K.L.N. College of Engineering

(An Autonomous Institution Affiliated to Anna University, Chennai)

by National Assessment and Accreditation Council (NAAC)
Pottapalayam – 630612.(11 km From Madurai City) TamilNadu, India.

Department of Mechanical Engineering

Accredited by NBA, New Delhi
Approved Research Center by Anna University, Chennai
Approved Nodal Center for e – YANTRA Lab

Regulations – 2020

Odd Semester

20ME3L2
Fluid Mechanics and Machinery

Laboratory Manual

Lab In charge

Mr. S. Nallthambi, Asst. Prof. / Mech.

Prepared by

Mr. S. Nallthambi, Asst. Prof. / Mech.

Approved by

Dr. P. Udhayakumar

HOD / Mech. Engg.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To become a Centre of excellence for Education and Research in Mechanical Engineering.

MISSION

- **Attaining academic excellence through effective teaching learning process and state of the art infrastructure.**
- **Providing research culture through academic and applied research.**
- **Inculcating social consciousness and ethical values through co-curricular and extra-curricular activities.**

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO I	**Graduates will have successful career in Mechanical Engineering and service industries.**
PEO II	**Graduates will contribute towards technological development through academic research and industrial practices.**
PEO III	**Graduates will practice their profession with good communication, leadership, ethics and social responsibility.**
PEO IV	**Graduates will adapt to evolving technologies through lifelong learning.**

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	**Derive technical knowledge and skills in the design, develop, analyze and manufacture of mechanical systems with sustainable energy, by the use of modern tools and techniques and applying research based knowledge.**
PSO 2	**Acquire technical competency to face continuous technological changes in the field of mechanical engineering and provide creative, innovative and sustainable solutions to complex engineering problems.**
PSO 3	**Attain academic and professional skills for successful career and to serve the society needs in local and global environment.**

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General Instructions for Laboratory Classes

- Students must attend the lab classes with **ID cards**
- Enter Lab with **CLOSED FOOTWEAR**
- Boys should **"TUCK IN"** the shirts
- Students should wear **uniform only**
- **LONG HAIR** should be protected
- Any other machines/ equipments **should not be operated** other than the prescribed one for that day.
- POWER SUPPLY to your test table should be obtained only through the **LAB TECHNICIAN**
- Do not **LEAN** and do not be **CLOSE** to the machine components.
- **TOOLS, APPARATUS & GUAGE** Sets are to be returned before leaving the Lab.
- **Any damage** to any of the equipment / instrument / machine caused due to carelessness, the **cost** will be fully recovered from the individual (or) group of students.

20ME3L2 **FLUID MECHANICS AND MACHINERY LABORATORY**

L	T	P	C
0	0	3	1.5

OBJECTIVES:

- To determine the coefficient of discharge for Orifice meter and Venturimeter.
- To measure rate of flow using rotameter.
- To study the performance characteristics of various hydraulic pumps.
- To conduct performance tests in hydraulic turbines.
- To gain practical knowledge about friction factor.

PREREQUISITE: NIL

LIST OF EXPERIMENTS

1. Determination of coefficient of discharge for Orifice meter.
2. Determination of coefficient of discharge for Venturimeter
3. Determination of rate of flow using Rotameter and its calibration.
4. Performance characteristics of Centrifugal pump
5. Performance characteristics of Submergible pump.
6. Performance characteristics of Reciprocating pump
7. Performance characteristics of Gear pump.
8. Performance characteristics of Pelton turbine.
9. Performance characteristics of Francis turbine.
10. Performance characteristics of Kaplan turbine.
11. Determination of friction factor for flow through pipes.

TOTAL: 45 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

- Determine the coefficient of discharge for Orifice meter and Venturimeter
- Determine the rate of flow using Rota meter and calibrate it
- Predict performance characteristics of centrifugal pump and submergible pump.
- Predict performance characteristics of reciprocating pump and gear pump.
- Predict performance characteristics of turbines.
- Determine the friction factor for flow through pipes.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S. No.	Name of The Equipment	Quantity
1	Orifice meter	1
2	Venturimeter	1
3	Rotameter	1
4	Centrifugal pump	1
5	Submergible pump.	1
6	Reciprocating pump	1
7	Gear pump.	1
8	Pelton turbine.	1
9	Francis turbine.	1
10	Kaplan turbine.	1
11	Pipe friction apparatus	1

K.L.N. College of Engineering

Department of Mechanical Engineering

Fluid Mechanics and Machinery Laboratory

Semester: III **Subject Code:** 20ME3L2

Fluid Mechanics and Machinery Laboratory

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.

INDEX

Name : ……………………………………… Batch ………………………….………….

Roll No.:…………………… Year ……………..Section…………………………………....

CONTENTS

S. No.	*Date of Experiment*	*Name of the Experiments*	*Marks Awarded*	*Signature of the Staff*
1.				
2.				
3.				
4.				
5.				
6.				
7.				
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9.				
10.				
11.				
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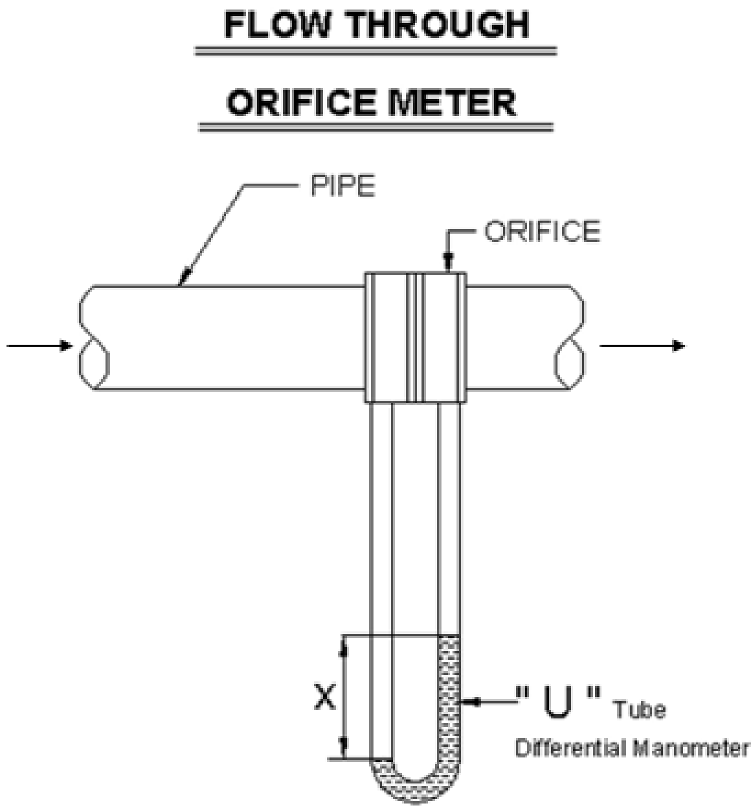


Observation and Tabulation:

Diameter of Inlet of Orificemeter = m

Diameter of Orifice = m

Internal dimensions of collecting tank,

Length = m

Breadth = m

Reading No.	Manometric Reading in cm			Time for H rise in the collecting tank T in sec		
	Left limb reading h_1	Right limb reading h_2	($h_1 \sim h_2$)	Trial 1	Trial 2	Average
1						
2						
3						
4						
5						

Ex No: 1 ***Date :***

Flow Through Orificemeter

Aim:

To determine the co-efficient of discharge of given Orificemeter.

Apparatus Required:

1. Orificemeter 2. Differential "U" tube Manometer

Collecting tank fitted with piezometer and control valve

Theory:

Orificemeter is a device used to measure the discharge of any liquid flowing through it. The pressure difference between the inlet and the diaphragm of the orificemeter is recorded using a U tube manometer and the time is recorded for a measured discharge.

Formula :

Theoretical Discharge $(Q_t) = \dfrac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

where,

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 in m / sec^2

h = Orificemeter's Pressure Head difference in m

1. Difference head in pressure , $h = \left(h_1 \sim h_2\right) \times \left(\dfrac{S_m - S_f}{S_f}\right)$ in m

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m= Specific gravity of manometric fluid (Mercury) = 13.6

S_f = Specific gravity of flowing fluid (Water) = 1

2. Actual Discharge (Q_a) = (A ×H) / T = m^3 / sec

A = Area of the collecting tank in m^2

H = Rise of liquid in collecting tank in m

T = Time of collection for H rise of liquid in collecting tank in sec

3. Co – efficient of Discharge (C_d) = Q_a / Q_t

Calculation Table:

Reading No.	Pressure difference between inlet and throat in m	√h	Discharge in m^3 / sec		Coefficient of discharge C_d
			Actual (Q_a)	Theoretical (Q_t)	
					Mean =

Model Calculation:

1. Theoretical Discharge $(Q_t) = \dfrac{a_1 \, a_2 \sqrt{2 \, g \, h}}{\sqrt{a_1^2 - a_2^2}}$ m^3/sec.

2. Actual Discharge $(Q_a) = (A \times H) / T =$ m^3/sec.

3. Co-efficient of Discharge $(C_d) = Q_a / Q_t$

Procedure:

1. The dimensions of the inlet and the throat are recorded and the internal dimensions of the collecting tank are measured.
2. The outlet valve of the collecting tank is opened fully and inlet valve is opened fully.
3. Due to pressure difference of flowing fluid between inlet and throat, the difference in the level of the manometric fluid in the manometer limbs h1 and h2 are noted.
4. The difference in the pressure head h is calculated using the formula.
5. The outlet valve of the collecting tank is closed tightly and the time T required for H rise of water in the collecting tank is observed using a Stop watch. The readings are taken for two trials.
6. The experiment is repeated by gradually closing the outlet valve.
7. The time taken and the difference in pressure head for various positions of the outlet valve are observed.
8. The observations are tabulated and the co-efficient of discharge of the orificemeter is computed.

Graph:

A graph of Q_a vs h and Q_a vs $\sqrt{h}$ are drawn, taking h and $\sqrt{h}$ on X – Axis.

Observation from the Graph:

Actual Discharge	Q_a =		in m^3 / sec
Difference head in pressure	$\sqrt{h}$ =		in m
Graph Calculation:			
Difference head in pressure	h =		in m
Theoretical Discharge	Q_t =		in m^3 / sec
Co-efficient of discharge	C_d =		

Result:

The Co-efficient of discharge of the Orificemeter

By Calculation =

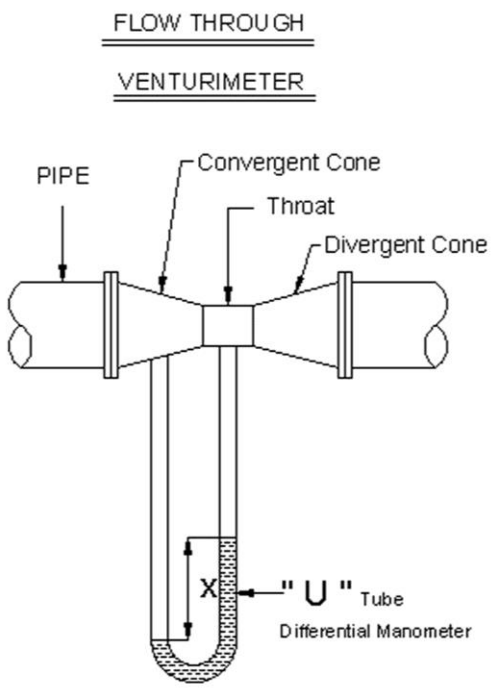
By Graph =

Inference:

Orificemeter is another application of Bernoulli's equation. Orificemeters are preferred for measuring discharge of single phase continuous fluid flow.

Applications:

Orifice plates are most commonly used to measure flow rates in Pelton wheel and Francis turbines.



