लिए रेनॉल्ड्स संख्या ज्ञात करना।

Objective: To find Reynolds number for determination of regimes of flow.

सिद्धांत/Theory: The flow of real fluids can basically occur under two very different regimes namely laminar and turbulent flow. The laminar flow is characterized by fluid particles moving in the form of lamina sliding over each other. The lamina near the flow boundary has lower velocity as compared to those away from boundary. This type of flow occurs in viscous fluids, fluids moving at low velocity and fluids flowing through narrow passages.

The turbulent flow is characterized by random motion and intermixing of fluid particles such that their velocity changes from point to point and even at the same point from time to time. The Reynolds number is non-dimensional and it is ration of inertia to viscous force. This number is used to classify laminar and turbulent flow. The flow in pipe with Reynolds number less than 2000 is laminar and flow with Reynolds number more than 4000 is turbulent. There is transition flow for Reynolds number between 2000 to 4000.

प्रयुक्त उपकरण/Instruments used:

1. A graduated glass cylinder Fig. 12 .1 Experimental setup 2. Stop watch 3. Reynolds apparatus

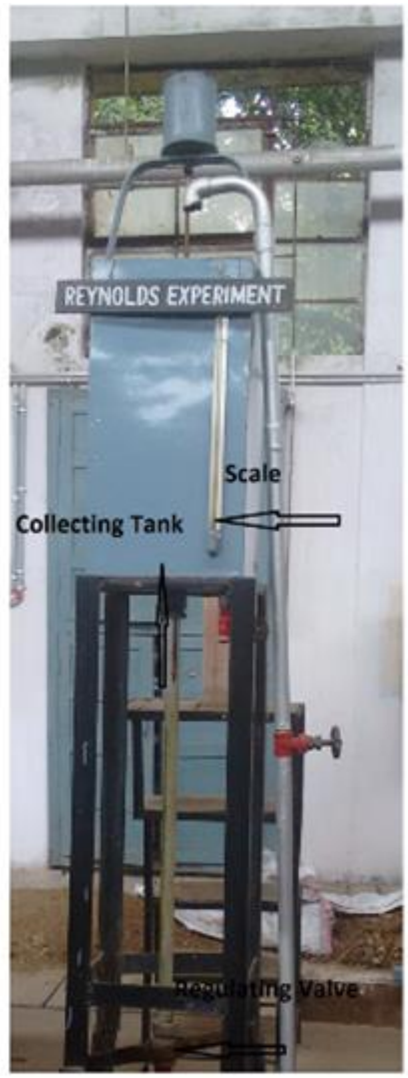

Fig.6.1 Experimental setup of Reynold’s experiment

उपयोग किये जाने वाले सूत्र
Formulae used:

Discharge

$$Q = \frac{A \times h}{t}$$

Velocity of flow in pipe $$V = \frac{Q}{A}$$

Reynolds number $$R_e = \frac{V \times D}{\nu}$$

Where

A - Area of graduated glass cylinder (cm^2)

h - depth of water in cylinder (cm)

t- Time of water collection (sec)

ν - kinematic viscosity of fluid (cm^2/s)

D- diameter of transparent glass tube (cm)

प्रक्रिया/Procedure:

1. सप्लाई लाइन वाल्व खोलकर पानी के टैंक को पानी से भरें और इसे ओवरफ्लो होने दें ताकि टैंक में पानी की गहराई स्थिर बनी रहे।
2. पानी का तापमान नोट करें।
3. कांच की नली के सिरे पर लगे आउटलेट वाल्व को आंशिक रूप से खोलें और बहुत धीमी दर से पानी का प्रवाह होने दें।
4. प्रवाह को स्थिर होने दें और फिर डाई इंजेक्टर के इनलेट पर वाल्व खोलें और डाई को नली के माध्यम से जाने दें। धागे की प्रकृति का निरीक्षण करें।
5. पानी को ग्लास सिलेंडर में इकट्ठा करें और पानी की मात्रा और संग्रहण के समय को नोट करें और डाई वाल्व बंद कर दें।
6. कांच की नली का वाल्व खोलने की मात्रा को बदलें और विभिन्न वाल्व खोलने के लिए चरण 3 और 5 को दोहराएं।

