FLUID MACHINERY AND IC ENGINE LABORATORY

LAB MANUAL

Academic Year	:	**2019-2020**
Subject Code	:	**AMEB13**
Regulations	:	**IARE-R18**
Class	:	**IV Semester**
Branch	:	**Mechanical Engineering**

Prepared By

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MECHANICAL ENGINEERING

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043.

2019-2020

Vision
The Department of Mechanical Engineering envisions value based education, research and development in the areas of Manufacturing and Computer Aided Engineering as an advanced center for Mechanical Engineering, producing graduates of world-class competence to face the challenges of global market with confidence, creating effective interface with various organizations.

Mission
The mission of the Mechanical Engineering Department is to prepare effective and responsible engineers for global requirements by providing quality education & to improve pedagogical methods employed in delivering the academic programs to the needs of the industry and changing world by conducting basic and applied research and to generate intellectual property.

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Department of Mechanical Engineering

Program Outcomes	
PO1	**Engineering Knowledge:** Capability to apply knowledge of Mathematics, Science Engineering in the field of Mechanical Engineering
PO2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of Mathematics, Science and Engineering.
PO3	**Design/ Development of solution:** Competence to design a system, component or process to meet societal needs within realistic constants.
PO4	**Conduct investigation of complex problems:** To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.
PO5	**Modern Tool usage:** An ability to formulate solve complex engineering problems using modern engineering and information technology tools.
PO6	**The Engineer society:** To utilize the engineering practices, techniques, skills to meet needs of health, safety legal, cultural and societal issues.
PO7	**Environment and Sustainability:** To understand the impact of engineering solution in the societal context and demonstrate the knowledge for sustainable development.
PO8	**Ethics:** An understanding and implementation of professional and Ethical responsibilities.
PO9	**Individual Team work:** To function as an effective individual and as a member or leader in multi-disciplinary environment and adopt in diverse teams.
PO10	**Communication:** An ability to assimilate, comprehends, communicate, give and receive instructions to present effectively with engineering community and society.
PO11	**Project Management and Finance:** An ability to provide leadership in managing complex engineering project at multi-disciplinary environment and to become a professional engineer.
PO12	**Life-Long learning:** Recognition of the need and an ability to engage in lifelong learning to keep abreast with technological changes.
Program Specific Outcomes	
PSO1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical system including allied engineering streams.
PSO2	**Design/ Analysis:** An ability to adapt and integrate current technologies in the design and manufacturing domain to enhance the employability.
PSO3	**Successful Career and Entrepreneurship:** To build the nation by imparting technological inputs and managerial skills to become a Technocrats.

SYLLABUS

Week-1	**CALIBRATION OF FLOW METERS**
Determination of coefficient of discharge (C_d) and generation of various characteristic curves for water flowing through venturimeter Determination of coefficient of discharge (C_d) and generation of various characteristic curves for water flowing through Orifice meter.	
Week-2	**DETERMINATION OF FRICTION FACTOR**
Determination of friction factor for a given pipe line.	
Week-3	**BERNOULLI'S THEOREM**

Verification of Bernoulli‟s theorem.	
Week-4	**PERFORMANCE TEST ON REACTION TURBINES**
Performance Test on Francis Turbine and generate various characteristic curves. Performance Test on Kaplan wheel and generate various characteristic curves.	
Week-5	**PERFORMANCE TEST ON IMPULSE TURBINE**
Performance test on Pelton wheel and generate various characteristic curves.	
Week-6	**PERFORMANCE TEST ON POSITIVE DISPLACEMENT PUMP**
Performance Test on Reciprocating Pump and generate various characteristic curves	
Week-7	**PERFORMANCE TEST ON ROTODYNAMIC PUMPS**
Performance Test on Centrifugal Pumps and generate various characteristic curves	
Week-8	**IC Engines Valve/Port timing diagram**
Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.	
Week-9	**IC Engine performance test for 4-stroke SI Engine**
Performance test for 4-stroke SI engine and draw performance curves	
WeeK-10	**IC Engine performance test on 4-Stroke CI engine**
Performance Test on 4-stroke CI engine and to draw the performance curves	
Week-11	**Performance Test on Air Compressor Unit**
Volumetric Efficiency of Reciprocating Air compressor unit	
Week-12	**Performance test on Variable Compression Ratio(VCR) engine**
Performance Test on CI engine when the compression ratio is changing.	
Week-13	**Examination**

S. No.	LIST OF EXPERIMENTS	Pg. No.
1	Determination of coefficient of discharge (C_d) and generation of various characteristic curves for water flowing through venturimeter Determination of coefficient of discharge (C_d) and generation of various characteristic curves for water flowing through Orifice meter.	6
2	Determination of friction factor for a given pipe line.	9
3	Verification of Bernoulli's Theorem	12
4	Performance Test on Francis Turbine and generate various characteristic curves. Performance Test on Kaplan wheel and generate various characteristic curves.	15
5	Performance test on Pelton wheel and generate various characteristic curves.	19
6	Performance Test on Reciprocating Pump and generate various characteristic curves	23
7	Performance Test on Centrifugal Pumps and generate various characteristic curves	28
8	Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.	32
9	Performance test for 4-stroke SI engine and draw performance curves	37
10	Performance Test on 4-stroke CI engine and to draw the performance curves	40
11	Volumetric Efficiency of Reciprocating Air compressor unit	44
12	Performance Test on CI engine when the compression ratio is changing.	48

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Certificate

This is to certify that it is a bonafied record of Practical work done by Sri/Kum. ______________________________________ bearing the Roll No. ______________________ of ____________ class ____ branch in the ____________________________ laboratory during the academic year ___________________ under our supervision.

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

External Examiner **Internal Examiner**

ATTAINMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Exp. No.	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Determination of coefficient of discharge (C_d) and generation of various characteristic curves for water flowing through venturimeter Determination of coefficient of discharge (C_d) and generation of various characteristic curves for water flowing through Orifice meter.	PO1, PO2, PO3, PO5	PSO1,
2	Determination of friction factor for a given pipe line.	PO1, PO2, PO3, PO5	PSO1,
3	Verification of Bernoulli‟s Theorem	PO1, PO2, PO3, PO5	
4	Performance Test on Francis Turbine and generate various characteristic curves. Performance Test on Kaplan wheel and generate various characteristic curves.	PO1, PO2, PO3, PO5	PSO1,
5	Performance test on Pelton wheel and generate various characteristic curves.	PO1, PO2, PO3, PO5	PSO1,
6	Performance Test on Reciprocating Pump and generate various characteristic curves	PO1, PO2, PO3, PO5	PSO1,
7	Performance Test on Centrifugal Pumps and generate various characteristic curves	PO1, PO2, PO3, PO5	PSO1, PSO2
8	Drawing valve and port timing diagram for 4-stroke diesel and 2-stroke petrol engine respectively.	PO1, PO2, PO3, PO5	PSO1, PSO2
9	Performance test for 4-stroke SI engine and draw performance curves	PO1, PO2, PO3, PO5	PSO1
10	Performance Test on 4-stroke CI engine and to draw the performance curves	PO1, PO2, PO3, PO5	PSO1, PSO2
11	Volumetric Efficiency of Reciprocating Air compressor unit	PO1, PO2, PO3, PO5	PSO1, PSO2
12	Performance Test on CI engine when the compression ratio is changing.	PO1, PO2, PO3, PO5	PSO2
	Content Beyond Syllabus		
1	Flow through Wiers and Notches	PO1, PO2, PO3, PO5	PSO1, PSO2
2	Determination of Reynold‟s Number	PO1, PO2, PO3, PO5	PSO1, PSO2

EXPERIMENT -1

Calibration of Venturimeter

AIM:- To determine the coefficient of discharge of the given flow meter.

APPARATUS:-Venturimeter experimental setup, stop watch.

THEORY: A flow meter is used to measure the flow rate of a fluid in a pipe. A venturimeter consist of short length of a pipe narrowing to a throat in the middle and then diverging gradually to the original diameter of the pipe. As the water flow through these meters, velocity is increased due to the reduced area and hence there is a pressure drop.

A venturimeter is a device which is used for measuring the rate of flow of fluid through the pipe.

PRINCIPLE:-The basic principle on which a venturimeter works is that by reducing the cross sectional area of the flow passage, a pressure difference created and the measurement of the pressure difference enables the determination of the discharge through the pipe.

Venturimeter consist of 1. An inlet section which is in the form of convergent cone 2. Throat 3.outlet section which is in the form of divergent cone. The inlet section of the venturimeter is of the same diameter as that of the pipe diameter. The convergent cone is a short pipe which tapers from the original size of the pipe so that the throat of the venturimeter. The throat is a short pipe having its cross sectional area smaller than that of the pipe .The divergent cone of the venturimeter is a gradually diverging pipe with its cross section area increasing from that of throat i.e 1 and 2 of the venturimeter

Pressure taps are provided through the pressure ring as shown in the figure.

The length of convergent cone is equal to the (D-d).where „D" is the diameter of the inlet section and „d" diameter of throat .The length of the pipe is equal to the diameter of the pipe. The diameter of the throat may vary from 1/3 to ¾ of the pipe diameter.

The divergent cone has more length as that of the convergent cone due to avoid the possibility of flow separation (eddies) and energy loss.

The cross section area of the throat is smaller than the cross section area of the inlet section .According to the continuity equation the velocity of the flow at the throat will become greater than that at inlet section .The increase in the velocity of the flow at the throat result in the decrease in the pressure .so the pressure difference will be developed between the inlet and the throat .This pressure difference can be determined by using suitable manometer.