Observation and Tabulation:

Diameter of Inlet of Venturimeter = **m**

Diameter of Throat = **m**

Internal dimensions of collecting tank,

Length = **m**

Breadth = **m**

Reading No.	Manometric Reading in cm			Time for H rise in the collecting tank T in sec		
	Left limb reading h_1	Right limb reading h_2	$(h_1 \sim h_2)$	Trial 1	Trial 2	Average
1						
2						
3						
4						
5						

Ex No: 2 *Date :*

Flow Through Venturimeter

Aim:

To determine the co-efficient of discharge of given Venturimeter.

Apparatus Required:

1. Venturimeter 2. Differential "U" tube Manometer
2. Collecting tank fitted with piezometer and Gate valve.

Theory :

Venturimeter is a device used to measure the discharge of any liquid flowing through it. The pressure difference between the inlet and the throat of the venturimeter is recorded using a U tube manometer and the time is recorded for a discharge.

Formula:

Theoretical Discharge (Q_1) $= \dfrac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

where,

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 in m / sec^2

h = Orificemeter's Pressure Head difference in m

1. Difference head in pressure , $h = \left(h_1 \sim h_2\right) \times \left(\dfrac{S_m - S_f}{S_f}\right)$ in m

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m= Specific gravity of manometric fluid (Mercury) = 13.6

S_f = Specific gravity of flowing fluid (Water) = 1

2. Actual Discharge (Q_a) = (A ×H) / T = m^3 / sec

A = Area of the collecting tank in m^2

H = Rise of liquid in collecting tank in m

T = Time of collection for H rise of liquid in collecting tank in sec

3. Co – efficient of Discharge (C_d) = Q_a / Q_t

Calculation Table:

Reading No.	Pressure difference between inlet and throat in m	√h	Discharge in m^3 / sec		Coefficient of discharge C_d
			Actual (Q_a)	Theoretical (Q_t)	
				Mean =	

Model Calculation:

1. Theoretical Discharge (Q_1) = $\dfrac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3/sec.

2. Actual Discharge (Q_a) = (A × H) / T = m^3/sec.

3. Co-efficient of Discharge (C_d) = Q_a / Q_t

Procedure:

1. The dimensions of the inlet and the throat are recorded and the internal dimensions of the collecting tank are measured.
2. The outlet valve of the collecting tank is opened fully and inlet valve is opened fully.
3. Due to pressure difference of flowing fluid between inlet and throat, the difference in the level of the manometric fluid in the manometer limbs h1 and h2 are noted.
4. The difference in pressure head h is calculated using the formula.
5. The outlet valve of the collecting tank is closed tightly and the time T required for H rise of water in the collecting tank is observed using a Stop watch. The readings are taken for two trials.
6. The experiment is repeated by gradually closing the outlet valve.
7. The time taken and the difference in pressure head for various positions of the outlet valve are observed.
8. The observations are tabulated and the co-efficient of discharge of the venturimeter is computed.

Graph:

A graph of Q_a vs h and Q_a v_s $\sqrt{h}$ are drawn, taking h and $\sqrt{h}$ on X – Axis.

Observation from the Graph:

Actual Discharge Q_a = in m^3 / sec

Difference head in pressure $\sqrt{h}$ =

Graph Calculation:

Difference head in pressure h = in m

Theoretical Discharge Q_t = in m^3 / sec

Co-efficient of discharge C_d =

Result:

The Co-efficient of discharge of the Venturimeter

By Calculation =

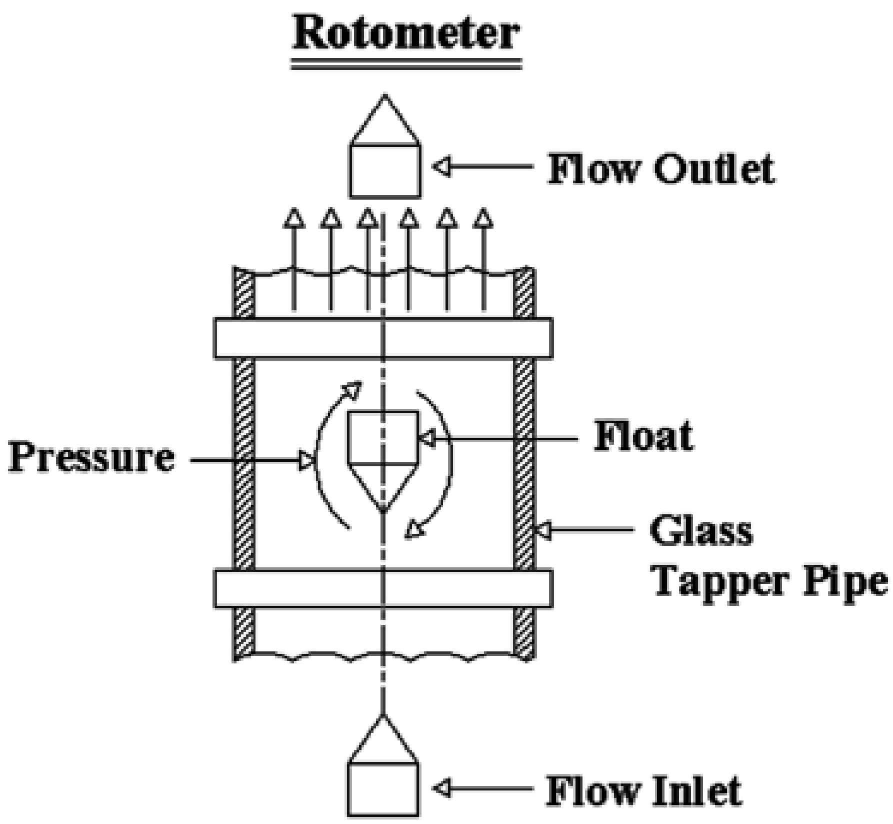
By Graph =

Inference:

Venturimeter is based on the principle of Conservation of mass (Bernoulli's Equation).Venturimeter is preferred over orificemeter since the head loss in the venturimeter is less compared to the orificemeter.

Applications:

Venturimeters are used to measure the flow rate in Kaplan turbines.


Rotometer
Flow Outlet
Pressure
Float
Glass
Tapper Pipe
Flow Inlet

Ex No: 3 ***Date:***

Performance Study of Rotameter

Aim :

To determine the percentage error by using rotameter test and study its operation.

Apparatus Required:

1. Rotameter

Theory:

Rotameter consists of a gradually tapered glass tube mounted vertically in a frame with the large end up. The fluid flows upward through the tapered tube and suspends freely a float (which does not actually float but is completely submerged in the fluid). The float is the indicating element and the greater the flow rate, the higher the float rides in the tube. The entire fluid stream must flow through the annular space between the float and the tube wall. The tube is marked in divisions, and the reading of the meter is obtained from the scale reading at the reading edge of the float, which is taken at the largest cross section of the float. Rotameters can be used for either liquid or gas flow measurement.

Formula :

1. $\% \text{ of error} = \left(\frac{\text{Rotameter Discharge} - \text{Actual Discharge}}{\text{Rotameter Discharge}} \right) \times 100$

Where,

2. Actual Discharge (Q_a) = (A ×H) / T = m^3 / sec

   A = Area of the measuring tank in m^2.

   H = Rise of water level (say 10 cm) in m.

   T = Time in **sec** for raise of water level (say 10 cm)

3. Actual Discharge (Q_A in lpm) = Q_A in m^3 / sec × 1000 × 60 in lpm.

Observation and Tabulation:

Internal dimensions of collecting tank,

Length = m

Breadth = m

Reading No	Rotometer discharge in lpm	Time for H rise in the collecting tank in sec	Actual Discharge (Q_A) in m^3 / sec	Actual Discharge (Q_A) in lpm	% Error

Model Calculation:

1. $\% \text{ of error} = \left(\frac{\text{Rotameter Discharge} - \text{Actual Discharge}}{\text{Rotameter Discharge}} \right) \times 100$

2. Actual Discharge (Q_a) = $(A \times H) / T$ = m^3 / sec

3. Actual Discharge (Q_A in lpm) = Q_A in m^3 / sec $\times$ 1000 $\times$ 60 in lpm.

Procedure:

1. The internal dimension of the collecting tank, and datum head (h_{dt}) is measured.
2. The delivery valve is partially opened and the bypass valve is fully closed.
3. By adjusting delivery valve and by adjusting bypass valve the float is kept to required flow rate and the discharge readings are noted.
4. For the particular flow rate, the drain cock is closed and the time taken (T) for "h" rise in the collecting tank is noted.
5. The drain valve is opened and the procedure is repeated.
6. From the time taken the actual discharge is calculated.

Graph:

A graph of

Actual Discharge (Q_A in lpm) vs Error (%)

are drawn , taking Q_A in lpm on X – Axis.

Result:

Rotometer experiment is conducted and flow rate is found and the percentage of error is determined.

The Minimum % error =

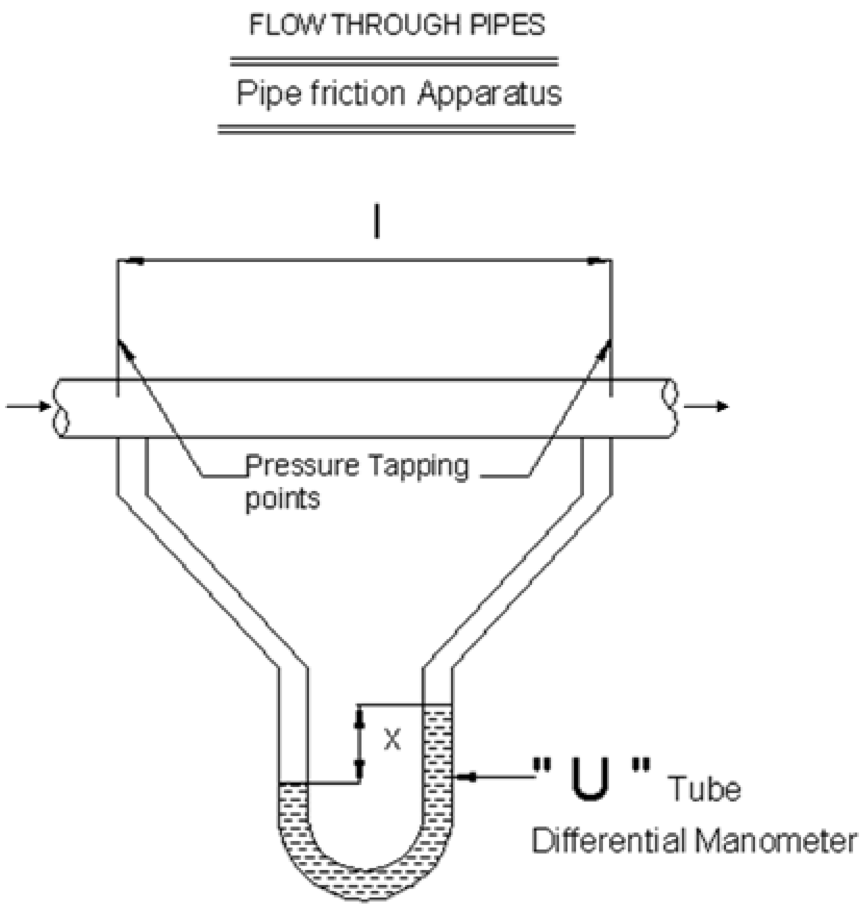
The Maximum % error =

Inference:

The float is in equilibrium position when the rising force, buoyancy and viscous float suffered gravity lift are equal. The float rises as the flow rate increases.

Application:

Rotameter can be used to measure the flow rates of corrosive and non-corrosive liquids since the float can be made of any material like aluminum, stainless steel etc.,


FLOW THROUGH PIPES
Pipe friction Apparatus
l
Pressure Tapping
points
X
" U " Tube
Differential Manometer

Ex No. : 4 ***Date :***

Flow Through Pipes

Aim :

To determine the friction factors (f) of the pipes.