1. Fill the water tank with water by opening the supply line valve and allow it to overflow so that depth of water in tank remains constant.
2. Note the temperature of water.
3. Partially open the outlet valve fitted end of glass tube and allow the flow to take place at a very low rate.
4. Allow the flow to stabilize and then open the valve at the inlet of the dye injector and allow the dye to move through the tube. Observe the nature of the filament.
5. Collect water in glass cylinder and note down volume of water and time of collection of water and close the dye valve.
6. Vary the glass tube valve opening and repeat the steps 3 and 5 for different valve openings.

अवलोकन /Observations:

Mean temperature of water T = °C Kinematic viscosity of water, ν =
Diameter of glass tube D = Dia of cylinder container used for collecting water =

Sr. No.	Collection time ‘T’ (sec)	Water depth in cylinder ‘h’ (cm)	Discharge ‘Q’ (cm3/s)	Velocity ‘V’ (cm/s)	Reynolds number ‘Re’	Type of flow
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

नमूना गणना/Sample calculations:

टिप्पणियाँ/Comments:

प्रयोग क्रमांक. 7
Experiment no. 7

उद्देश्य: पेल्टन पहिये की दक्षता विशेषताओं को प्राप्त करना।

Objective: To derive the efficiency characteristics of the Pelton wheel.

आवश्यक उपकरण:
Apparatus Required:

1. Pelton Wheel unit with water supply rig.
2. Venturi meter with manometer to measure discharge
3. Tachometer to measure speed
4. Dynamometer or break drum to measure the torque on the shaft.

Fig.7.1 Experimental setup of Pelton wheel experiment

सिद्धांत /Theory:

Pelton wheel is an impulse turbine where in the total energy of water is converted in to kinetic energy by putting nozzle at the end of penstock. The jet of water coming out of the nozzle is made to impinge in air on buckets fixed on the periphery of a wheel mounted on a shaft. The impact of water on the surface of bucket produces the force which causes

the wheel to rotate, thus develop torque or mechanical power to the shaft. The jet of water strikes the double hemispherical cup-shaped bucket at the center and is deflected to both sides leading to change in momentum, and then the water drops into tail race.
The main parts of the Pelton turbine are: 1. Flow regulation mechanism, 2. Bucket and runner, 3. Hydraulic brake.

Flow regulation mechanism

This mechanism controls the quantity of water passing through the nozzle to meet the variable demand of power. The mechanism consists of a spear fixed to the end of a shaft which is operated by servomotor through governor. When the speed of the wheel increases, the spear is pushed into the nozzle, thereby reducing the quantity of water striking the bucket. If the speed falls, the spear is drawn back allowing a greater quantity of water to pass through the nozzle.

Runner

Each bucket is divided vertically into two parts by a sharp edge splitter at the center, thus giving the shape of double-spherical cup. The splitter divides the jet into two parts moving side-ways in opposite directions. Cast steel runner is used for low–head but for higher head, bronze or stainless steel is used. The buckets are bolted or integrally casted on the circumference of circular disk mounted on shaft. The buckets and disc together form the runner of Pelton turbine.

Hydraulic brake

The brake consists of small nozzle fitted in such a way that it directs a jet on the back on the buckets to bring the revolving runner to rest quickly.

Characteristic curves of turbine

Turbines are always designed to work under a given design data. But in practice they have to run under varying conditions. The turbine is designed with various simplifying assumptions and it is impracticable to test the prototype. Therefore the exact behaviour of the turbine under varied conditions is predetermined through model tests to finalise the design. This is graphically represented by set of curves known as characteristic curves of the turbine.