EXPERIMENTAL PROCEDURE:

1. Select the required flow meter.

2. Open its pressure valves and close the other pressure valves, so that only pressure for the flow meter in use is communicated to the manometer.

3. Open the flow control valve and allow a certain flow rate.

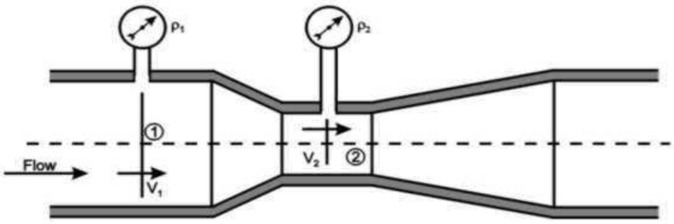
$\frac{specific\ gravity\ of\ ccl4}{specific\ gravity\ of\ water}$

4. Observe the reading of the manometer. And change the flow rate.

5. Note down the readings of the manometer.

6. Collect the water in the collecting tank .Close the drain valve and find the time taken for 5cm rise in the tank.

Schematic diagram of venturimeter:



venturimeter

CALCULATIONS:

$h_{1=}$ manometric head in the left limb.

$\frac{Qa}{Qt}$

$h_{2=}$ manometric head in the right limb.

t=time taken for h_{cm} rise of water in tank.

Manometeric head h=(h_{2-} h_1)x -1

D_1 (Dia. Of Pipe) = 40 mm and

D_2 (Dia. Of Throat) = 24 mm

Specific gravity of ccl_4=1.6.

Specific gravity of water=1.

Theoretical discharge Q_t =k x $\sqrt{(h)}$ m^3/s.

$$= k \frac{a1xa2\sqrt{2g}}{(a1)2-(a2)2}$$

Where
a_1=area of cross section of pipe.

a_2=area of cross section of the throat.

Q_a =volume of the water collected in the tank i.e. [area of the tank x rise of water level in the tank] m^3/s.

Coefficient of discharge (C_d)=

Observation table and Tabular column:

S.No	Manometeric reading		Time taken for h cm rise of water in tank (s)	Theoretical discharge Q_t m^3/sec	Actual discharge Q_a m^3/sec	Coefficient of discharge (C_d)
	h_1(cm)	h_2(cm)				
1						
2						
3						
4						
5						

GRAPH:

1. C_d versus Q_a
2. C_d versus Q_t

RESULT: The coefficient of discharge of venturimeter is C_d=

Calibration of Orifice meter

Aim: To determine the coefficient of discharge of the given flow meter.

Apparatus: orifice meter experimental setup, stopwatch.

Theory: An orifice meter is another simple device used for measuring the discharge through a pipe. Orifice meter also works on the same principle as that of venturimeter i.e. by reducing the cross sectional area of the flow passage a pressure difference between the two sections is developed and the measurement of the pressure difference enables the determination of the discharge through the pipe.An orifice meter is a cheaper arrangement for discharge measurement through pipes and its installation requires a smaller length, as compared with venturimeter. As such where the space is limited, the orifice meter may be used for discharge of through pipes.

An orifice meter consists of a flat circular plate with circular perforated hole called orifice which is concentric with the pipe axis. The thickness of the plate is less than an equal to 0.05 times the diameter of the pipe. The diameter of the orifice may vary from 0.2 to 0.85 times the pipe diameter but generally the diameter is kept as 0.5 times pipe diameter.

Two pressure taps are provided at section-1 on the upstream side of the orifice plate and other at section-2 on the downstream side of the orifice plate since in the case of an orifice change in the cross section as area of the flow passage is provided and there being a gradual change in the cross sectional area of the flow passage as in the case of venturimeter there is a gradual loss of energy in a orifice meter than in a venturimeter.

The experimental setup consist of 200mm pipe lines fixed to an MS stand .The pipe is connected with an orifice meter with the action valves for pressure tapping‟s. The meter is connected to a common middle chamber, which is in turn connected to a mercury chamber. The pipe line is provided with a flow control valve.

Experimental Procedure:

1. Select the required flow meter.

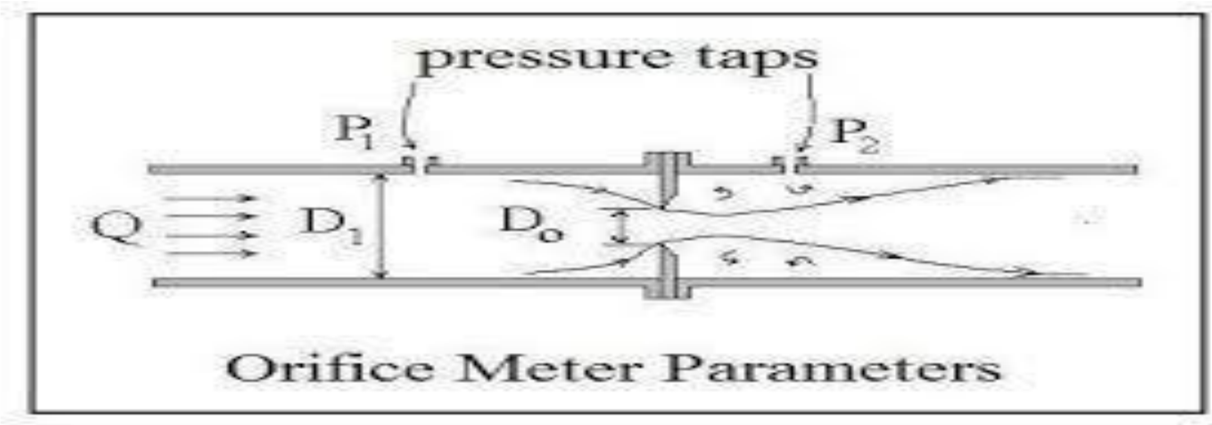
2. Open its pressure valves and close the other pressure valves so that only pressure for the meter in use is communicated to the manometer.

3. Open the flow control valve and allow certain a flow rate.

4. Observe the reading in the manometer.

5. Collect the water in the collecting tank .close the drain valve and find the time taken for 5cm rise in the tank.

Schematic diagram of Orificemeter



Calculations:

Theoretical discharge(Q_t)

$h_{1=}$ manometric head in the left limb.cm $h_{2=}$ manometric head in the right limb.cm Difference in the manometer level =h=h_1-h_2 cm t=time taken for h_{cm} rise of water in tank. Theoretical discharge $Q_t=K\sqrt{h}$

$$k = \frac{a1xa2\sqrt{2g}}{(a1)2-(a2)2}$$

D_1 (Dia. Of Pipe) = 40 mm and

D_2 (Dia. Of Throat) = 24 mm

Actual discharge (Q_a)

The area of the collecting tank =50cm*50 cm

Rise of water level in the tank =5cm

Time taken for collecting „ h „in the collecting tank

Qa=AR/t

Coefficient of discharge $C_d=Q_a/Q_t$

Observation &calculation Tabular column of orifice-meter:

S.NO	Manometer Reading			$H=x(\frac{so}{sw}-1)$	**Time taken (t sec) for 5cm rise water**	**$Q_t= K\sqrt{h}$ (cm^3/sec)**	**Q_a=AR/t Cm^3/sec**	**Coefficient discharge of orifice-meter (C_d)**
	$h_{1(Cm)}$	h_{2}(cm)	$H=h_2-h_{1(cm)}$					
1								
2								
3								
4								

Graphs:

1. Actual discharge versus Theoretical discharge.
2. Actual discharge versus Coefficient of discharge.

Result: The coefficient of discharge (C_d) for orificemeter is ________________

Precautions:

Viva Voce:

1. Classify flow meter.
2. What is orificemeter.
1. Compare orificemeter with venturimeter.

EXPERIMENT -2

Determination of friction factor for a given pipe line

Aim: To find the friction factor for a given pipe line.

Apparatus: Pipe friction test rig, stopwatch.

Theory:

Any fluid flowing through a pipe experiences resistance from the walls of the pipe due to shear force viscosity.The amount of loss depends on the velocity of flow and area of contact between the pipe surface and fluid.It also depend upon the type of flow i.e Laminar or Turblent.This friction resistance causes loss of pressure head in the direction of flow

The relation of dropof head derivedby Darchy's-Weisbach is

$hf = 4flv^2/2gd$

Coefficient of friction is given by $f = 2gdh_f/4Lv^2$

Desciption of the Apparatus: It consist of piping system with two pipe lines of 20 mm (Square), and 15 mm (Round) with pressure tappings are connected to a multiport manifold which in turn connected to manometer at a distance of 2.5 meters and flow control valves.The whole unit is assembled to a steardy MS stand . A collecting tank with a guage glass and scale fittings and assembly

When water flows through a pipe, a certain amount of energy (or pressure energy)has to be spent to overcome the friction due to the roughness of the pipe surface. This roughness effect depends on the roughness effect or frictional effect depends on the material of the pipe and scale formation if any. If the surface is smooth the friction effect is less first. For an old pipe due to the scale formation or chemical deposits the roughness and hence the friction effect is higher.