Apparatus Required:

1. A pipe provided with inlet and outlet valves and pressure tapping cocks.
2. Differential "U" tube Manometer
3. Collecting tank fitted with piezometer and Gate valve

Theory:

When the liquid is flow through a pipe line, it is subjected to the frictional resistance. The frictional resistance depends upon the roughness of the inner surface of the pipe line. More the roughness greater is the frictional resistance.

The loss of head between selected lengths of the pipes is observed for a measured discharge. The friction factor (f) is calculated by using the following expression.

Formula:

1. Head loss due to friction, $h_f = (h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f} \right)$ in m

Where,

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m = Specific gravity of manometric fluid = 13.6

S_f = Specific gravity of flowing fluid = 1

2. Velocity of flow in pipe, v $= \left[\frac{\frac{A \times H}{T}}{a} \right]$ m / sec

A = Area of the collecting tank in m^2

H = Rise of liquid in collecting tank in m

T = Time of collection for H rise of liquid in collecting tank in sec

a = Cross sectional area of the pipe in m^2

Observation and Tabulation :

Diameter of Pipe (GI) = in m

Diameter of Pipe (PVC) = in m

Length of Pipe between pressure cock = in m

Internal dimensions of collecting tank,

Length = in m

Breadth = in m

Reading No.	Manometric Reading in cm			Time for H rise in the collecting tank T in sec		
	h_1	h_2	$x = (h_1 \sim h_2)$	Trial 1	Trial 2	Average
GI Pipe						
1.						
2.						
3.						
4.						
5.						
PVC Pipe						
1.						
2.						
3.						
4.						
5.						

3. Friction Factor, f = $\left[\frac{h_f\, 2gd}{l V^2}\right]$

h_f = Head loss due to friction

g = Acceleration due to gravity = 9.81 m / sec^2

d = Diameter of pipe in m

l = Length of pipe (between pressure tapping cock) in m

v = Velocity of flow in pipe in m / sec

Procedure:

1. The dimension of the pipe is recorded and the internal dimensions of the collecting tank and length of the pipe line between the two pressure tapping cocks are measured.
2. With the outlet valve in fully open condition for the required Pipe. And open its manometer valves also.
3. The inlet valve is opened slightly and the manometer heads in both the limbs (h_1 and h_2) are noted.
4. The outlet valve of the collecting tank is closed tightly and the time T required for H rise of water in the collecting tank is observed using a Stop watch.
5. The above procedure is repeated by gradually increasing the flow rate and the readings are observed.
6. The observations are tabulated and the friction factor (f) of the pipe is computed.

Calculation Table:

Reading No.	Head loss due to friction (hf) in m	Discharge (Q) in m3 / sec	Velocity of Flow (v) in m/Sec	Friction factor (f)
GI Pipe				
1.				
2.				
3.				
4.				
5.				
Mean Value of GI Pipe's Friction factor (f)				
PVC Pipe				
1.				
2.				
3.				
4.				
5.				
Mean Value of PVC Pipe's Friction factor (f)				

Model Calculation:

1. Head loss due to friction , h_f = $(h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f} \right)$ in m

2. Velocity of flow in pipe , v = $\left[\frac{\frac{A \times H}{T}}{a} \right]$ m / sec

3. Friction Factor , f = $\left[\frac{h_f \, 2gd}{1V^2} \right]$

Graph:

A graph of h_f Vs v^2 is drawn, taking h_f on X – Axis.

Result:

The friction factor (f) of the given

GI pipe =

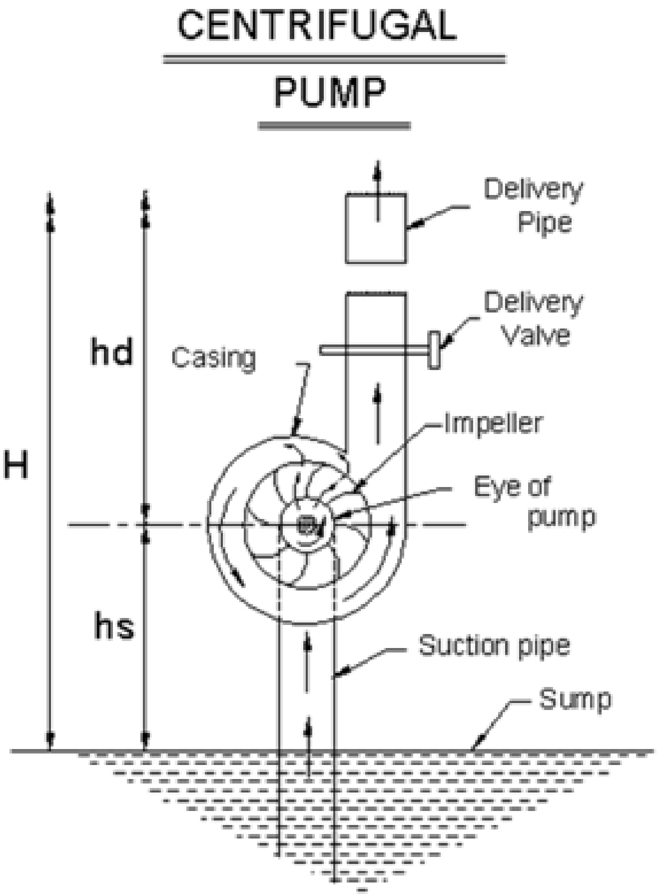
PVC pipe =

Inference:

From this experiment it is understood that friction factor of PVC pipe is less than GI pipe and this due to surface roughness of the pipe.

Applications:

Friction factor (f) is used in pipe designing


CENTRIFUGAL
PUMP
Delivery
Pipe
Delivery
Valve
hd
Casing
Impeller
H
Eye of
pump
hs
Suction pipe
Sump

Ex No : 5 ***Date :***

Performance Characteristics of Centrifugal Pump

Aim:

To study the performance of the Centrifugal pump and to draw the characteristics curves of the Centrifugal pump.

Apparatus Required:

1. Centrifugal pump 2. Energy meter
3. Pressure Gauge 4. Vacuum Gauge
5. Digital Tacho Meter 6. Collecting tank fitted with piezometer and control valve

Theory:

Centrifugal pump is a device used to lift liquids from a lower level to higher level. The rotary motion imparted to the liquid by the blades of the impeller, causes a centrifugal force to act on it. The centrifugal force forces the liquid to flow radially outward with a very high velocity. The kinetic energy of the leaving liquid is then converted to pressure energy, as a result, the liquid is lifted to the required level.

Formula:

1. Total Head = (Delivery Pressure gauge reading + Vacuum gauge reading + Datum head) in mm
2. Datum Head = Distance between center of the pump and the point at which the Pressure gauge is connected in the delivery pipe in m.
3. Discharge (Q) = $\frac{A \times H}{T}$ m^3 / sec

where,

A = Area of the measuring tank in m.

h = Rise of water level (say 10 cm) in m.

T = Time for raise of water level (say 10 cm) in sec

4. Output Power (Po) = 9.81 x H x Q kW

where ,

w = Specific weight of water in N / m3 = 9.81 kN / m^3

H = Total Head in m

Q = Discharge in m3 / sec

Observation and Tabulation:

Suction Head (h_s) = in m

Datum Head (h_{dt}) = 0.3 in m

Energy meter constant (E) = 3200 in impulse / kW.h

Internal dimensions of collecting tank,

Length = in m

Breadth = in m

Reading No.	Delivery pressure Gauge reading		Vacuum pressure Gauge reading		Time for h rise in the collecting tank T in sec			Time for 5 revolutions / impulse of Energy meter disc (t) in sec
	in kg /cm^2	in m	in kg/cm^2	in m	Trial 1	Trial 2	Average	
1								
2								
3								
4								
5								

Calculation Table:

Reading No.	Discharge (Q) in m^3 / sec	Total Head (H) in m	Input power (P_i) in kW	Output power (P_o) in kW	Efficiency (η) in%
1.					
2.					
3.					
4.					
5.					

5. Input Power (Pi) = $\frac{X}{t} \times 3600 \times \frac{1}{E} \times 0.8 \text{ kW}$

where,

X = No. of revolutions of energy meter disc (say 5 Rev.)

t = Time for energy meter revolution disc (say 5 Rev.)

E = Energy meter constant

= Efficiency of the motor

6. Efficiency (η) = $\frac{P_o}{P_i} \times 100 \text{ in } \%$

Procedure :

1. The internal dimension of the collecting tank and datum head (h_{dt}) is measured.
2. The pump is primed and started with the delivery valve and the gauge cocks in the full opened position.
3. The delivery valve is slowly closed and adjusted it to the required delivery head up to 1 kg/cm^2.
4. The delivery pressure gauge reading is noted.
5. For the delivery pressure gauge reading, the time taken (T) for "h" rise in the collecting tank is noted. The readings are taken for two trials.
6. The time taken (t) for 5 revolutions / impulse of the energy meter disc is noted.
7. Theabove procedure is repeated for various delivery pressures and the performance characteristics curves are drawn.
8. Multispeed can be achieved by adjustment of belt drive and the same procedure is repeated.
9. The efficiency of the centrifugal pump is calculated using the formulae.

Model Calculation:

1. Total Head = (Delivery Pressure gauge reading + Vacuum gauge reading + Datum head) in mm

2. Datum Head = Distance between center of the pump and the point at which the Pressure gauge is connected in the delivery pipe in m.

3. Discharge (Q) = $\frac{A \times H}{T}$ m^3/sec

4. Output Power (P_o) = 9.81 x H x Q kW

5. Input Power (Pi) = $\frac{X}{t} \times 3600 \times \frac{1}{E} \times 0.8$ kW

6. Efficiency (η) = $\frac{P_o}{P_i} \times 100$ in %

Graph :

A graph of

i. Total Head (H) vs Efficiency (η)

ii. Total Head (H) vs Discharge (Q)

iii. Total Head (H) vs Input power (P_i) are drawn , taking H on X – Axis.

Result :

Thus the performance of centrifugal pump test is studied and the characteristics curves of centrifugal pump are drawn.

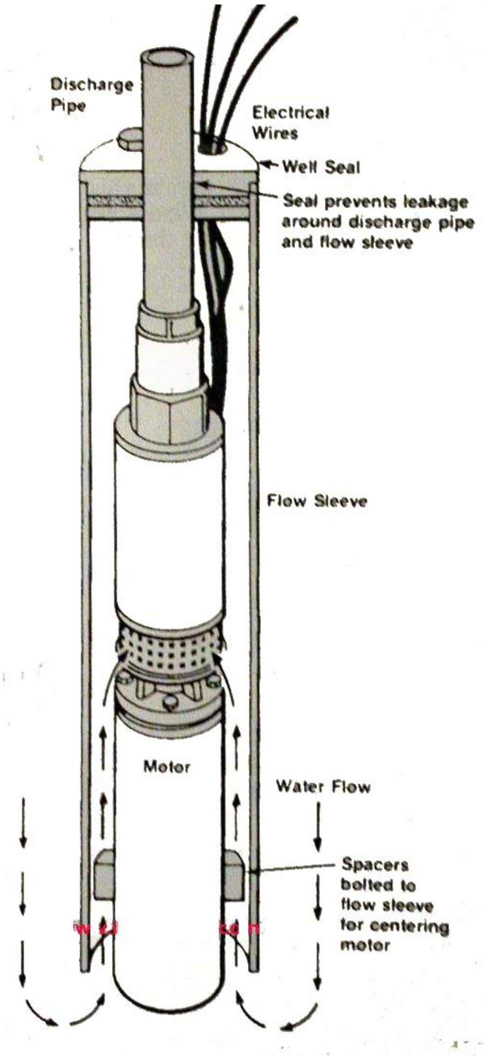
Maximum Efficiency =

Inference:

The discharge is continuous and smooth. The centrifugal pump can handle large quantity of fluid through small heads.