प्रयोग विधि /Procedure:

1. ब्रेक ड्रम और वेंचुरीमीटर के व्यास को मापें।
2. नोजल के केंद्र और प्रेशर गेज के स्थान के बीच की लंबवत दूरी नोट करें।
3. सेंट्रीफ्यूगल पंप को चालू करें, पंप का डिलीवरी वाल्व और टरबाइन का सुई वाल्व बंद रखते हुए।

4. सुई स्पिंडल से जुड़े एक सूचक द्वारा दिखाए गए वांछित मानों के अनुसार भाला खोलने को सेट करें।
5. आपूर्ति लाइन के डिलीवरी वाल्व को धीरे-धीरे पूरी तरह खोलें।
6. ब्रेक ड्रम पर लोड को समायोजित करें ताकि गति अनुमेय सीमा के भीतर रहे।
7. लोड**,** वेंचुरीमीटर और प्रेशर गेज पर रीडिंग नोट करें।
8. गति को **50** या **100 RPM** तक बदलने के लिए ड्रम पर लोड बदलें।
9. चरण **7** और **8** को दोहराकर **5-6** सेट रीडिंग लें।
10. सुई खोलने को बदलें और चरण **6** से **9** को दोहराएं जब तक कि सभी आवश्यक नोजल खोलने के परीक्षण पूरे न हों।

1. Measure the diameter of brake drum and diameters of Venturi meter.
2. Note the vertical distance between nozzle center and location of pressure gauge.
3. Start the centrifugal pump, keeping the delivery valve of pump and the needle valve of the turbine closed.
4. Set the spear opening to desired values shown by a pointer attached to the needle spindle.
5. Open fully the delivery valve of supply line gradually.
6. Adjust the load on the break drum so that the speed is kept within the allowable limit.
7. Note down the reading on load, venturi meters and pressure gauge
8. Change the load on drum to vary the speed by 50 or 100 rpm.
9. Take 5-6 set of readings by repeating steps 7 and 8.
10. Change the needle opening and repeat step 6 to 9 till tests for all required nozzle openings are over.

उपयोग किये जाने वाले सूत्र
Formulae Used:

Differential head in manometer limbs $h = 12.6\,\Delta y$

Discharge

$$Q = \frac{C_d\, a_1\, a_2}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh}$$

Area of pipe

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

Velocity at pipe

$$v = \frac{Q}{A}$$

Corrected Head $$H = \frac{p}{\gamma} + Z + \frac{V^2}{2g}$$

Net break load $$T = (W_1 - W_2)$$

Output power $$P_o = \frac{2\pi RnT \times 9.81}{60}\ watts$$

Input power $$P_i = 9810QH \text{ watts}$$

Efficiency (%) $$\eta = \frac{P_o}{P_i} * 100$$

$$p = 9.81 * P * 10^4$$

Where,

h - Differential head in manometer limbs (m)
Δy – difference in mercury level in two limbs of manometer (m)
R – Radius of the break drum (m)
n – Rotational speed in rpm of the shaft

नमूना गणना:

Sample Calculation:

परिणाम की प्रस्तुति/Results

चित्रात्मक प्रतिनिधित्व/Graphical representation

For each gate opening plot:

1. Head v/s Discharge.
2. Efficiency v/s speed.

अवलोकन तालिका/Observation Table:

Dia of pipe .’d’=   (m)   Pitch circle dia. of wheel ‘ D’ =
(m)   Radius of Brake drum’R’ =   (m)

Difference in elevation of pressure gauge and center of nozzle ‘z’=   (m)

Spear Opening.	Pressure gauge reading $P(Kg/cm^2)$	Corrected head H(m)	Venturi meter reading h(m)	Discharge $Q(m^3/s)$	Input power Pi (Watts)	Speed n(rpm)	Load on rope (Kg)		Net Load T(Kg)	Output power Po (Watts)	Efficiency (%)
							W1	W2			

प्रयोग क्रमांक. 8
Experiment no. 8

उद्देश्य: सेन्ट्रीफ्यूगल पम्प की H-Q कैरेक्टरस्टिक्स और एफ्फीसिएन्सी कैरेक्टरस्टिक्स प्राप्त करना
Objective: To derive H-Q and efficiency characteristics of centrifugal pump.