Pipe line system in general includes several auxiliary components. In addition to types. These components include the following:

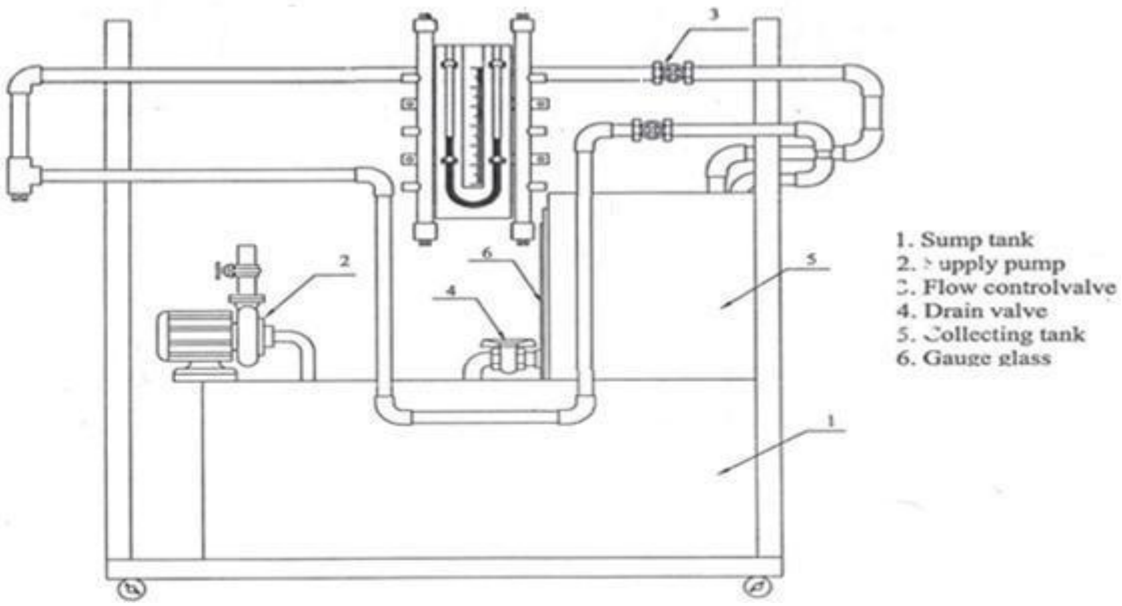
1. Transitions or sudden expansion And contraction for changing pipe size.
2. Elbows and bends for changing flow directions.

These components introduce disturbances in the flow that cause turbulence and as mechanical energy loss in addition to that which occur in basic type flow due to friction. The energy loss although occurs over a finite distance, then viewed from the perspective of an entire pipe system are localized near the component. Hence these losses are referred to as local losses or minor losses. It should be remembered that these losses sometimes are the dominant losses in piping system and hence the term minor losses is a misnomer often.

Experimental procedure:-

1. Select the required pipe line
2. Connect the pressure tapping‟s of the required pipe line to the manometer by opening the appropriate pressure valves and closing all the pressure valves.
3. Note down the pressure difference from the manometer mercury column.
4. Collect the water in the collecting tank for 5 cm rise of level and note down the time taken.
5. Repeat the experiment, at other flow rates.

Schematic diagram of friction losses through a pipe(Square and circular pipe):



Observation & calculation Tabular column:

S(I)For square pipe:

S.NO	Manometric head			Time taken for h cm raise of water in tank t 's'	Discharge (Q) m^3/s	Velocity (v) m/s	Friction factor (f)
	$h_{1(Cm)}$	$h_{2(cm)}$	$h_{(cm)}$				
1							
2							
3							
4							
5							

(II) For circular pipe:

S.NO	Manometric head			Time taken for h cm raise of water in tank t 's'	Discharge (Q) m^3/s	Velocity (v) m/s	Friction factor (f)
	$h_{1(Cm)}$	$h_{2(cm)}$	$h_{(cm)}$				
1							
2							
3							
4							
5							

CALCULATIONS:

The distance between the pressure tapping"s and pipe line L=200 cm.

Diameter of round pipe =1.5 cm.

Length of square pipe= 2 cm.

Loss of head due to friction $h=(\frac{Sm}{S}-1)(h_2-h_1)$

Area of the collecting tank A =50x50 cm^2.

Where S_m :specific gravity of mercury -13.6

S: specific gravity of water -1

Rise of water level for 5 cm in collecting tank R = 5cm

Time taken for collecting water = t sec"s.

Discharge Q=(A*R/t) cm^3/sec

Manometer Readings

Reading in the left limb=$h_1$cm Reading in the right limb=h_2 cm

Darcy"s constant $f = \frac{2gdh_f}{4Lv^2}$

Result: The friction factor f for circular pipe is_______________.

The friction factor f for square pipe is_______________.

EXPERIMENT-3

Verification of Bernoulli's theorem

AIM: To verify the Bernoulli‟s theorem.

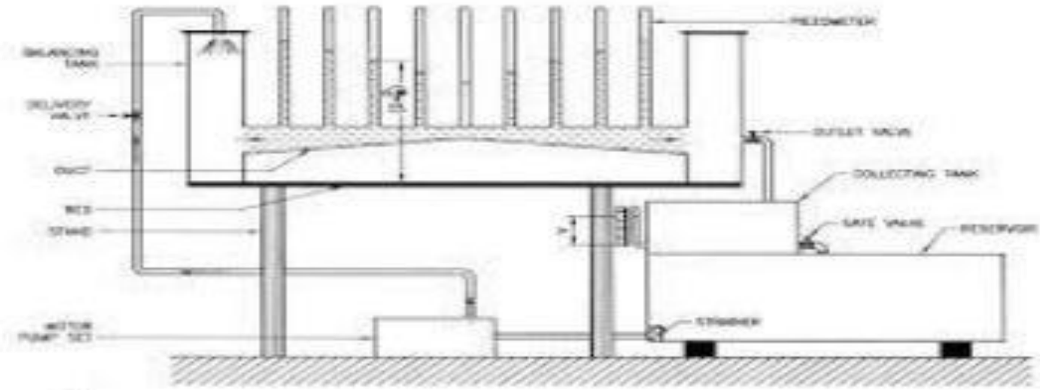
APPARATUS: Beroulli‟s Equipment, stop watch.

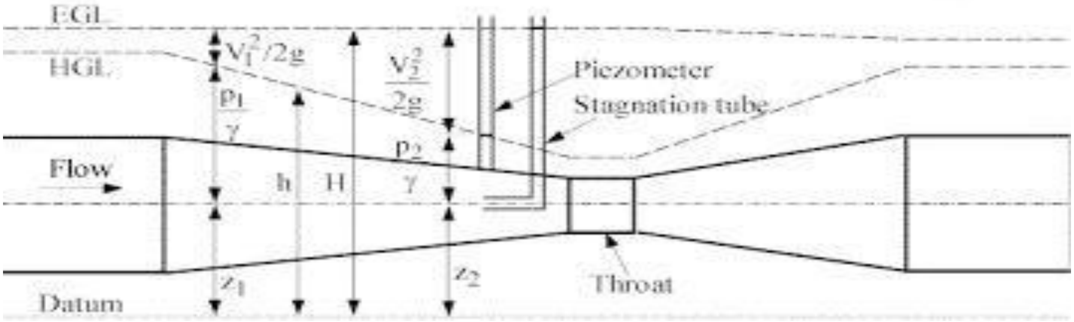
DESCRIPTION: The apparatus consist of two reservoirs to store water to required head, a closed conduit of varying cross-section, number of piezometers take along the path of the conduit, to measure the pressure head at the point, and a controlling valve to control rate of flow of water. A collecting tank is provided to find out the actual discharge. According to bernoulli‟s theorem the sum of the pressure head, velocity head, datum head is constant at all points along a continuous conduit of friction flow.

PROCEDURE:

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

SCHEMATIC DIAGRAM:





Throat

<u>Observation & Calculation Tabular column:</u>

Trail-1:

S.No	Duct point	Piezeometer Reading	time for 5cm rise	Discharge Q m^3/s	Pressure Head m	Velocity Head m	Datum head m	Total Head M
1								
2								
3								
4								
5								
6								
7								

Trail -II

S.NO	Duct Point	Pizeometer Reading	time for 5cm rise	Discharge Q m3/s	Pressure Head m	Velocity Head m	Datum head m	Total Head M
1								
2								
3								
4								
5								
6								
7								

Trial-III

S.NO	Duct Point	Pizeometer Reading	time for 5cm rise	Discharge Q m3/s	Pressure Head m	Velocity Head m	Datum head m	Total Head m
1								
2								
3								
4								
5								
6								
7								

CALCULATIONS:

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

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

Datum head = Z = 0 (for this experiment)

Velocity of water flow = v

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

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

Also

Q= velocity of water in pipe × area of cross section = v × A_x

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

A_t = Area of Throat

A_i = Area of Inlet Diameter of throat = 25mm

Diameter of inlet = 50mm

L_n= distance between throat and corresponding pizeometer

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

Distance between each piezometer = 75mm

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

RESULT: By conducting experiment on Bernoulli‟s apparatus and taking Trail-I,Trail-II,Trail-III ,we have got constant total head.

Hence Bernoulli‟s theorem is proved.

PRECAUTIONS:

1. Note the piezometer readings carefully.

Viva Question:

1. State bernoulli‟s theorem.
2. What are assumptions of Bernoulli‟s theorem.

EXPERIMENT -4

Performance Test on Reaction Turbines

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

APPARATUS REQUIRED: U-tube manometer, Tachometer.

Techanical Specification:

Supply pump:

Rated head-20 m,
Discharge-2000 Lps.
Normal speed-1440 Rpm
Power required-11.2 KW
Size of the pump-100x100 mm.
Pump Type: Centrifugal High speed single suction volute.

Francis turbine:

Rated supply head-20 m.
Discharge-2000 Lps.
Rated speed-1250 Rpm. Runner diameter-150 mm. Number of guide vanes-8. Brake drum dia-300 mm.