Applications:

1. In Energy and Oil - refineries, power plants
2. In Building Services - pressure boosting, heating installations, fire protection sprinkler systems, drainage, air conditioning
3. In Industry and Water engineering - boiler feed applications, water supply (municipal, industrial), wastewater management, irrigation, sprinkling, drainage and flood protection
4. In Chemical and Process Industries - paints, chemicals, hydrocarbons, pharmaceuticals, cellulose, petro-chemicals, sugar refining, food and beverage production
5. In Secondary systems - coolant recirculation, condensate transport, cryogenics, refrigerants



Submersible pump

Ex No : 6 ***Date :***

Performance Characteristics of Submersible Pump

Aim:

To study the performance of the Submersible pump and to draw the characteristics curves of the Submersible pump.

Apparatus Required:

1. Submersible pump

Theory :

The submersible pump is the pump located the below the water level in the sump so that there is always positive suction head. This pump is used for pumping liquids from deep well. These multistage pumps with vertical shaft are capable of pumping water against pipe. Since there is a limitation on the suction head of a ordinary pumps, this (submersible) pump is used where the suction head is large. In the submersible deep well pump, the pump assembly is connected to a submersible electric motor. The pump together with electric motor operates below the liquid surface in the borehole. The electric current is conducted through a water proof cable.

Normally this pump is used to provide high discharge with medium total head. The outlet of the pump is connected to a 50mm delivery pipe with a pressure gauge to indicate the total head developed and a flow control valve. A Orifice meter of outer diameter 60mm and the inlet (throat) diameter 30mm is connected to the delivery pipe with a manometer to measure discharge. Panel with switch, starter and energy meter provided to note the input energy for the pump.

Formula :

1. Pressure Head , $h = (h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f} \right)$ in m

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m = Specific gravity of manometric fluid = 13.6

S_f = Specific gravity of flowing fluid = 1

Observation and Tabulation :

The inlet pipe diameter (d_1) = 50×10^{-3} in m

The Orifice diameter (d_2) = 30×10^{-3} in m

The energy meter constant (E) = 1600 in Impulse/kW.h

Reading No	Pressure Gauge Reading (H)		Manometer Reading in cm		Pressure Difference ($h_1 \sim h_2$)		Time for 10 impulse / Revolution of energy meter in sec
	in kg/cm^2	in m	h_1	h_2	in cm	in m	

Calculation Table:

Reading No	Pressure head (h) in m	Discharge (Q) in m^3/sec	Output Power (Po) in kW	Input Power (Pi) in kW	Efficiency (η) in %

2. Discharge (Q) = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

Where,

a_1 = Area of the Inlet pipe.

a_2 = Area of the Orifice Meter

3. Output Power (Po) = 9.81 × H × Q kW

Where,

w = Specific weight of water in kN / m^3 = 9.81 kN / m^3

H = Total Head in m.

Q = Discharge in m^3 / sec

4. Input Power (Pi) = $\frac{X}{t} \times 3600 \times \frac{1}{E} \times 0.8$ kW

Where,

X = No. of revolutions of energy meter disc (say 10 Rev)

t = Time for energy meter revolution disc (say 10 Rev)

E = Energy meter constant

5. Efficiency (η) = $\frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Procedure :

1. The Pump is started with the delivery valve fully opened and the gauge cocks in the full open position.
2. The delivery valve is partially closed and adjusted to the required delivery head up to 1 kg/cm^2.
3. The delivery pressure gauge reading is noted.
4. The Manometer reading is noted.
5. For the delivery pressure gauge reading, the time taken (t) for 10 revolutions / impulse of the energy meter disc/ LED in the energy meter is noted.
6. The above procedure is repeated for various delivery pressures and the performance characteristic curves are drawn.

Model Calculation :

1. Pressure Head , h = $(h_1 \sim h_2)\times\left(\frac{S_m - S_f}{S_f}\right)$ in m

\

2. Discharge (Q) = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

3. Output Power (Po) = 9.81 × H × Q kW

4. Input Power (Pi) = $\frac{X}{t}\times 3600\times\frac{1}{E}\times 0.8$ kW

5. Efficiency (η) = $\frac{\text{Output Power }(P_O)}{\text{Input Power }(P_i)}\times 100$ in %

Graph :

A graph of

Discharge (Q) v_s Efficiency (η)

Discharge (Q) v_s Total Head (H)

Discharge (Q) v_s Input power (P_i)

are drawn , taking Discharge (Q) on X – Axis.

Result :

Thus the performance of submersible pump test is studied and the characteristics curves of submersible pump are drawn

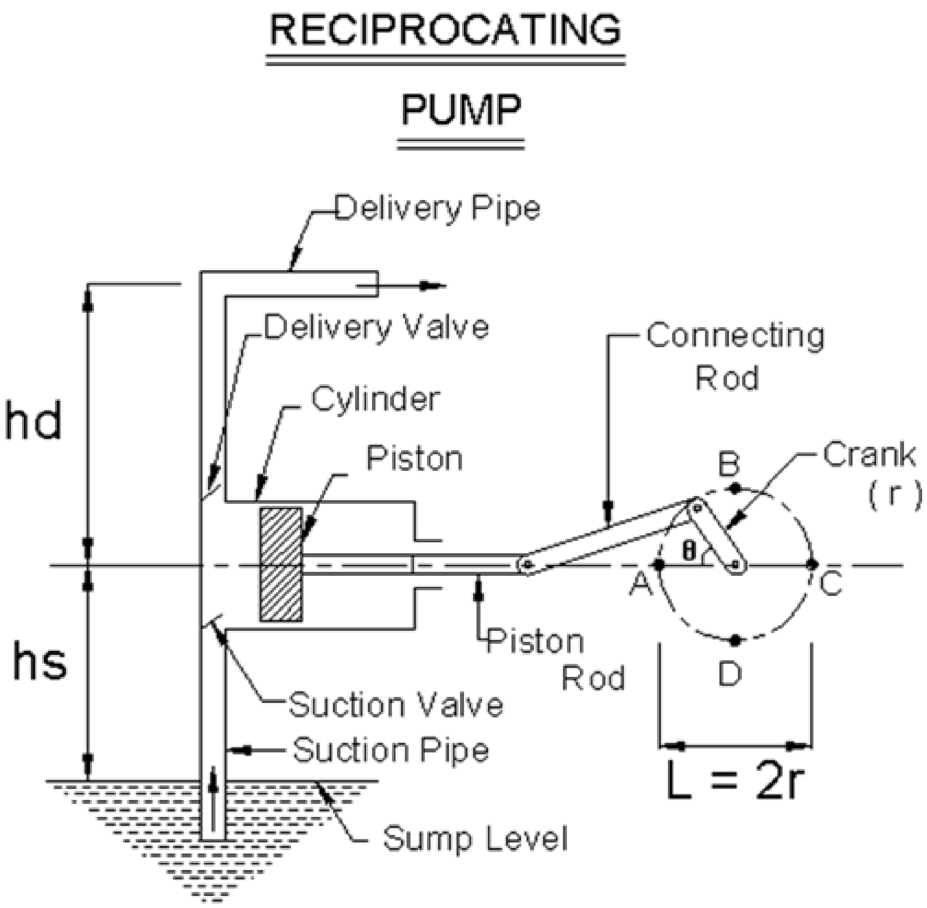
Maximum Efficiency =

Inference:

It is inferred that the discharge is higher for lesser input power. Noise is less.

Applications:

It is used for deep well drilling, Sewage pumping, Industrial pumping and in Oil industry.


RECIPROCATING
PUMP
Delivery Pipe
Delivery Valve
Cylinder
Piston
Connecting
Rod
Crank
(r)
B
θ
A
C
D
hd
hs
Piston
Rod
Suction Valve
Suction Pipe
Sump Level
L = 2r

Ex No : 7 ***Date :***

Performance Characteristics of a Reciprocating Pump

Aim :

To study the performance of the Reciprocating pump and to draw the characteristics curves of the Reciprocating pump.

Apparatus Required :

1. Reciprocating pump
2. Energy meter
3. Pressure Gauge
4. Vacuum Gauge
5. Collecting tank fitted with piezometer and control valve

Theory :

A Reciprocating pump consists primarily of a piston or a plunger reciprocating inside a close fitting cylinder thus the performing the suction and delivery strokes. Movement of the piston or plunger creates a vacuum and atmospheric pressure forces the water up through the suction pipe into the cylinder. Suction pipe and clearance volume of the cylinder are first filled with water to replace the air. This is done with the help of air vessel. With the help of air vessel, water follows closely the piston or the plunger on its forward stroke. As a matter of fact, with the movement of piston this water column moves up from the water sump though the suction pipe with the forces of cohesion (i.e. molecules of water of suction pipe attracting the molecules of water in the sump) and the water moves with this piston with the forces of adhesion (i.e. molecules of water in the cylinder attracting the molecules of piston material). In the return of backward stroke water is pushed upwards into the delivery pipe.

Suction and delivery pipes are connected to the cylinder as shown in fig. Each of the two pipes is provided with a non-return valve the suction pipe valve allows the water only to enter the cylinder while the delivery pipe valve permits only its discharge from the cylinder.

Formula:

1. Total Head = (Delivery Pressure gauge reading + Vacuum gauge reading + Datum head) in mm

2. Datum Head = Distance between center of the pump and the point at which the Pressure gauge is connected in the delivery pipe in m.

Observation and Tabulation:

Datum Head (h_{dt}) = 0.30 in m

Energy meter constant (E) = 3600 in impulse / kW.h

Internal dimensions of collecting tank,

Length = in m

Breadth = in m

Reading No.	**Delivery pressure Gauge reading**		**Vacuum pressure Gauge reading**		**Time for h rise in the collecting tank T in sec**			**Time for 5 revolutions / impulse of Energy meter disc (t) in sec**
	in kg / cm2	**in m**	**in kg / cm2**	**in m**	**Trial 1**	**Trial 2**	**Average**	
1.								
2.								
3.								
4.								
5.								

Calculation Table:

Reading No.	**Discharge (Q) in m^3 / sec**	**Total Head (H) in m**	**Input power (Pi) in kW**	**Output power (Po) in kW**	**Efficiency (η) in %**
1.					
2.					
3.					
4.					
5.					

3. Discharge (Q) = $\frac{A \times H}{T}$ m^3 / sec

where,

A = Area of the measuring tank in m.

h = Rise of water level (say 10 cm) in m.

T = Time for raise of water level (say 10 cm) in sec

4. Output Power (Po) = 9.81 x H x Q kW

where ,

w = Specific weight of water in N / m3 = 9.81 kN / m^3

H = Total Head in m

Q = Discharge in m3 / sec

5. Input Power (Pi) = $\frac{X}{t} \times 3600 \times \frac{1}{E} \times 0.8 \text{ kW}$

where,

X = No. of revolutions of energy meter disc (say 5 Rev.)

t = Time for energy meter revolution disc (say 5 Rev.)

E = Energy meter constant

= Efficiency of the motor

6. Efficiency (η) = $\frac{P_o}{P_i} \times 100$ in %

Procedure :

1. The internal dimension of the collecting tank, suction head (hs) and datum head (hdt) is measured.
2. With the delivery valve fully opened position and the gauge cocks in the full opened position the pump is started.
3. The delivery valve is partially closed and adjusted it to the required delivery head up to 1 kg/cm^2.
4. The delivery pressure gauge reading is noted.
5. For the delivery pressure gauge reading, the time taken (T) for “h” rise in the collecting tank is noted.
6. The time taken (t) for 5 revolutions / impulse of the energy meter disc / LED in the energy meter is noted.
7. The above procedure is repeated for various delivery pressures, and the performance characteristics curves are drawn.

Model Calculation:

1. Total Head = (Delivery Pressure gauge reading + Vacuum gauge reading + Datum head) in mm

2. Datum Head = Distance between center of the pump and the point at which the Pressure gauge is connected in the delivery pipe in m.