आवश्यक उपकरण:
Apparatus Required:

1. A pump set up with prime mover
2. Supply and delivery pipe line
3. Pressure and vacuum gauge
4. Flow measuring system

Fig.8.1 Experimental setup of centrifugal pump experiment

सिद्धांत/Theory:

A pump is a mechanical device that converts mechanical energy into hydraulic energy of water to increase the pressure. Depending on the way the energy is transferred to the to the liquid, pumps are broadly classified as

(a) Positive displacement pump

(b) Rotodynamic (centrifugal) pump.

A centrifugal pump unit has following parts-

i) Suction pipe with strainer (screen) and a foot valve at the lower end.
ii) An impeller (rotor) and a volute type casing with diffuser outlet.
iii) Delivery pipe fitted with pressure gauge and a control valve.

The pump is driven by electric motor. In rotodynamics pumps energy is added to increase the liquid velocity within the impeller by centrifugal action and subsequently the velocity of liquid is converted in to pressure energy within the volute casing of pump.

प्रयोग विधि /Procedure:

1. सेंट्रीफ्यूगल पंप स्थापना का अध्ययन करें।
2. डिलीवरी वाल्व बंद करें और सेंट्रीफ्यूगल पंप को प्राइम करें।
3. पंप को चलाने के लिए इलेक्ट्रिक मोटर चालू करें और इसकी पूरी गति प्राप्त करें।
4. डिलीवरी वाल्व खोलें और इसे वांछित डिस्चार्ज पर सेट करें।
5. वॉट मीटर **W (**जो इलेक्ट्रिक मोटर से जुड़ा है)**,** मैनोमीटर (**h1** और **h2)** की रीडिंग नोट करें**,** जो ओरिफिस मीटर से जुड़ा है**,** और कैलीब्रेशन ग्राफ से संबंधित डिस्चार्ज**,** वैक्यूम गेज या सक्शन पाइपलाइन पर मैनोमीटर (**y1** और **y2)** की रीडिंग और डिलीवरी पाइपलाइन से जुड़े प्रेशर गेज की रीडिंग नोट करें।
6. प्रेशर गेज कनेक्शन और वैक्यूम गेज/सक्शन लाइन मैनोमीटर कनेक्शन के बीच की लंबवत दूरी नोट करें।
7. डिलीवरी वाल्व की सेटिंग बदलें और चरण **5** के सभी अवलोकनों को दोहराएं।
8. डिस्चार्ज की पूरी रेंज को कवर करने वाले **6-8** डिस्चार्ज रीडिंग के लिए माप लें।

1. Study the centrifugal pump installation.
2. Close the delivery valve and prime the centrifugal pump
3. Start the electric motor to run the pump and attain its full speed.
4. Open the delivery valve and set it at desired discharge.
5.Note the reading of watt meter W (connected to electric motor), readings of manometer (h_1 and h_2), connected to the orifice meter and corresponding discharge from the calibration graph, vacuum gauge or the manometer on the suction pipe line (y_1 and y_2) and reading of the pressure gauge fitted to the delivery pipeline.
6. Note the vertical distance between the pressure gauge connection and vacuum gauge/suction line manometer connection.
7. Change the setting of delivery valve and repeat all observation as in step 5.
8. Take measurement for 6-8 discharge readings covering full range of discharge.

उपयोग किये जाने वाले सूत्र
Formulae Used:

1. Calculate the manometer head developed by the pump.

Pump head (H) = (Pressure Gauge Reading×10000/1000) – Vacuum/suction manometer Reading ‘hs’ (m) +correction for location of pressure gauge/vacuum gauge ‘z’ (m)

$$H s = hd + hs + z \text{ (m)}$$

2. The input power to the pump is calculated from: $P_{input} = W \times \eta_m \times 1000$ (watts)

3. Calculate power output of pump as: $P_{output} = \gamma QH$ (Watts)

Where ‘γ’ is the specific weight of liquid (N/m^3)

‘Q’ is the discharge delivered by the pump (m^3/s)

4. The overall efficiency of the pump is then calculated as $\eta = \frac{P_{output}}{P_{input}} \times 100$

Velocity head at inlet and outlet of the pump are not being considered, because the diameter of suction and delivery pipe is same and hence velocity head will be same and will get cancelled with each other.