Flow measuring unit:

Manometer –U-tube differential column.
Size of venturimeter-100 mm
Throat diameter- 60mm.

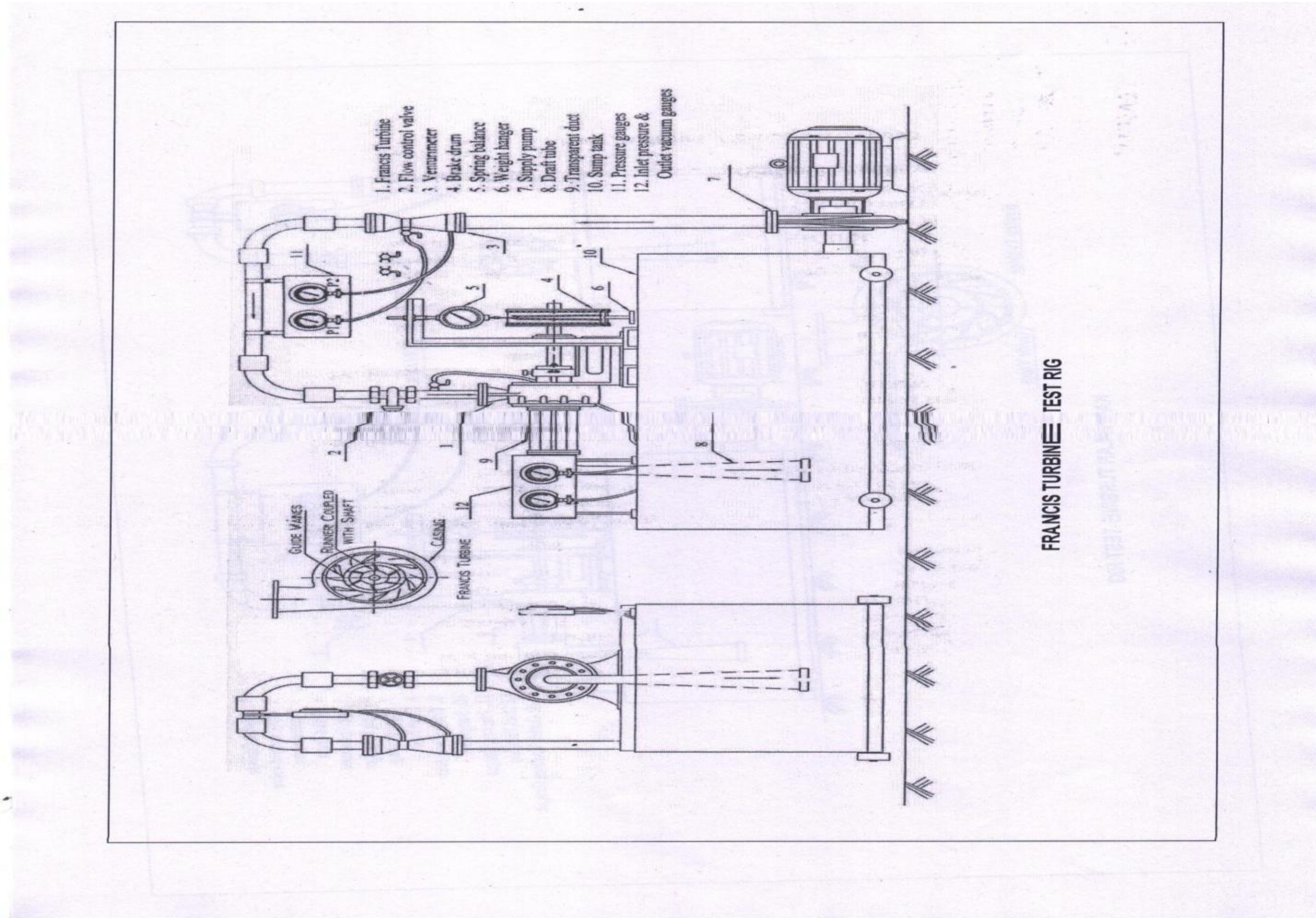
Description:

The water from the penstock enters a scroll casing which completely surrounds the runner. The purpose of the casing is to provide an even distribution around the circumference of the turbine runner, maintaining an constant velocity of water.
In order to keep the velocity of water constant thought its path around the runner, the cross-sectional area of casing is gradually decreased. The casing is made up of material depending upon the pressure nto which it is subjected
From the scroll casing the water passes through the speed ring consist of upper and lower ring
Held together by a series of fixed vanes called stay vanes. The number of stay vanes is usually taken as half number of guide vanes.
The speed ring has two functions to perform. It directs the water to scroll casing to guide vanes
Francis turbine consists of runner mounted on a shaft and enclosed in a spiral casing with guide vanes. The cross section of flow between the guide vanes can be varied, known as gate opening. It can be adjusted ¼, ½, ¾, or full gate opening. A brake drum is fixed to the turbine shaft. By means of this drum the speed of the turbine can be varied. The discharge can be varied by operating a throttle valve on the pipe line. The water after doing work leaves the turbine through a draft tube and flows down into the tail race. A Venturimeter is fitted to the pipe for measuring discharge.

PROCEDURE:

1. Keep the guide vane at required opening (say ½ th)
2. Prime the pump if necessary.
3. Close the main gate valve and start the pump.
4. Open the gate valve for required discharge

5. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Note the Venturimeter pressure gauge readings
7. Note the inlet pressure gauge & outlet vacuum gauge readings
8. Note down applied weights spring balance.
9. Measure the turbine runner speed in rpm with tachometer.
10. Repeat the experiment for different loadings**.**



Observation & Calculation Tabular Column (Mechanical Loading):

S.NO	Gate opening	Pressure Gauge (Kg/cm^2)	Vacuum Gauge (mm of Hg)	Manometer Reading		Speed of Break drum Dynamometer 'N'(Rpm)	Spring Balance		Power Output (P) (KW)	Power Input (P) (KW)	Efficiency 'η' %
				h1(cm)	h2(cm)		T_1(kg)	T_2(kg)			
1											
2											
3											
4											

OBSERVATIONS:

Venturimeter inlet Diameter, d= 100mm.

Venturimeter throat diameter d= 60mm.

Speed (N) =__________ Rpm

Radius of brake drum , R = 0.15 m

CALCULATION:

Inlet Pressure guage P = Kg/cm2

Outlet Vacuum guage V = mm of Hg.

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

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

Where C_d -0.98

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

ρ-Density of water $1000 kg/m^3$.

Q- Flow rate m^3/s

Acceleration due to gravity.9.81m/s H- Total head.

Power output $[P_o] = \frac{2\Pi NT}{60x1000}$ KW

N- speed of Brake drum dynamometer.

Mechanical load

$T= (T_1-T_2)x9.81x0.15$ N-m.

Efficiency $\eta = \frac{\text{power output}}{\text{Power input}}$

Electrical load

Power output =Vx I KW

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

Efficiency $\eta = \frac{\text{power output}}{\text{Power input}}$

Result: The efficiency of francis turbine=____________%.

Model graphs:

1. speed vs. efficiency
2. Discharge vs. power input
3. Input power vs. Speed
4. Output power vs speed

Preacutions:

1.The gate valve should be closed before starting the turbine.

2. The gate valve should be ½ opening only.

2.Mechanical loading should be at consequitive intervals.

Viva Question:

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

Performance of Kaplan Turbine

AIM: To conduct load test on Francis turbine and to study the characteristics of Kaplan turbine.

APPARATUS: Kaplan turbine, Manometer, Tachometer.
Theory: Kaplan turbine is a type of propeller turbine. It is an axial flow turbine, which is suiatable for relatively for low heads, and requires a large quantity of water to generate large amount of power. It is also a reaction type of turbine and hence it operates in an entirely closed conduit from head race to tail race.
The main parts of Kaplan turbine are scroll casing, stay ring, arrangement of guide vanes and draft tube.

Construction specifications:
Spiral casing:cast iron with smooth inner section and flanged connection.
Runner:Gun metal with four aerooil blades.The runner blade pitch can be adjusted by a suitable mechanism,operating shaft .All parts coming in contact with water are made of stainless steel.
Guide vane mechanism: consist of guides vanes made of gun metal.By suitable external mechanism these can be set at different relative position.

Technical specifications:
Rated supply head: 8 meters. Discharge - 2500Lpm.
Rated speed- 1200 Rpm. No of runner blades- 4
No of guide vanes-12
Brake drum diameter -300m
Supply Pump unit: Rated head - 14m. Discharge- 400-1800Lpm.
Normal speed- 1440 Rpm. Power required -10HP.

Flow measuring unit:
Inlet dia of venturimeter- 130mm. Throat diameter- 78mm.
Manometer: differential pressure type.