3. Discharge (Q) = $\frac{A \times H}{T}$ m^3 / sec

4. Output Power (Po) = 9.81 x H x Q kW

5. Input Power (Pi) = $\frac{X}{t} \times 3600 \times \frac{1}{E} \times 0.8$ kW

6. Efficiency (η) = $\frac{P_o}{P_i} \times 100$ in %

Graph :

A graph of

Total Head (H) vs Efficiency (η)

Total Head (H) vs Discharge (Q)

Total Head (H) vs Input power (P_i)

are drawn , taking H on X – Axis.

Result :

Thus the performance of reciprocating pump test is studied and the characteristics curves of reciprocating pump are drawn.

Maximum Efficiency =

Inference:

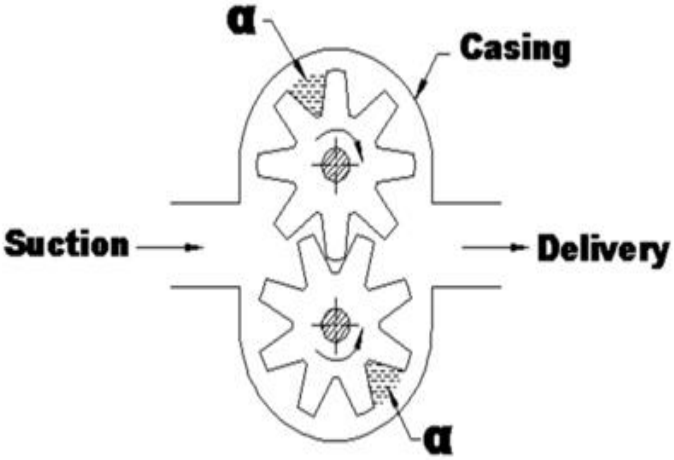
From this experiment the performance of reciprocating pump is studied. It is understood that as the head increases input power increases, discharge increases and efficiency increases.

Applications :

Reciprocating positive displacement pumps are widely used in chemical, petrochemical, refinery, pharmaceutical, cosmetic, food industry and water treatment industry where a high degree of accuracy and reliability under a range of conditions are required. Various types are available to meet the diverse demands of many processes which include Windmill, oil pump Hand pump, feeding small boilers condensate return and light oil pumping.

GEAR OIL

PUMP



Ex No : 8 ***Date :***

Performance Characteristics of Gear Oil Pump

Aim :

To study the performance of the gear oil pump and to draw the characteristics curves of the Gear oil pump.

Apparatus Required:

Gear oil pump

Energy meter

Pressure Gauge

Collecting tank fitted with piezometer and control valve

Theory :

The Gear pump is a rotary pump in which two gears mesh to provide the pumping action. This type of pump is mostly use for cooling water and pressure oil to be applied for lubrication to motors , turbines , machine tools etc. Although the gear pump is rotating machinery, yet its action on liquid to be pumped is not dynamic and it merely displaces the liquid from one side to the other. The flow of liquid to be pumped is continuous and uniform.

One of the gears is keyed to a diving shaft. The other gear revolves due to driving gear. The space between teeth and the casing is filled with oil. The oil is carried round between the gears from the suction pipe to the delivery pipe. The mechanical contact between the gears does not allow the flow from a part of moving oil. The oil pushed into the delivery pipe, cannot come back into the suction pipe due to the meshing of the gears.

Formula :

1. Total Head (H) = $h_s + h_d + h$ in m

Where,

h_s = Suction head , It is the distance from the level of water in the sump to the center of the pump in m.

h_d = Delivery head. h_d = (Pressure gauge reading (p) in kg / $cm^2 \times 10$) in m.

h = Datum head. i.e. Distance between center of the pump and the point at which the pressure gauge is connected in the delivery pipe in m.

Observation and Tabulation:

1. a. Length of the Collecting tank (L) = m.
   b. Breadth of the Collecting tank (B) = m.
   Area of the Collecting tank (L x B) = m^2
2. Suction head (h_s) = 0.55m
3. Datum head (h) = 0.15 m
4. Energy meter Constant (E) = 600 rev / kW.h.

S. No.	Delivery pressure gauge reading (h_d) in Kg / cm^2	Delivery pressure gauge reading (h_d) in m	Time for 5 cm rise in the collecting tank (T) in sec	Time for 5 revolutions of the energy meter disc (t) in sec

Calculation Table:

S. No	Discharge (Q) in m^3 / sec	Total Head (H) in m	Input Power (P_i) in kW	Output Power (P_o) kW	Efficiency (η) in %

2. Discharge (Q) = $\frac{A \times H}{T}$ m^3 / sec

A = Area of the collecting tank in m^2

H = Rise of liquid in collecting tank in m

T = Time of collection for H rise of liquid in collecting tank in sec

3. Input Power (P_i) = $\frac{3600 \times N}{t \times E}$ in kW

N = no. of revolutions made by the energy meter disc in the energy meter say 5 revolutions.

t = Time taken for 5 revolutions of energy meter disc in sec.

E = Energy meter constant in rev / kW.hr

4. Output Power (P_o) = $\frac{wQH}{1000}$ in kW

Fluid used = SAE 40

ρ = Density of flowing fluid in kg/m^3 = 860 kg/m^3

w = Specific weight of flowing fluid in N/m^3 = 8436.60 N/m^3

Q = Discharge in m^3/s

H = Total Head in m

5. Efficiency (η) = $\frac{P_o}{P_i} \times 100$ in %

Model Calculation:

1. Total Head (H) = $h_s + h_d + h$ in m

2. Discharge (Q) = $\frac{A \times H}{T}$ m^3 / sec

3. Input Power (P_i) = $\frac{3600 \times N}{t \times E}$ in kW

4. Output Power (P_o) = $\frac{wQH}{1000}$ in kW

5. Efficiency (η) = $\frac{P_o}{P_i} \times 100$ in %

Procedure:

1. The internal dimension of the collecting tank, suction head (h_s) and datum head (h) is measured.
2. The pump is switched on with the delivery valve in fully opened condition.
3. Then the delivery valve is partially closed and adjusted to the required delivery head up to 2.5 kg/cm^2.
4. The delivery pressure gauge reading is noted.
5. For the delivery pressure gauge reading, the time taken (T) for "H" rise in the collecting tank is noted.
6. The time taken (t) for 5 revolutions of the energy meter disc is noted.
7. The above procedure is repeated for various delivery pressures and the performance characteristics curves are drawn.

Graph:

A graph of

Total Head (H) vs Efficiency (η)

Total Head (H) vs Discharge (Q)

Total Head (H) vs Input power (Pi)

are drawn , taking H on X – Axis.

Result:

Thus the performance of Gear oil pump test is studied and the characteristics curves of Gear oil pump are drawn.

Maximum Efficiency =

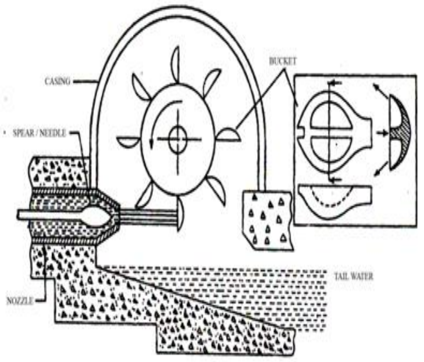
Inference:

It is inferred that gear pump is a rotary positive displacement pump. Small external gear pumps operate at relatively higher rpm than larger model gear pumps.

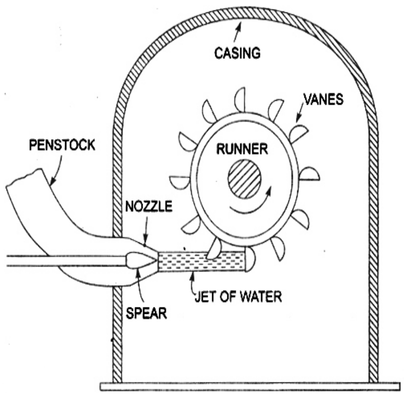
Applications:

Gear pumps are used in machine tools, fluid power transfer units and in precise transfer of polymers, fuels and chemical additives.

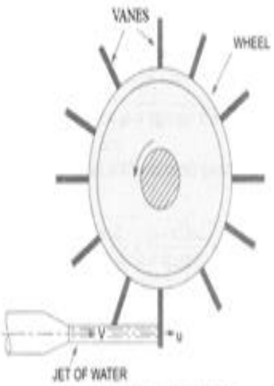
PELTON WHEEL TURBINE



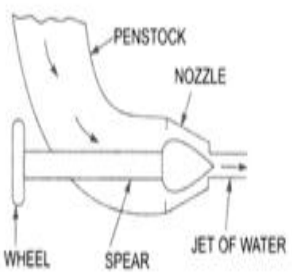
PELTON WHEEL (HIGH HEAD TURBINE)



Pelton turbine.



Jet striking a series of vanes.



Nozzle with a spear to regulate flow.

Ex No: 9 ***Date :***

Performance Characteristics of Pelton Wheel Turbine (Constant Speed)

Aim :

To study the performance of Pelton Wheel Turbine and draw the characteristic curves of the Pelton Wheel Turbine.

The experiment is conducted to:

Obtain Constant Speed characteristics

Apparatus Required :

The Pelton wheel turbine test rig.

Theory:

Hydraulic (Water) turbines are the machines that use the energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the turbines become the prim over to run Electric Generators to produce electricity, viz. Hydro Electric Power. That means the produced mechanical energy is used in running an electric generator which is directly coupled to the shaft of the turbine. Thus the mechanical energy is converted into electrical energy. At present the generation of hydroelectric power is the cheapest as compared by the power generated by other sources such as oil, coal etc.

Turbines are classified as Impulse and Reaction types. In impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. Pelton Wheel requires high Heads and Low Discharge

Pelton wheel turbine consists of following main parts

1. Mono block Centrifugal Pump
2. Turbine Unit
3. Sump Tank
4. Orifice Meter with Inlet and Outlet pressure tapping and “U” tube manometer arrangements
5. Brake drum with Flat belt and Spring balancers
6. Provision for measurement of Head on Turbine (by Pressure gauge)

Observations :

Diameter of inlet pipe (or) Size of Orifice meter = d_1 = 50 mm = 0.050 m

Diameter of Throat = d_2 = 30 mm = 0.030 m

Diameter of Brake Drum = D = 194 mm = 0.194 m

Thickness of flat belt = T = 6.5 mm = 0.0065 m

Co-efficient of discharge of Orifice meter = C_d = 0.60

Tabulations :

Reading No.	Spring Balance Reading in kg			Turbine Speed (N)	Pressure Gauge Reading (H)		Manometer Reading in cm			X
	T_1	T_2	Mass (m) = $(T_1 - T_2)$	in rpm	in kg / cm^2	in m	h_1	h_2	$X = h_1 - h_2$	in m

Technical specifications:

***UTE Pelton* Turbine**

1. Rated supply head = 30 m
2. Discharge = 450 1pm
3. Rated Speed = 800 rpm
4. Runner outside Diameter = 250 mm
5. No. of Pelton cups = 18 Nos.
6. Mean Brake drum diameter = 200 mm
7. Power Output = 1HP

Formula

Input Power (Pi) = w × Q × H in Watts

Where

w = Specific weight of water = 9810 in N / m^3

Q = Discharge in m^3 / sec

H = Total Head of the flow (or) Delivery pressure of the pump in m

Discharge (Q) = $\frac{C_d a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec.