गणना/Calculation :

परिणाम की प्रस्तुति/Presentation of the Results:

On a regular graph paper, plot of pump head (H_m), efficiency (ή) as ordinate and discharge (Q) abscissa. The result curves are known as characteristic curves.

अवलोकन /Observations:

Diameter of suction pipe =

Diameter of delivery pipe =

Vertical distance from suction gauge or manometer to delivery pressure gauge 'Z' (m)=

Efficiency of motor =

Speed of pump =

S.No.	Wattmeter Reading (W} (kW)	Manometer Reading (m)		Discharge Q (m^3/sec)	Pressure Reading (p) Kg/cm^2	Vacuum manometer reading (m)			Manometric head, H_m (m)	Power output P_{output} (kW)	Efficiency (%)
		h_1	h_2			y_1	y_2	Difference			

प्रयोग क्रमांक. 9
Experiment No. 9

उद्देश्य: फ्रांसिस टरबाइन की दक्षता विशेषताओं को प्राप्त करना।
Objective: To derive the efficiency characteristics of the Francis turbine.

आवश्यक उपकरण:
Apparatus Required:

1. Francis turbine.
2. Supply pump to supply water to the turbine.
3. Office meter with differential manometer.
4. Rope brake the torque.
5. Manometer or pressure gauges.
6. Tachometer to measure the shaft speed.

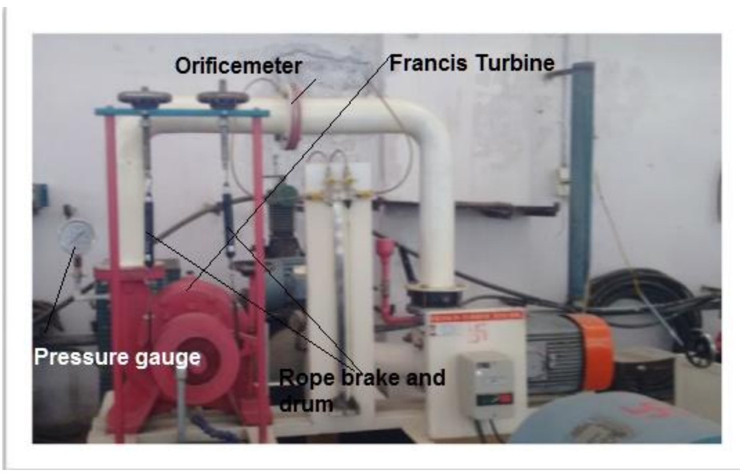

Fig.9.1 Experimental setup of Francis experiment

प्रयोग विधि /Procedure:

1. नेम प्लेट पर दी गई टरबाइन की जानकारी नोट करें।
2. गाइड वैन को पूरी तरह से बंद रखें और पंप चालू करें।
3. गाइड वैन को कुल खोलने का ¼ खोलें और ब्रेक ड्रम पर लोड को समायोजित करते हुए ताकि गति अनुमेय सीमा के भीतर रहे।
4. वेंचुरीमीटर प्रेशर गेज के मैनोमीटर से रीडिंग नोट करें।
5. टरबाइन के केंद्र से प्रेशर गेज तक की दूरी मापें।
6. रस्सी ब्रेक पर लोड और टरबाइन की गति नोट करें।
7. ड्रम पर लोड को बदलकर गति को लगभग 100 RPM से बदलें।
8. गाइड वैन के प्रत्येक खोलने के लिए गति को 6 बार बदलें।
9. अब गाइड वैन के खोलने को बदलें और उपरोक्त चरणों को 4 से 5 खोलने के लिए दोहराएं।
10. ब्रेक ड्रम के व्यास को नोट करें।