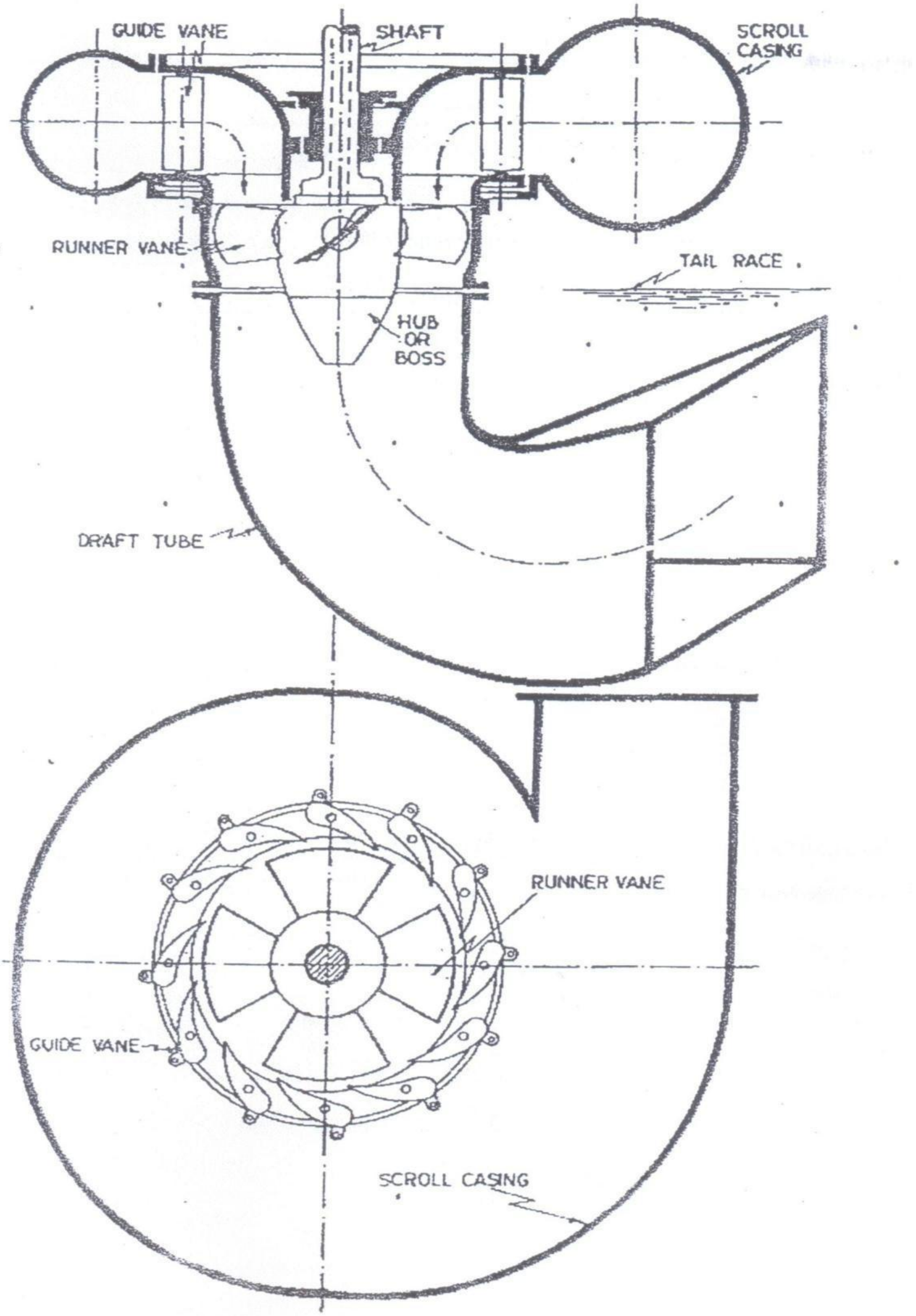


Fig: Sectional arrangement of Kaplan Turbine

PROCEDURE:

1. Keep the guide vane at required opening (say ½ th)
2. Prime the pump if necessary.
3. Close the main gate valve and start the pump.
4. Open the gate valve for required discharge
5. Open the brake drum cooling water gate valve for cooling the brake drum.
6. Note the Venturimeter pressure gauge readings
7. Note the inlet pressure gauge & outlet vacuum gauge readings
8. Note down applied weights spring balance.
9. Measure the turbine runner speed in rpm with tachometer.
10. Repeat the experiment for different loadings.

OBSERVATIONS:

Venturimeter inlet Diameter, d= 100mm.
Venturimeter throat diameter d= 60mm.
Speed (N) =__________ Rpm
Radius of brake drum, R = 0.15 m

Observation & Calculation Tabular Column (Mechanical Loading):

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

Electrical loading:

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

CALCULATION:

Inlet Pressure guage P = Kg/cm2

Outlet Vacuum guage V = mm of Hg

Total Head, $H = H_s+H_d+Z$ m of Water

H_s= m

$$H_d=\frac{P_d \times 9.81\times 10^2}{9.81\times 1000} \text{ m}$$

Z=2.2 m

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

Where C_d -0.98

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

ρ-Density of water 1000kg/m^3.

Q- Flow rate m^3/s

cceleration due to gravity.9.81m/s

H- head available at the turbine (pressure head in terms of water column).

$$\text{Power output } [P_o] = \frac{2\Pi NT}{60} \text{ W}$$

N- speed of Brake drum dynamometer.

Mechanical load:

$T= (T_1-T_2)$x9.81x0.15 N-m.

$$\text{Efficiency } \eta = \frac{\text{power output}}{\text{Power input}}$$

Electrical load:

Power output =VxI KW

$$\text{Power input} = \frac{\rho QgH}{1000} \text{ KW}$$

RESULT: The efficiency of Kaplan turbine

Mechanical efficiency_________%.

Electrical efficiency___________%.

Model graphs:

1. speed vs. efficiency
2. Discharge vs. power input
3. Input power vs. Speed
4. Output power vs speed
5. Head vs discharge

Expected Graphs: -

Precautions:

1. Gate valve should be closed before starting the turbine.
2. Mechanical loading should be at consequitive intervals.
3. Break drum should be cooled by passing water at regular intervals,

Viva question

1. What is reaction turbine?
2. How Kaplan turbine different from pelton wheel?
3. Which type of flow is there in Kaplan turbine.

EXPERIMENT - 5

Performance Test on Impulse Turbine

AIM: To draw the following characteristic curves of pelton wheel under constant head.

APPARATUS REQUIRED:

1. Venturimeter 2. Stopwatch 3. Tachometer 4. Dead weight

DESCRIPTION:

Pelton wheel turbine is an impulse turbine, which is used to act on high loads and for generating electricity. All the available heads are classified into velocity energy(i.e) kinetic energy by means of spear and nozzle arrangement. Position of the jet strikes the knife-edge of the buckets with least relative resistances and shocks. While passing along the buckets the velocity of the water is reduced and hence an impulse force is supplied to the cups which in turn are moved and hence shaft is rotated. Pelton wheel is an impulse turbine which is used to utilize high heads for generation of electricity. It consists of a runner mounted on a shaft.

To this a brake drum is attached to apply brakes over the speed of the turbine. A casing is fixed over the runner. All the available head is converted into velocity energy by means of spear and nozzle arrangement. The spear can be positioned in 8 places that is, 1/8, 2/8, 3/8, 4/8, 5/8 6/8, 7/8 and 8/8 of nozzle opening. The jet of water then strikes the buckets of the Pelton wheel runner. The buckets are in shape of double cups joined at middle portion. The jet strikes the knife edge of the buckets with least resistance and shock. The jet is deflected through more than 160˚ to 170˚. While the specific speed of Pelton wheel changes from 10 to 100 passing along the buckets, the velocity of water is reduced and hence the impulsive force is supplied to the cups which in turn are moved and hence the shaft is rotated. The supply of water is arranged by means of centrifugal pump. The speed of turbine is measured with tachometer.

CONSTRUCTIONAL FEATURES:

CASING: casing is fabricated from MS Plates with integral base is provided.

RUNNER: Runner is made of steel and machined precisely and fixed to horizontal shaft. The bucket resembles to a hemispherical cup with a dividing wall in its center in the radial direction of the runner. The buckets are arranged uniformly on the periphery of the runner. The compact assembly Nickel plated to prevent corrosion and to have a smooth finish.

NOZZLE ASSEMBLY: Nozzle assembly consists essentially of a spear, a hand wheel and the input pipe. The water from the supply pump is made to pass through the nozzle before it enters the turbine. shaft is made of stainless steel and carries the runner and brake drum.

Brake arrangement :Brake arrangement consist of machined and polished brake drum, cooling water pipes internal water scoop, discharge pipe spring balance, discharge pipe, spring balance, belt arrangement supporting stand.

Base frame: Base frame is made is made of MS channel for sturdy construction and it is an integral part of the casing.

TECHANICAL SPECIFICATIONS: TURBINE:

1. Rated supply head-40m.
2. Discharge-660 Lpm.
3. Rated speed-800 Rpm.
4. Runner outside diameter-300m.
5. No of pelton buckets- 20 No‟s
6. Brake drum diameter-300m
7. Power output-3.5

HP SUPPLY PUMP:
Centrifugal pump Multistage

FLOW MEASURING UNIT:

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

PROCEDURE:

1. Gradually open the delivery valve of the pump.
2. Adjust the nozzle opening at about ½ th of the opening by oerating the spear valve by Hand wheel.
3. The head should be made constant by operating the delivery valve and the head should be maintained at constant value.
4. Observe the speed of the turbine using the tachometer.
5. Observe the readings of h_1 and h_2 corresponding the manometric fluid in the two limbs, which are connected to the venturimeter.
6. Adjust the load on the brake drum; note the speed of the turbine using tachometer and spring balance reading.
7. Repeat the experiment for different loadings