Where,

C_d = Co-efficient of discharge of Orifice Meter

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 in m / sec^2

h = Orifice Meter's Pressure Head difference in m

Difference head in pressure, h = $(h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f}\right)$ in m

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m = Specific gravity of manometric fluid / Mercury = 13.6

S_f = Specific gravity of flowing fluid / Water = 1

Reading No.	orifice meter pressure head (h) in m	Discharge(Q) in m^3 / sec	Input Power (Pi) in Watts	Torque (T) in Nm	Output Power (Po) in Watts	Efficiency (η) in %
1						
2						
3						
4						
5						

Output Power (PO) = $\frac{2 \times \pi \times N \times T}{60}$ in Watts

Where,

N = Speed of the Turbine in rpm

T = Produced Torque on Brake Drum in Nm

Torque (T) = Force (F) x Perpendicular Distance (R)

F = Mass (m) × g

Perpendicular Distance (R) = Mean radius of Brake Drum

= (Radius of Brake Drum (D / 2) + Half of the flat belt Thickness (T/2)

$$\text{Turbine Efficiency } (\eta) = \frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100 \text{ in } \%$$

Procedure:

1. The delivery valve is kept closed before switching “ON” the pump,.
2. The pump is started.
3. The delivery valve is gradually opened until to reach the turbine speed is 900 rpm.
4. The nozzle is opened with the help of hand wheel.
5. The turbine speed is kept constant by operating the delivery valve.
6. The required mechanical load is applied on the brake drum using screw rod.
7. The spring balance reading is noted for the applied load.
8. The delivery of the turbine is adjusted to maintain the constant speed of 900 rpm
9. The pressure gauge and vacuum gauge reading are noted for the applied load.
10. The difference in head levels h_1 and h_2 in the manometer, connected to the orificemeter are noted.
11. The experiment is repeated and the readings are noted.
12. Using the observations the efficiency is calculated by using the formulae.

Model Calculation:

1. Input Power (Pi) = w × Q × H in Watts

2. Discharge (Q)= $\frac{C_d a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec.

3. Difference head in pressure, h = $(h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f} \right)$ in m

4. Output Power (PO) = $\frac{2 \times \pi \times N \times T}{60}$ in Watts

5. Perpendicular Distance (R) = Mean radius of Brake Drum

   = (Radius of Brake Drum (D / 2) + Half of the flat belt Thickness (T/2)

6. Turbine Efficiency (η) = $\frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Graph:

The graphs are drawn for

Characteristics Analysis:

Total Head (H) v_s Discharge (Q)

Total Head (H) v_s Input power (P_i)

Total Head (H) v_s Efficiency (η)

taking H on X – Axis.

and

Performance Analysis:

Brake Power (P_o) v_s Efficiency (η)

Torque (T) v_s Total Head (H)

Torque (T) V_s Discharge (Q)

taking P_o , T on X – Axis.

Result:

Thus the performance of Pelton wheel turbine test is studied and the characteristics curves of turbine are drawn.

Maximum Efficiency =

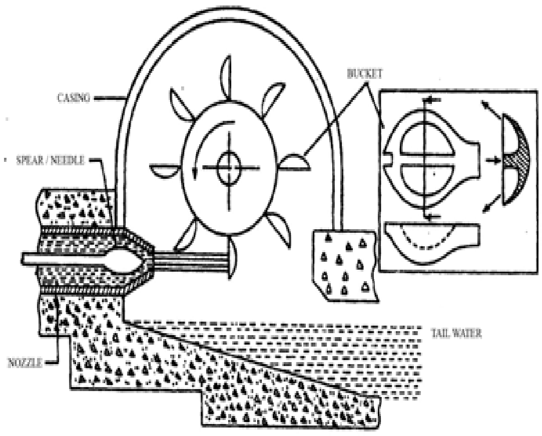
Inference:

It is inferred that discharge and efficiency increases with the head at constant speed condition.

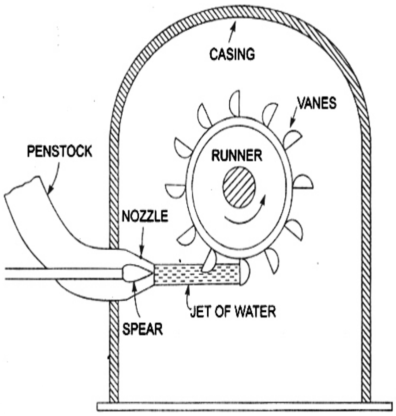
Applications:

Pelton wheels are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates, where the Pelton wheel is most efficient. It is used in Aliyar Power House, Pykara Singara Power House, Suruliar Power House and in Idukki Power House

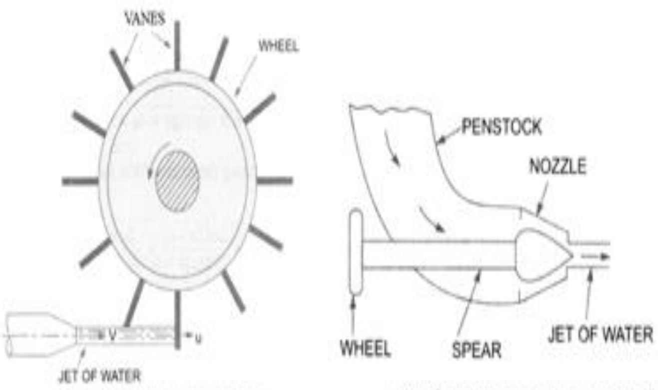
PELTON WHEEL TURBINE



PELTON WHEEL (HIGH HEAD TURBINE)



Pelton turbine.



Jet striking a series of vanes. *Nozzle with a spear to regulate flow.*

Ex No: 10 ***Date :***

Performance Characteristics of Pelton Wheel Turbine(Constant Head)

Aim :

To study the performance of Pelton Wheel Turbine and draw the characteristic curves of the Pelton Wheel Turbine.

The experiment is conducted to:

Obtain Constant Head characteristics

Apparatus Required :

The Pelton wheel turbine test rig.

Theory:

Hydraulic (Water) turbines are the machines that use the energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the turbines become the prim over to run Electric Generators to produce electricity, viz. Hydro Electric Power. That means the produced mechanical energy is used in running an electric generator which is directly coupled to the shaft of the turbine. Thus the mechanical energy is converted into electrical energy. At present the generation of hydroelectric power is the cheapest as compared by the power generated by other sources such as oil, coal etc.

Turbines are classified as Impulse and Reaction types. In impulse Turbine, the head of the water is completely converted into a jet, which impulse the force on the Turbine. Pelton Wheel requires high Heads and Low Discharge

Pelton wheel turbine consists of following main parts

1. Mono block Centrifugal Pump
2. Turbine Unit
3. Sump Tank
4. Orificemeter with Inlet and Outlet pressure tapping and “U” tube manometer arrangements
5. Brake drum with Flat belt and Spring balancers
6. Provision for measurement of Head on Turbine (by Pressure gauge)

Observation and Tabulation :

1) Diameter of inlet pipe (or)Size of Orifice meter(D_1) =50mm = 0.050m
2) Diameter of Throat(D_2) =30mm =0.030m
3) Diameter of Brake Drum(D) =194mm =0.194m
4) Thickness of flat belt(T) =6.5mm =0.0065m
5) Co-efficient of discharge of Orificemeter (c_d) = 0.60

Reading No	Spring Balance Reading in kg			Pressure Gauges Reading(H)		Manometer Reading in cm			X in m	Turbine Speed in rpm
	T_1	T_2	Mass (m) = (T_1 – T2)	in kg / cm^2	in m	h_1	h_2	X= h_1 – h_2		

Technical specifications:

UTE Pelton Turbine

1. Rated supply head = 30 m
2. Discharge = 450 1pm
3. Rated Speed = 800 rpm
4. Runner outside Diameter = 250 mm
5. No. of Buckets = 18 Nos.
6. Mean Brake drum diameter = 200 mm
7. Power Output = 1HP

Formula

1. Input Power (Pi) = w × Q × H in Watts

Where

w = Specific weight of water = 9810 in N / m^3

Q = Discharge in m^3 / sec

H = Total Head of the flow (or) Delivery pressure of the pump in m

2. Discharge (Q)= $\dfrac{C_d a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec.

Where,

C_d = Co-efficient of discharge of Orifice Meter

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 in m / sec^2

h = Orifice Meter's Pressure Head difference in m

3. Difference head in pressure, $h = (h_1 \sim h_2) \times \left(\dfrac{S_m - S_f}{S_f} \right)$ in m

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m = Specific gravity of manometric fluid / Mercury = 13.6

S_f = Specific gravity of flowing fluid / Water = 1

Calculation Table:

Reading No.	orifice meter pressure head (h) in m	Discharge(Q) in m^3 / sec	Input Power (Pi) in Watts	Torque (T) in Nm	Output Power (Po) in Watts	Efficiency (η) in %
1						
2						
3						
4						
5						

4. Perpendicular Distance (R) = Mean radius of Brake Drum
   = (Radius of Brake Drum (D / 2) + Half of the flat belt Thickness (T/2)

5. Turbine Efficiency (η) = $\frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Procedure :

1. The delivery valve is kept closed before switching "ON" the pump,.
2. The pump is started.
3. The delivery valve is gradually opened until to reach the full open condition.
4. The turbine head is kept constant by operating the nozzle.
5. The required mechanical load is applied on the brake drum using screw rod.
6. The spring balance reading is noted for the applied load.
7. The pressure gauge and vacuum gauge reading are noted for the applied load.
8. The turbine speed is noted for the applied load.
9. The difference in head levels h_1 and h_2 in the manometer, connected to the orificemeter are noted.
10. The experiment is repeated and the readings are noted.
11. Using the observations the efficiency is calculated by using the formulae.

Model Calculation:

1. Input Power (Pi) = w × Q × H in Watts

2. Discharge (Q) = $\frac{C_d a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec.

3. Difference head in pressure, h = $(h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f} \right)$ in m

4. Output Power (PO)= $\frac{2 \times \pi \times N \times T}{60}$ in Watts

5. Perpendicular Distance (R) = Mean radius of Brake Drum
   = (Radius of Brake Drum (D / 2) + Half of the flat belt Thickness (T/2)

6. Turbine Efficiency (η) = $\frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Graph :

The graphs are drawn for

Characteristics Analysis :

Turbine Speed (N) v_s Discharge (Q)

Turbine Speed (N) v_s Input power (P_i)

Turbine Speed (N) v_s Efficiency (η)

taking N on X – Axis.

and

Performance Analysis :

Brake Power (P_o) v_s Efficiency (η)

Torque (T) v_s Turbine Speed (N)

taking P_o , T on X – Axis.

Result :

Thus the performance of Pelton wheel turbine test is studied and the characteristics curves of turbine are drawn.

Maximum Efficiency =

Inference:

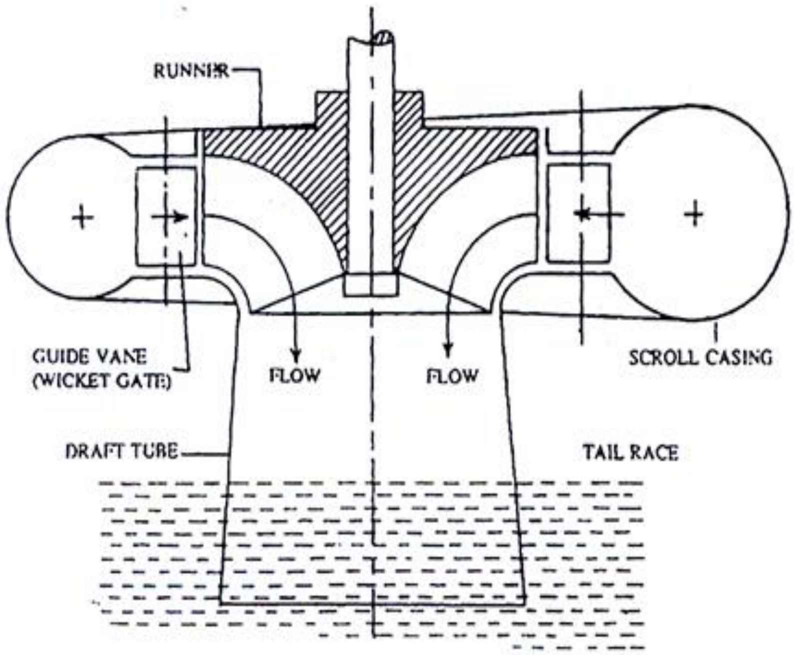
As speed increases, the efficiency increases. The discharge and power input remains constant at constant head.