1. Note down the details of the turbine given on the name plate.
2. Keep the guide vanes completely closed and start the pump.
3. Open the guide vanes ¼ of the total opening simultaneously adjusting the load on the brake drum. So that speed is within allowable limit.
4. Note down the reading from the manometer of the venturimeter pressure gauge.
5. Measure the distance from the centre of the turbine to the pressure gauge.
6. Note down the load on the rope brake and the speed of the turbine.
7. Vary the load on the drum to change the speed by about 100 RPM.
8. For each opening of guide vane vary the speed 6 times.
9. Now change the guide vane opening and repeat the above steps for 4 to 5 openings.
10. Note down the diameter of the brake drum.

उपयोग किये जाने वाले सूत्र

Formulae used:

1. Calculate the discharge (Q_{act}) from the orifice meter manometer.

$$Q_{act} = C_d \frac{a_1\, a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh \times 12.6} \ (m^3/s)$$

Where,
C_d – Coefficient of discharge
a_1 - Area of supply pipe (m^2)
a_2 - Area of orifice (m^2)
h – difference between the level of mercury in left and right limb of manometer (m)

2. Calculate the velocities (V_{ent} & V_{exit}) in pipe at pressure and tube exit of the turbine.
3. Calculate the effective head as

$$H = \frac{P}{\gamma} + Z_1 + Z_2 + \frac{V_{ent}^2 - V_{exit}^2}{2g} \ (m)$$

Where,
H_{gauge} = Pressure head at inlet in meter of water = (P×10000/1000) m
Z_1 = Vertical distance from the Centre line of the runner shaft to the pressure gauge
Z_2 = Vertical distance from the Centre line of the runner shaft to the d/s water level (tailrace).

4. Torque or turning moment T = $9.81 \times (L_1 - L_2) \times R$ (N-m)

Where,
$L_1 - L_2$ = Net brake load in kg

R = Radius of brake drum in m.

5. Power input $P_{in} = \gamma QH$ Watts
6. Power output $P_{out} = \frac{2\pi NT}{60}\ Watts$
7. Turbine efficiency $\eta = \frac{P_{out}}{P_{in}} \times 100\%$

अवलोकन तालिका/Observation table:-

Dia of Runner, D = **Radius of brake drum = m** **Dia of supply line = m**

Z_1 = Vertical distance from the centre line of the runner shaft to the pressure gauge= m

Z_2= Vertical distance from the centre line of the runner shaft to the d/s water level = m

Guide Vane Opening	**Pressure Gauge Reading (kg/cm^2)**	**Net Head H (m)**	**Orificemeter Reading, h(m)**			**Discharge Q**	**Input Power (watts)**	**Speed N (rpm)**	**Load on drum**		**Output Power (watts)**	**Efficiency η (%)**
			Left limb (m)	Right limb (m)	Difference(m)	m^3/s			T_1 kg	T_2		

गणना/Calculation:

परिणामों का प्रतिनिधित्व/Representation of results:

For each gate opening plot η against speed

चर्चा**/Discussion:**

प्रयोग क्रमांक. 10
Experiment No. 10

उद्देश्य: रेसिप्रोकेटिंग पंप दक्षता में दक्षता और प्रतिशत स्लिप की गणना करना
Objective: To compute the efficiency and percentage slip in reciprocating pump.

आवश्यक उपकरण:
Apparatus required

1. A reciprocating pump
2. Supply and delivery pipe line
3. An electric motor
4. Pressure and vacuum gauges
5. A collecting tank

Fig.10.1 Experimental setup of Reciprocating experiment

सिद्धांत/Theory :

A reciprocating pump comprises of-

i. Suction pipe fitted with a strainer and a foot valve at lower end.
ii. Reciprocating pump unit with speed reduction gear box.
iii. Air vessel fitted on the suction and delivery end of pump.
iv. Delivery pipeline with a pressure gauge and a control valve.
v. Electric motor with pulley and belt system connected to pump.

In a reciprocating pump, the liquid is sucked at the suction end of the cylinder, trapped, pushed and discharged completely at the delivery end with every stroke of piston. Depending on whether the liquid is sucked and the delivered from one end or both the ends of the cylinder, a pump is called single acting or double acting.