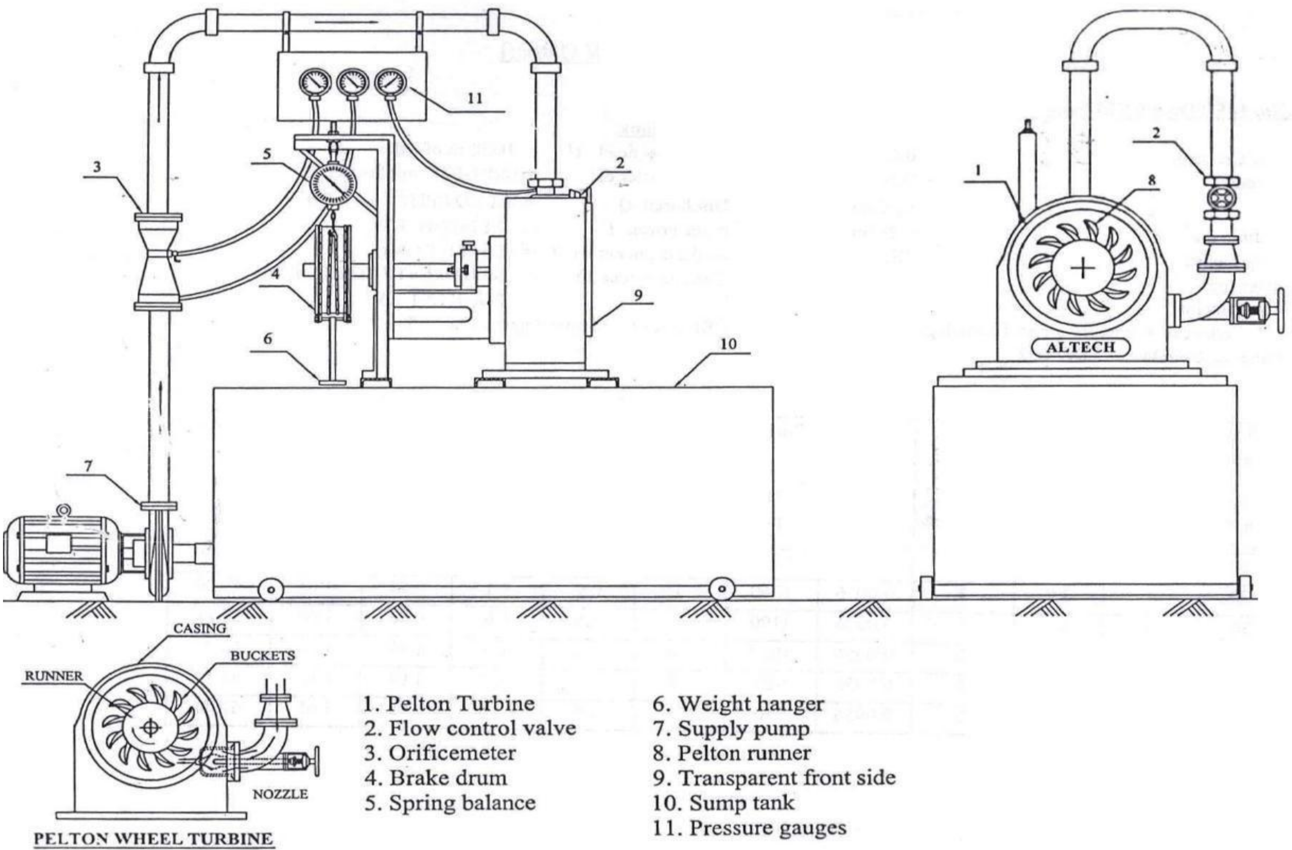
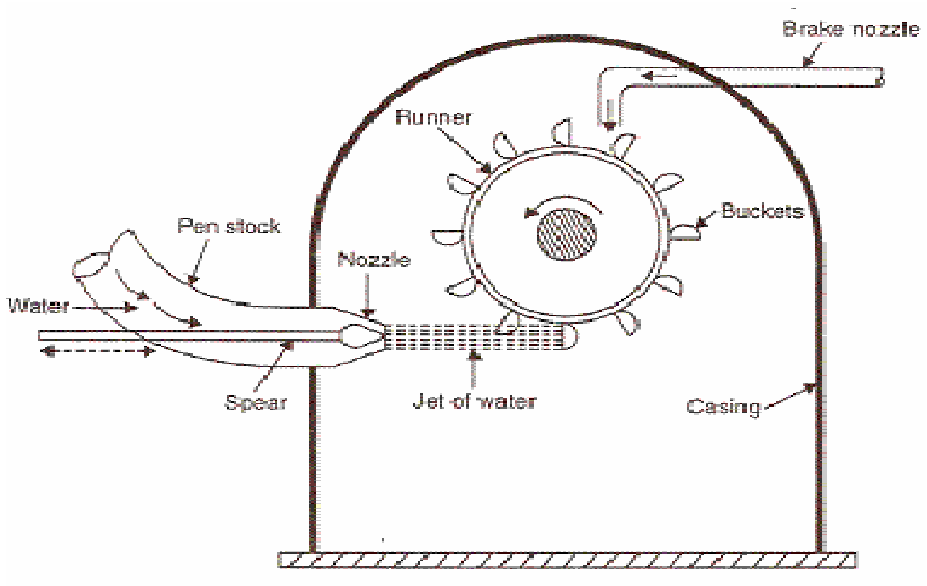


Fig: schematic representation of Pelton wheel



Observation & Calculation Tabular Column(Mechanical Loading):

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

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

OBSERVATIONS:

Venturimeter inlet Diameter, d1= 65 mm.

Venturimeter inlet area, a1 =____________.

Venturimeter throat diameter, d2= 39mm.

Venturimeter throat area, a2 =___________.

Speed (N) = ________ Rpm.

Diameter of brake drum, D = 300mm

CALCULATIONS:

Inlet Pressure, P = Kg/cm2

Vaccum gauge =mm of Hg

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

Where C_d -0.98

h- Manometric difference = $h_1 - h_2 \left[\frac{s1}{s2} - 1\right]$

Where s_1-specific gravity of mercury-13.6

s_2 - specific gravity of water-1

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

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

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

T = (T_1-T_2) ×g × radius of break drum N-m

T_1=load applied on Brake drum dynamometer(Kg).

T_2=load applied on Brake drum dynamometer(Kg).

Radius Of break drum = 0.15m.

N = speed of Brake drum Dynamometer (Rpm).

Efficiency of the turbine η_m%= P_o/P_i

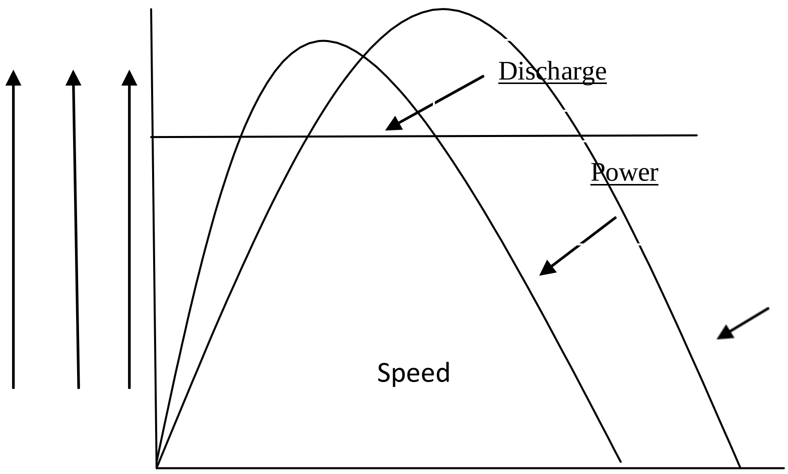
Electrical efficiency = η_e% = p_o / P_i

p_o= electrical output = V × I w.

GRAPHS:

1. Speed vs. efficiency
2. Discharge vs. power input
3. Input power vs. Speed
4. Output power vs speed
5. Head vs Speed

Model Graphs:



RESULT:

The Efficiency of Pelton wheel at constant load is ___________

The characteristics curves are drawn.

PRECAUTIONS:

1. Delivery valve should closed before start of the turbine valve.
2. Don"t apply Mechanical loading when Electrical loading is performed.
3. Note down the readings carefully.
4. Maintain the gate opening constantly throught the experiment for (constant head openings)

Viva questions:

1. Classify turbines.
2. Pelton wheel is which type of turbine.
3. What is input energy given to turbine? What are main components of Pelton turbine?
4. Draw velocity diagrams (at inlet and outlet) for Pelton blade
5. Why is Pelton turbine suitable for high heads?
6. What is the function of spear mechanism?
7. What is the normal range of specific speed of a Pelton turbine?
8. What are the characteristics of Pelton wheel? What are their uses?
9. After the nozzle water has atmospheric pressure through out, then why is a casing provided to the wheel?

EXPERIMENT-6

Performance Test on Reciprocating pump

AIM: To study the performance characteristics of reciprocating pump and to find slip.

APPARATUS : Reciprocating test Rig, Pressure gauges at the inlet and delivery pipes, Energy meter to measure the input electrical energy, stopwatch ,Tachometer.

THEORY: Reciprocating pumps are positive displacement pump as a definite volume of liquid is trapped in a chamber which is alternatively filled from the inlet and empited at a higher pressure through the discharge.

The fluid enters a pumping chamber through an inlet and is pushed out through outlet valve by the action of piston.