Applications of pelton wheel:

Pelton wheels are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates, where the Pelton wheel is most efficient. It is used in

Aliyar Power House, Pykara Singara Power House, Suruliar Power House and in Idukki Power house.

FRANCIS TURBINE (MIXED FLOW)



FRANCIS TURBINE (MEDIUM HEAD TURBINE)

Ex No : 11 *Date :*

Performance Characteristics of Francis Turbine (Constant Speed)

Aim :

To study the performance of Francis Turbine and draw the characteristic curves of the Francis Turbine. The experiment is conducted to obtain Constant Speed characteristics.

Apparatus Required :

1. Francis turbine test rig.

Theory:

Hydraulic (Water) turbines are the machines that use the energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the turbines become the prim over to run Electric Generators to produce electricity, viz. Hydro Electric Power.

Turbines are classified as Impulse and Reaction types. Francis turbine comes into the category of Reaction Turbines. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Francis (Reaction Turbines) requires low Heads and high Discharge.

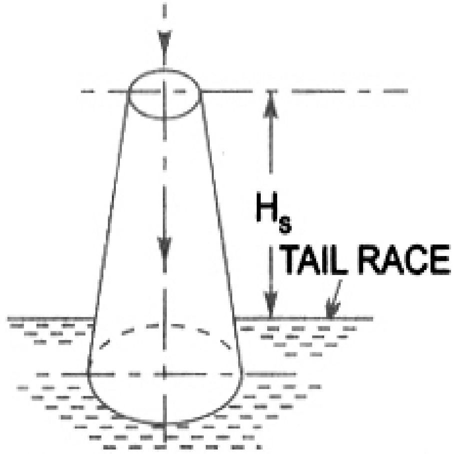
The Francis turbine consists of the following major parts

1. Mono block Centrifugal Pump
2. Turbine Unit
3. Sump Tank
4. Orificemeter with Inlet and Outlet pressure tapping and “U” tube manometer arrangements
5. Brake drum with Flat belt and Spring balancers
6. Provision for measurement of Head on Turbine (by Pressure gauges)

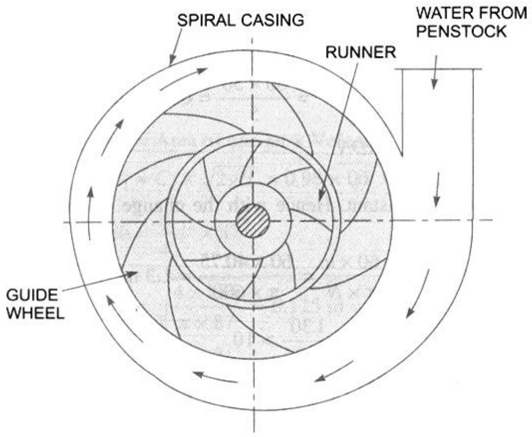
Technical specifications:

***UTE* Francis Turbine**

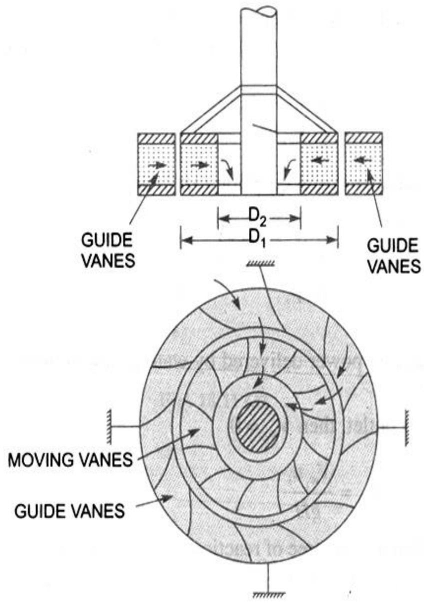
1. Rated supply head = 7 meters.
2. Discharge = 1200 lpm
3. Rated speed = 800 rpm.
4. Power Output = 1 HP
5. Mean Brake drum diameter = 200 mm.



(a) CONICAL DRAFT-TUBE



Main parts of a radial reaction turbines.



Inward radial flow turbine.

Formula:

Input Power (P_i) = W × Q × H in Watts

Where,

w = Specific weight of water = 9810 in N / m^3

Q = Discharge in m^3 / sec

H = Total Head of the flow (or) the sum of Delivery pressure of the pump and Vacuum pressure of turbine in m

Discharge (Q) = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec.

Where,

C_d = Co-efficient of discharge of Orificemeter

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 in m / sec^2

h = Orificemeter's Pressure Head difference in m

Difference head in pressure, $h = (h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f} \right)$ in m

h_1 = Manometric head in one limb of the manometer in m

h_2 = Manometric head in other limb of the manometer in m

S_m = Specific gravity of manometric fluid / Mercury = 13.6

S_f = Specific gravity of flowing fluid / Water = 1

Procedure:

1. The delivery valve is kept closed before switching "ON" the pump,.
2. The pump is started.
3. The delivery valve is gradually opened until to reach the turbine speed is 900 rpm.
4. The turbine speed is kept constant by operating the delivery valve.
5. The required mechanical load is applied on the brake drum using screw rod.
6. The spring balance reading is noted for the applied load.
7. The delivery valve of the turbine is adjusted to maintain the constant speed of 900 rpm
8. The pressure gauge and vacuum gauge reading are noted for the applied load.
9. The difference in head levels h_1 and h_2 in the manometer, connected to the orificemeter are noted.
10. The experiment is repeated and the readings are noted.
11. Using the observations the efficiency is calculated with the formulae.

Observations :

Diameter of inlet pipe (or) Size of Orifice meter	=	d_1	=	100 mm	=	**0.100 m**
Diameter of Throat	=	d_2	=	80 mm	=	**0.080 m**
Diameter of Brake Drum	=	D	=	195 mm	=	**0.195 m**
Thickness of flat belt	=	T	=	6.5 mm	=	**0.0065 m**
Co-efficient of discharge of Orifice meter	=	C_d	=	**0.60**		

Tabulations :

Reading No.	Spring Balance Reading in kg			Turbine Speed (N) in rpm	Pressure Gauge Reading		Vacuum Gauge Reading			Manometer Reading in cm			X in m
	T_1	T_2	Mass (m) = $(T_1 - T_2)$		in kg/cm^2	in m	in mm.Hg	in kg/cm^2	in m	h_1	h_2	X = $h_1 - h_2$	

Model Calculation:

1. Difference head in pressure, h = $(h_1 \sim h_2) \times \left(\frac{S_m - S_f}{S_f}\right)$ in m

2. Discharge (Q) = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec.

3. Total Head (H) = Pressure Gauge Reading + Vacuum Gauge Reading in m

4. Input Power (Pi) = W × Q × H in Watts

5. Force (F) = mass (m) × gravity (g)

6. Perpendicular Distance (R) = Mean radius of Brake Drum
   = (Radius of Brake Drum (D/2) + Half of the flat belt Thickness (T/2)

7. Torque (T) = Force (F) x Perpendicular Distance (R)

8. Output Power (P_O) = $\frac{2 \times \pi \times N \times T}{60}$ in Watts

Where,

N = Speed of the Turbine in **rpm**

T = Produced Torque on Brake Drum in **Nm**

9. Efficiency (η) = $\frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Calculation Table:

Reading No	Orifice meter Pressure head (h) in m	Discharge (Q) in m^3/sec.	Input Power (P_i) in Watts	Torque (T) in Nm	Output Power (P_O) in Watts	Efficiency (η) in %

Graph:

The graphs are drawn for

Characteristics Analysis:

Total Head (H) vs Discharge (Q)

Total Head (H) vs Input power (P_i)

Total Head (H) vs Efficiency (η)

taking H on X – Axis.

And

Performance Analysis :

Brake Power (P_o) vs Efficiency (η)

Torque (T) vs Total Head (H)

Torque (T) vs Discharge (Q)

taking P_o , T on X – Axis.

Result:

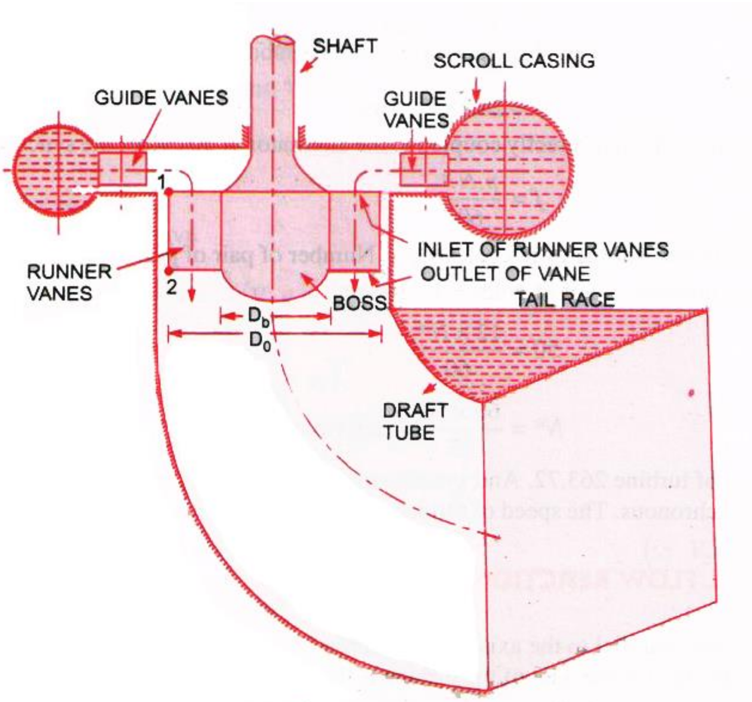
Thus the performance of Francis turbine test is studied and the characteristics curves of turbine are drawn.

Inference:

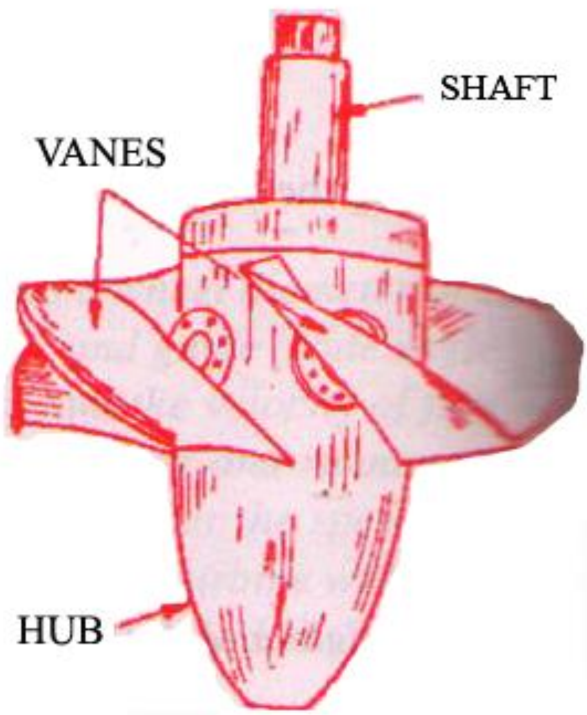
It is inferred that as head increases, efficiency and discharge increases.

Applications:

Francis turbines may be designed for a wide range of heads and flows. This, along with their high efficiency, has made them the most widely used turbine in the world. Francis turbine is used in Periyar power house, Sholayar Power House, Sarkarpathy Power House, Papanasam Power House, Indira Sagar Power House, Bhakra Left Bank Power House and in Mettur Dam Power House.



Main components of Kaplan turbine.