प्रक्रिया/Procedure

1. इलेक्ट्रिक मोटर को चालू करें ताकि पंप चल सके।
2. डिलीवरी वाल्व खोलें और इसे वांछित डिस्चार्ज पर सेट करें।
3. वॉट मीटर (W) की रीडिंग, वैक्यूम गेज (pv) या सक्शन पाइपलाइन में मैनोमीटर (h1 और h2) की रीडिंग, और डिलीवरी साइड प्रेशर गेज (pd) की रीडिंग नोट करें।
4. संग्रहण टैंक में पानी के स्तर में ज्ञात (सेट) वृद्धि के लिए आवश्यक समय नोट करें।
5. सिलेंडर में पिस्टन द्वारा किए गए निश्चित संख्या में स्ट्रोक के लिए लिया गया समय रिकॉर्ड करें।
6. प्रेशर गेज कनेक्शन और वैक्यूम गेज या मैनोमीटर कनेक्शन के बीच की लंबवत दूरी नोट करें।
7. डिलीवरी वाल्व की सेटिंग बदलें और माप 3-5 को दोहराएं।
8. विभिन्न डिस्चार्ज के लिए माप 6-7 को दोहराएं।

1. Start the electric motor to run the pump
2. Open the delivery valve and set it to a desired discharge.
3. Note the reading of watt meter W, reading of vacuum gauge, pv or the manometer in the suction pipe line (h1 &h2), delivery side pressure gauge reading pd.
4. Note the time required for the known (set) rise of water level in the collecting tank.
5. Record the time taken for fixed number of strokes made by the piston in the cylinder.
6. Note the vertical distance between pressure gauge connection and vacuum gauge or monometer connection.
7. Change the setting of delivery valve and repeat the measurement 3-5.
8. Repeat measurements for 6-7 for different discharges.

अवलोकन/Observations

Diameter of Cylinder= Area of Cylinder=
Length of stroke=

Area of collecting Tank=

Distance from pressure gauge to suction gauge or manometer=

S No	Watt meter reading	Discharge	Pressure gauge reading	Delivery head, hd	Vacuum gauge reading	Total/manometric head, Hm	Input power	Output power	Efficiency	Time for fixed number of strokes	No. of strokes per sec.	Theo. discharge	Slip	% slip

गणना/Calculations

1. Using cross sectional area of collecting tank and the observed time for the water level in the tank to rise by a known height, calculate the discharge by volumetric method, $Q = A \times h/t$
2. Calculate the static head and manometric head developed by the pump.
   Static head = pressure gauge reading – vacuum gauge or suction manometer reading + correction for the location of pressure gauge and vacuum gauge or suction manometer.
   $H_s = h_d - (\pm h_s) + Z_1 + Z_2$
   Manometric head, $H_{mano} = Hs + h_{losses}$
3. The input power (h.p.) to the reciprocating unit is-
   $P_{input} = \dfrac{W}{0.736}$ h.p.
4. The power output from the pump is-
   $P_{output} = \dfrac{\Upsilon QH}{75}$ h.p.
   Where Υ is specific weight of liquid
5. The overall efficiency of the pump is then calculated
   $\eta_o = \dfrac{P_{output}}{P_{input}} \times 100$
6. Calculate theoretical discharge from pump, $Q_{th} = a.L.N$
   Where, a = cross sectional area of the cylinder, L = length of the stroke and N = number of strokes per seconds.
7. Then find slip, $S = (Q_{th} - Q_{actual})$, and $\%slip = \dfrac{Q_{th} - Q_{actual}}{Q_{th}} \times 100$

नमूना गणना/Sample calculations

परिणाम/Results

The manometric head developed, pump efficiency, slip and %slip are tabulated.

प्रयोग क्रमांक. 11
Experiment no. 11

उद्देश्य
केप्लान टर्बाइन का अध्ययन

Objective
Study of Kaplan Turbine