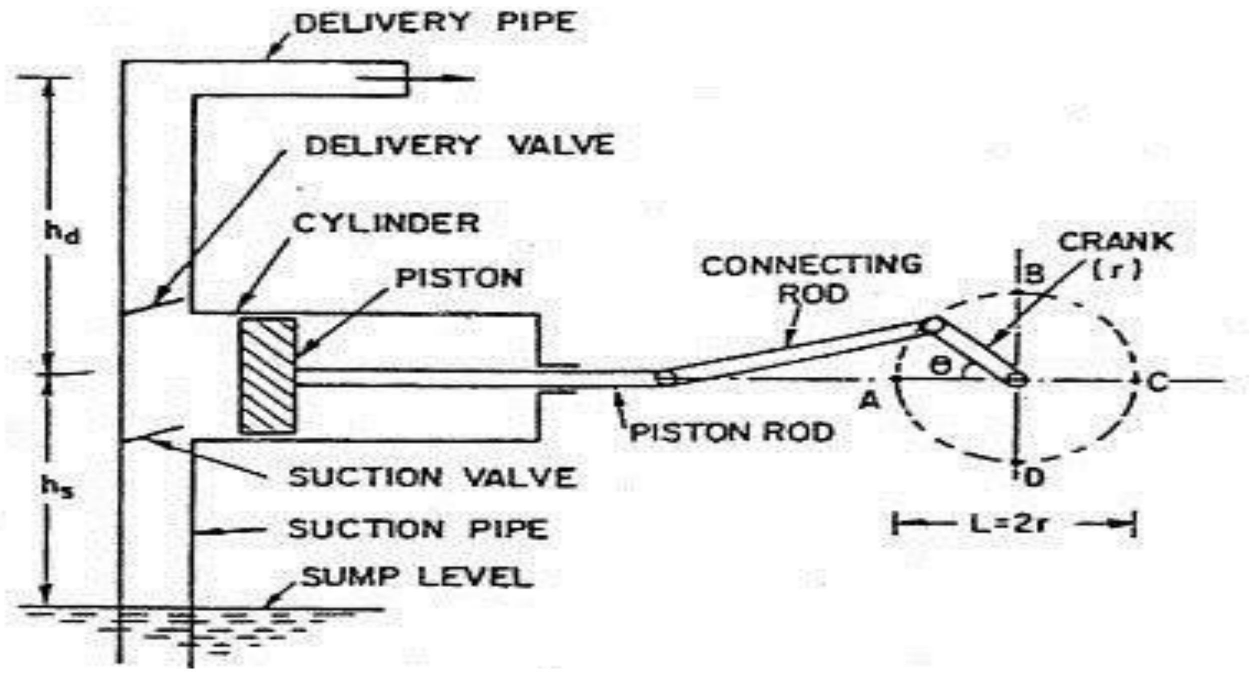
They are either single acting independent suction and delivery strokes or double acting suction and delivery both the directions.

Reciprocating pumps are self priming pumps and are suitable for very high head at low flows.They deliver reliable discharge flows and is often used for metering duties because of constancy of flow rate.

DESCRIPTION: It consist of a double action reciprocating pump of size 25x20mm with a air vessel coupled to 1HP, 1440Rpm, collecting tank with a piezometer.

PROCEDURE:

1. Keep the delivery valve open and switch on pump slowly close the delivery valve and maintain a constant head.
2. Note the delivery and suction pressure gauge reading.
3. Note the time for 10 revolutions of Energy meter.
4. Note the time for 10cm rise in water level in collecting tank.
5. Note the speed of the pump.
5. Repeat the test for 4 other different head.



Observation &Calculation Tabular Column:

S.NO	Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mm of Hg(P_s)	Time for 3 rev of Energy meter (t_e)sec	Time for 10 cm rise in collecting tank (t)sec	Speed N_P Rpm	Discharge (Q) m^3/sec	Input Power P_i KW	Output Power P_o KW	η %
1									
2									
3									
4									
5									

CALCULATIONS:

Stroke length of the pump (L) = 0.045m
Bore (d) = 0.04m
Piston area (a) = (π/4) × $(0.04)^2$
Area of the collecting tank (A) = 50 X 50 cm^2
N_P = speed of mortar in rpm

To find the percentage of slip = $\frac{Qt - Qa}{Qt}$ × 100 Q_t = theoretical discharge = $\frac{2\,L \times a \times Np}{60}$ m/sec Q_a = Actual discharge = Q= $\frac{A \times h}{t}$ m/sec

A = Area of the collecting tank
t = time for (h) rise in water level.

To find the overall efficiency of the pump = P_o/P_i Input power P_i = $\frac{3600 \times N}{E \times te}$ Kw
Where
N = Number of blinks of energy meter disc
E = Energy meter constant = 1600 (rev / Kw hr) T = time taken for „Nr" revolutions (seconds)

Output power P_o = $\frac{\rho \times g \times Q \times H}{1000}$ Kw
Where,
ρ = Density of water = 1000 (kg / m³)
g = Acceleration due to gravity = 9.81(m / s^2) H = Total head of water (m)
H = suction head (H_s) + delivery Head (H_d) + Datum Head
Where H_d = delivery head = $\frac{P_d \times 9.81 \times 10^4 \text{ m}}{\rho \times g}$
H_s = suction head m
Z= Friction loss = 2.2 m

GRAPHS:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

RESULT: The efficiency of the reciprocating pump is___________. To study and draw the characteristics curves.

EXPERIMENT-7

Performance Test on Centrifugal Pump

AIM To find the efficiency and draw the performance curves of centrifugal pump.

APPARATUS: Centrifugal pump test rig, energy meter to measure the input electrical energy, pressure gauges (Suction and delivery), stop watch.

THEORY:

The pump which raises water from lower level to higher level by the action centrifugal force is known as centrifugal pump. The pump lifts water because of atmospheric pressure acting on the surface of the water. A centrifugal pump is rotodynamic pump that uses a rotating impeller to increase the pressure of the fluid. It works by rotational kinetic energy, typically from an electric motor to an increase the static fluid pressure. They are commonly used to move liquid through a piping system.

Fluid enters axially through the middle portion of the pump call the eye, after which it encounters the rotating blades. It acquires tangential and radial velocity by the momentum transfer with impeller blades and acquires additional radial velocity by centrifugal force.

PROCEDURE

1. Prime the pump, close the delivery valve and switch on the unit.
2. Open the delivery valve and maintain the required delivery head. Note the reading.
3. Note the corresponding suction head pressure reading.
4. Measure the area of the collecting tank.
5. Close the drain the valve and note down the time taken for 10cm rise of the water level in the collecting tank.
6. For different delivery heads repeat the experiment.
7. For every set of reading note the time taken for 10 revolutions of Energy meter.

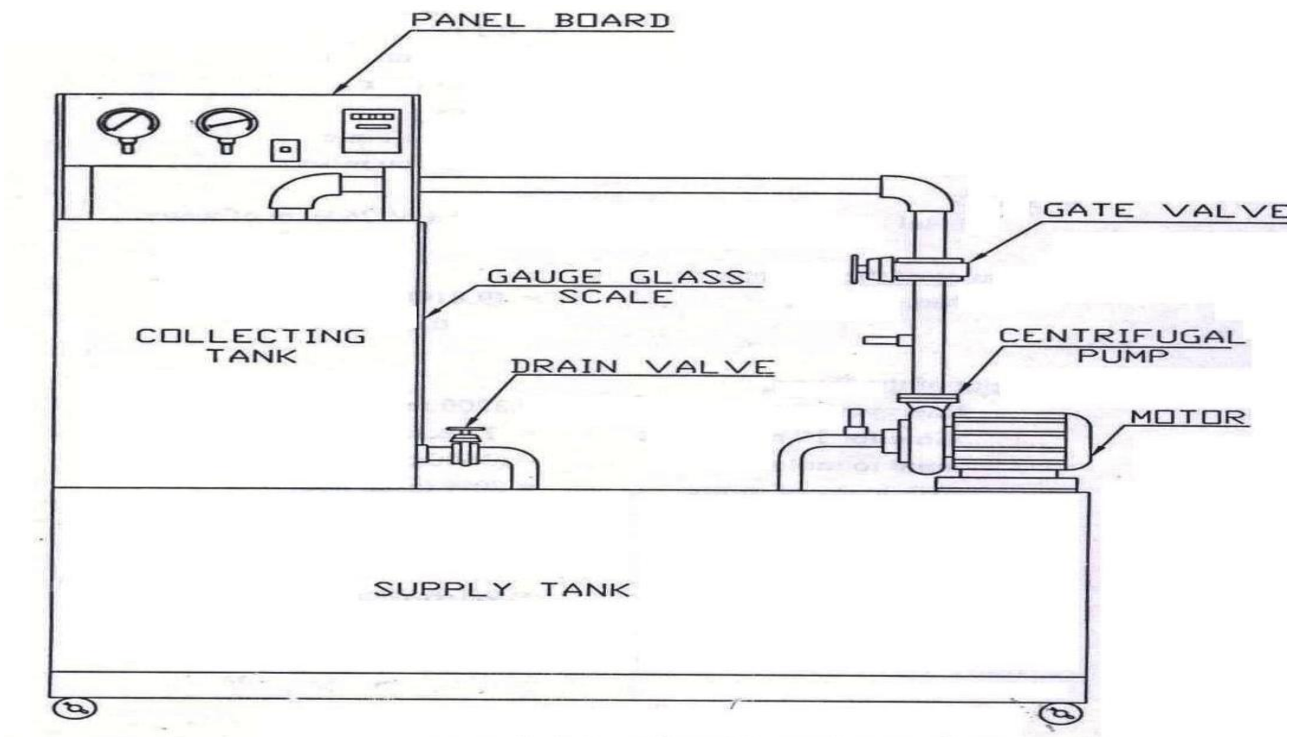


Fig: centrifugal pump

Observation & calculation Tabular column:

S.NO	Pressure gauge reading P_d (Kg/cm^2)	Vacuum gauge reading mm of Hg(P_s)	Time for 3 rev of Energy meter seconds (t_e)	Time for 10 cm rise in collecting tank (t) seconds	Discharge (Q) m^3/sec	Input Power P_i (KW)	Output Power P_o (KW)	Efficiency%
1								
2								
3								
4								

CALCULATIONS:

The total effective head H in meters of Working of centrifugal pump

$$\text{Total head } H=H_s+H_d+Z$$

Since the delivery pressure is in kg/cm2 and suction gauge pressure are in mm of Hg the total head developed by the pump to be converted in to meters of water column.