KAPLAN TURBINE

Ex No : 12 ***Date :***

Performance Characteristics of Kaplan Turbine (Constant Speed)

Aim :

To study the performance of Kaplan Turbine and to draw the characteristic curves of the Kaplan Turbine.

The experiment is conducted to:

Obtain Constant Speed characteristics

Apparatus Required :

Kaplan turbine test rig.

Theory:

Hydraulic (Water) turbines are the machines that use the energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the turbines become the prim over to run Electric Generators to produce electricity, viz. Hydro Electric Power.

Turbines are classified as Impulse and Reaction types. Kaplan turbine comes into the category of Reaction Turbines. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Kaplan (Reaction Turbines) requires low Heads and high Discharge.

Kaplan turbine test rig consists of the following major parts

1. Mono block Centrifugal Pump
2. Turbine Unit
3. Sump Tank
4. Venturimeter with Inlet and Outlet pressure tapping & Gauge arrangements
5. DC power generator
6. Provision for measurement of Turbine speed (digital RPM indicator) , Head on Turbine
    a. (Pressure gauge) and digital Volt, Ammeters are built in on the control panel.

Observation and Tabulation:

Co-efficient of Discharge of the Venturimeter (Cd) = **0.95**

Inlet Pipe Diameter (D1) = **100 mm**

Throat Diameter of Venturimeter (D2) = **50 mm**

Reading No.	Turbine speed (N) in rpm	Delivery pressure Gauge reading		Vacuum pressure Gauge reading		Venturimeter Pressure head (h) in m				Power Output	
		in kg/cm^2	in m	in kg/cm^2	in m	in kg/cm^2	P_2 in kg/cm^2	$P_1 - P_2$ in kg/cm^2	$P_1 - P_2$ in m	Voltage "V" in volts	Current "I" in amps
1											
2											
3											
4											
5											

Formula:

1. Total Head = Delivery pressure head reading + vacuum gauge reading
2. Discharge (Q) = $\dfrac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

where,

C_d = Co-efficient of discharge of Venturimeter

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 m / sec^2

h = Venturimeter's Pressure Head in m

3. Input Power (Pi) = 9.81 × H × Q kW

Where,

w = Specific weight of water in kN / m^3 = 9.81 kN / m^3

H = Total Head in m.

Q = Discharge in m^3 / sec

4. Output Power (P_o) = $\dfrac{V \times I}{\eta_T \times \eta_A \times 1000}$ kW

Where,

V = Voltmeter Reading in volts

I = Ammeter Reading in amps

η_T = Transmission Efficiency (Belt Transmission) = 0.75

η_A = Alternator Efficiency = 0.65

Calculation Table:

Reading No.	Total Head (H) in m	Discharge (Q) in m^3 / sec	Input power (P_i) in kW	Output power (P_o) in kW	Turbine Efficiency (η) in %
1.					
2.					
3.					
4.					
5.					

Model Calculation:

1. Total Head = Delivery pressure head reading + vacuum gauge reading

2. Discharge (Q) = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

3. Input Power (Pi) = $9.81 \times H \times Q$ kW

4. Output Power (P_o) = $\frac{V \times I}{\eta_T \times \eta_A \times 1000}$ kW

5. Efficiency (η) = $\frac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Procedure:

1. The Vane position is set to partial open condition.
2. The delivery valve is adjusted to the maximum discharge.
3. The turbine speed is kept constant by operating the delivery valve.
4. The electrical loading is applied.
5. The delivery valve of the turbine is adjusted to maintain the constant speed.
6. Turbine speed, vacuum head, venturimeter readings and power output (voltage and current) are noted.
7. The above procedure is repeated for various electrical loads and the efficiency of the turbine is calculated.

Graph:

A graph of

Total Head (H) v_s Efficiency (η)

Total Head (H) v_s Discharge (Q)

Total Head (H) v_s Input power (P_i)

are drawn , taking H on X – Axis.

Result :

Thus the performance of Kaplan Turbine test is studied and the characteristics curves of Turbine are drawn.

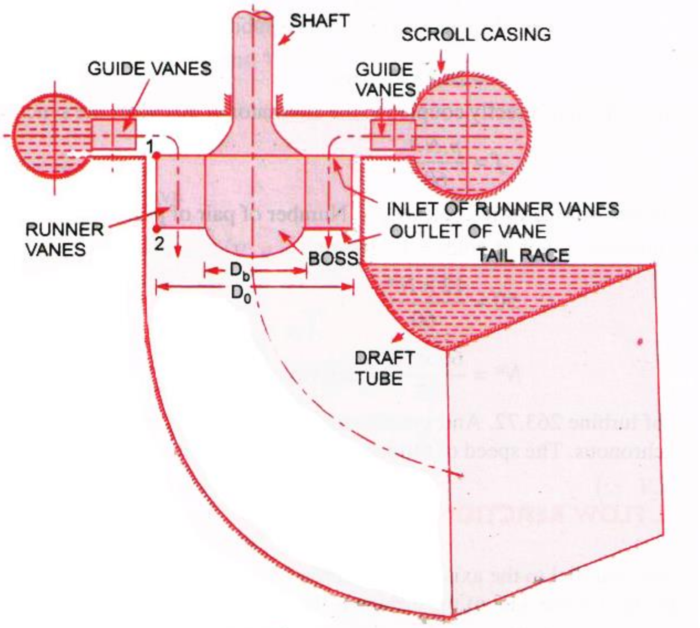
Maximum Efficiency =

Inference :

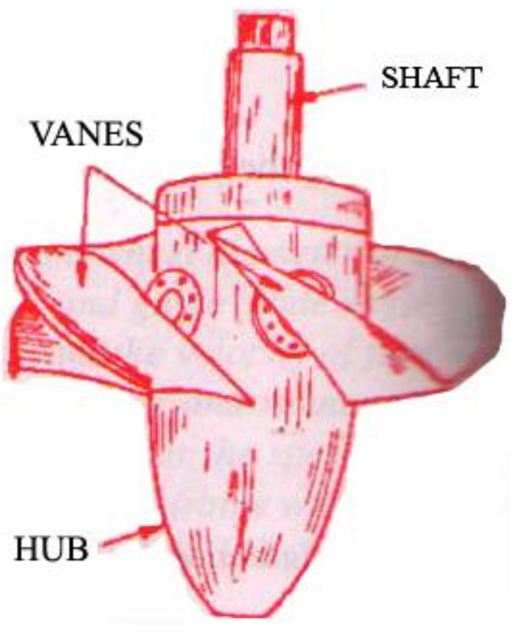
Discharge, efficiency of the turbine increases with the increase of head, at constant speed condition. Input remains the same for the increase of head.

Applications:

Kaplan turbines are widely used throughout the world for electrical power production. It is used in Mettur Tunnel Power House, Ghataprabha Power House, Kadra Power House.



Main components of Kaplan turbine.



KAPLAN TURBINE

Ex No : 13 ***Date :***

Performance Characteristics of Kaplan Turbine (Constant Head)

Aim :

To study the performance of Kaplan Turbine and to draw the characteristic curves of the Kaplan Turbine.

The experiment is conducted to:

Obtain Constant Head characteristics

Apparatus Required :

Kaplan turbine test rig.

Theory:

Hydraulic (Water) turbines are the machines that use the energy of water (Hydro – Power) and convert it into Mechanical Energy. Thus the turbines become the prim over to run Electric Generators to produce electricity, viz. Hydro Electric Power.

Turbines are classified as Impulse and Reaction types. Kaplan turbine comes into the category of Reaction Turbines. In Reaction Turbine, it is the pressure of the flowing water, which rotates the runner of the Turbine. Kaplan (Reaction Turbines) requires low Heads and high Discharge.

Kaplan turbine test rig consists of the following major parts

1. Mono block Centrifugal Pump
2. Turbine Unit
3. Sump Tank
4. Venturimeter with Inlet and Outlet pressure tapping & Gauge arrangements
5. DC power generator
6. Provision for measurement of Turbine speed (digital RPM indicator) , Head on Turbine
7. (Pressure gauge) and digital Volt , Ammeters are built in on the control panel.

Observation and Tabulation:

Co-efficient of Discharge of the Venturimeter (Cd) = **0.95**

Inlet Pipe Diameter (D1) = **100 mm**

Throat Diameter of Venturimeter (D2) = **50 mm**

Reading No.	Turbine speed (N) in rpm	Delivery pressure Gauge reading		Vacuum pressure Gauge reading		Venturimeter Pressure head (h) in m				Power Output	
		in kg/cm²	in m	in kg/cm²	in m	in kg/cm²	P_2 in kg / cm²	$P_1 - P_2$ in kg/cm²	$P_1 - P_2$ in m	Voltage "V" in volts	Current "I" in amps
1											
2											
3											
4											
5											

Formula:

1. Total Head = Delivery pressure head reading + vacuum gauge reading
2. Discharge (Q) = $\frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

where,

C_d = Co-efficient of discharge of Venturimeter

a_1 = Area of the inlet in m^2

a_2 = Area of the Throat in m^2

g = Acceleration due to gravity = 9.81 m / sec^2

h = Venturimeter's Pressure Head in m

3. Input Power (Pi) = 9.81 × H × Q kW

Where,

w = Specific weight of water in kN / m^3 = 9.81 kN / m^3

H = Total Head in m.

Q = Discharge in m^3 / sec

4. Output Power (P_o) = $\frac{V \times I}{\eta_T \times \eta_A \times 1000}$ kW

Where,

V = Voltmeter Reading in volts

I = Ammeter Reading in amps

η_T = Transmission Efficiency (Belt Transmission) = 0.75

η_A = Alternator Efficiency = 0.65

Calculation Table:

Reading No.	Total Head (H) in m	Discharge (Q) in m^3 / sec	Input power (P_i) in kW	Output power (P_o) in kW	Turbine Efficiency (η) in %
1.					
2.					
3.					
4.					
5.					

Model Calculation :

1. Total Head = Delivery pressure head reading + vacuum gauge reading

2. Discharge (Q) = $\dfrac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3 / sec

3. Input Power (Pi) = $9.81 \times H \times Q$ kW

4. Output Power (P_o) = $\dfrac{V \times I}{\eta_T \times \eta_A \times 1000}$ kW

5. Efficiency (η) = $\dfrac{\text{Output Power } (P_O)}{\text{Input Power } (P_i)} \times 100$ in %

Procedure:

1. The Vane position is set to partial open condition.
2. The Delivery valve is opened at the partial open condition.
3. The turbine head is kept constant by operating the delivery valve.
4. The electrical loading is applied.
5. The delivery valve of the turbine is adjusted to maintain the constant head.
6. Turbine speed, vacuum head, venturimeter readings and power output (voltage and current) are noted.
7. The above procedure is repeated for various electrical loads and the efficiency of the turbine is calculated.

Graph :

A graph of

Total Speed(N) v_s Efficiency (η)

Total Speed (N) v_s Discharge (Q)

Total Speed (N) v_s Input power (P_i)

are drawn , taking N on X – Axis.

Result :

Thus the performance of Kaplan Turbine test is studied and the characteristics curves of Turbine are drawn.

Maximum Efficiency =

Inference :

Discharge, efficiency of the turbine increases with the increase of speed, at constant head condition. Input remains the same for the increase of speed.

Applications:

Kaplan turbines are widely used throughout the world for electrical power production. It is used in Mettur Tunnel Power House, Ghataprabha Power House, Kadra Power House.

PROGRAM OUTCOMES (POs)

Mechanical Engineering Graduates will be able to

1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to solution of complex engineering problems.
2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	**Design / development of solutions:** Design solutions for complex engineering problems and design 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.
4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**Communication:** Communicate effectively on complex engineering activities withthe engineering community andwith society atlarge, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects in multidisciplinary environments.
12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

K.L.N. COLLEGE OF ENGINEERING

VISION

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the Society.

MISSION

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry.

Principal | **Secretary &Correspondent** | **President**