Where Hd=Delivery head

Hs =Suction head

Z= Friction loss

H_s= m

$$H_d=\frac{P_d \times 9.81 \times 10^2}{9.81 \times 1000} \text{ m}$$

Friction loss Z=2.2 m

Note: The velocity and the loss of head in the suction pipe are neglected

We know the discharge **Q=** $\frac{A \times h}{t}$ m^3/s

The work done by the pump is given by KW

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

Input power $P_i = \frac{3600 \times N}{E \times t_E}$ KW

E- Energy meter constant=150

t_E=time for 3 revolutions of Energy

meter. N-no of Revolutions.

The efficiency of the centrifugal pump=

η=Po/Pi x100%.

Graphs:

1) Plot Pi and Po versus Speed N

2) Head versus Speed N

3) Speed versus Efficiency.

4) Head vs Discharge

Results:

The performance characterstics of centrifugal pump are studied and the maximum efficiency was found to be__.

Precautions:

1.Close the delivery valve before starting the

pump. 2.Take readings correctly.

Viva Questions:

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

EXPERIMENT-8

VALVE TIMING DIAGRAM

AIM:

The experiment is conducted to

- Determine the actual valve timing for a 4-stroke diesel engine and hence draw the diagram.

DATA:*ENGINE- 4stroke, single cylinder, constant speed, and water cooled vertical diesel engine, 5BHP, and 1500rpm.*

THEORY:

In a four stroke engine opening and closing of valves and fuel injection do not take place exactly at the end of dead center positions. The valves open slightly earlier and close after that respective dead center position. The injection (ignition) also occurs prior to the full compression and the piston reaches the dead Centre position. All the valves operated at some degree on either side in terms of crank angles from dead center position.

INLET VALVE:

During the suction stroke the inlet valve must be open to admit charge into the cylinder, the inlet valve opens slightly before the piston starts downward on the suction stroke.

The reason that the inlet valve is open before the start of suction stroke is that the valve is necessary to permit this valve to be open and close slowly to provide quite operations under high speed condition.

INLET VALVE OPENS (IVO):

It is done at 10to 25^0in advance of TDC position.

INLET VALVE CLOSES (IVC):

It is done at 25 to 50^0after BDC position.

EXHAUST VALVE:

As the piston is forced out on the outstroke by the expanding gases, it has been found necessary to open the exhaust valve before the piston reaches the end of the stroke. By opening the exhaust valve before the piston reaches the end of its own power stroke, the gases have an outlet for expansion and begin to rush out of their own accord. This removes the greater part of the burnt gases reducing the amount of work to be done by the piston on its return stroke.

EXHAUST VALVE OPENS (EVO):

It is done at 30 to 50^0 in advance of BDC position.

EXHAUST VALVE CLOSES (EVC):

It is done at 10 to 15^0 after the TDC position.

PROCEDURE:

1. Keep the decompression lever in vertical position.
2. Bring the TDC mark to the pointer level closed.
3. Rotate the flywheel till the inlet valves moves down i.e., opened.
4. Draw a line on the flywheel in front of the pointer and take the reading.
5. Continue to rotate the flywheel till the inlet valve goes down and comes to horizontal position and take reading.
6. Continue to rotate the flywheel till the outlet valve opens, take the reading.
7. Continue to rotate the flywheel till the exhaust valve gets closed and take the reading.

2 Stroke Diesel Engine

OBSERVATIONS:

Sl. No.	Valve Position	Arc Length, S		Angle 'θ'indegrees
		cm	Mm	
1	TDC – Inlet Valve open			
2	BDC – Inlet Valve Close			
3	TDC – Exhaust Valve Open			
4	BDC – Exhaust Valve Close			

CALCULATIONS:

1. Diameter of the flywheel, D

$$D = \frac{\text{Circumference of the flywheel}}{\pi}$$

2. Angle 'θ' in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

, Where

S = Arc length, mm

RESULT:

Valve Timing diagram is drawn

PRE LAB QUESTIONS

1. Differentiate valve and port?
2. Define valve timing?.
3. Explain the importance of valve timing?
4. Define mechanism of valve operation?
5. Define the cam mechanism in IC engine?
6. Define crank mechanism?

POST LAB QUESTIONS

1. What is the position of inlet vale opening and closing?
2. What are the exhaust valve opening and closing positions?
3. Indicate the ignition period in the diagram?

PORT TIMING DIAGRAM

AIM:

The experiment is conducted to

- Determine the actual PORT timing for a 2-stroke Petrol engine and hence draw the diagram.

DATA: Engine: 2stroke single cylinder, constant speed, water cooled, vertical diesel engine, 5 BHP, 1500rpm.

THEORY: Here in this type of engine ports which take charges and remove exhaust are in the cylinder itself. By virtue of piston when the piston moves inside the cylinder it closes and opens ports. Here in this type of engine (two strokes) one revolution of crank shaft complete one cycle.

INLET PORT:

1. It is uncovered 45 to 50^0in advance of TDC.
2. It is covered 40 to 45^0after BDC.

EXHAUST PORT:

1. It is uncovered 40 to 45^0in advance of BDC.
2. It is covered 40 to 55^0after the TDC

TRANSFER PORT:

1. It is uncovered 35 to 45^0 in advance of BDC.
2. It is covered 35 to 45^0after the BDC.

PROCEDURE:

1. Identify the ports.
2. Find out the direction of rotation of the crank shaft.
3. Mark the TDC and BDC positions on the flywheel.
4. Mark the openings and closings of the inlet exhaust and transverse ports.
5. Using a rope or thread and scale, find out the circumference of the flywheel.
6. Find out the arc lengths of the events IPO, IPC, EPO, EPC, TPO and TPC.
7. Let the arc length be Xcm.
   Then angle q= $360 \times X/2\pi R$ Where R is the radius of the flywheel.
8. Draw the flywheel diagram with the help of four angles calculated from lengths.

Port Timing Diagram

OBSERVATIONS:

Sl. No	Event	Position of the crank	Arc distance from nearest dead center(cm)	Angle degree
1	IPO	BTDC		
2	IPC	ATDC		
3	TPO	BBDC		
4	TPC	ABDC		
5	EPO	BBDC		
6	EPC	ABDC		

Circumference of the fly wheel= 53cm

RESULT:

Sl.no	Event	Position of the crank	Arc distance from nearest dead center (cm)	Angle degree
1	IPO	BTDC		
2	IPC	ATDC		
3	TPO	BBDC		
4	TPC	ABDC		
5	EPO	BBDC		
6	EPC	ABDC		

PRE LAB QUESTIONS

1. Differentiate valve and port?
2. Define port timing?.
3. Explain the importance of port timing?
4. Define mechanism of port operation?
5. Define the air fuel mixing process in IC engine?
6. Define crank mechanism?

POST LAB QUESTIONS

1 .What are the position of inlet port opening and closing?
2. What are the transfer port opening and closing positions?
3. Indicate the exhaust port opening and closing position?

TABULAR COLUMN:

Sl. No.	Speed, rpm	Spring balance Wkg	Manometer Reading			Time for 10 cc of fuel collected, t sec
			$h_1$cm	h_2 cm	H_w=(h1~h2)	

CALCULATIONS:

1. Area of Orifice A_0 =(π/4) d_0^2 sq.cm (d_0 is orifice diameter = 25mm=0.025m)
2. Head of Air $H_a = \frac{(h1-h2)x\rho w}{\rho a}$ in mts; ρ_w=1000kg/cm^3

   ρ_a=1.2kg/ cm^3,h_1 and h_2 in mts
3. Mass flow rate of Air Ma in kg/hr

   $Ma= A_0 \text{ x } C_d \text{ x}3600 \text{ x } \rho_a \text{ x}\sqrt{2 \text{ x } g \text{ x } Ha}$ kg/hr
4. Total fuel consumption TFC : in kg/hr

   $TFC = \frac{10 \text{ x } 3600 \text{ x } \rho f}{t1 \text{ x } 1000}$

5. Brake Power BP in Kw
   a. With hydraulic brake dynamometer (reaction type)
   b. BP= [2 x π x 9.81 x N x W x R]/60,000 kW
      i. Where R= Load arm length = 0.3mts
      ii. W= load shown on spring balance,kg
      iii. N= speed in rpm

6. Specific fuel consumption: SFC in Kg/Kw-hr

   1. SFC = TFC/BP
7. Air Fuel ratio :A/F

   A/F = M_a/TFC
8. Brake Thermal efficiency
9. η_{bth} = [BP/TFC x CV]x 100%,
10. Indicated Thermal efficiency
11. η_{ith} = [IP/TFC x CV]x 100%,

GRAPHS:

Plot curves of BP vs. TFC, SFC, and A/F.

PRE LAB QUESTIONS:

1. What are the 4strokes of SI engines?
2. What is the working cycle of SI Engine?
3. List out the performance parameters?
4. Indicate the different types of loads?
5. Differentiate SFC and TFC?
6. Concept of mass flow rate of air?

EXPERIMENT-8

PERFORMANCE TEST FOR 4 STROKE S I ENGINE

INTRODUCTION:

The Test Rig is multi cylinder petrol engine coupled to a hydraulic brake and complete with all measurement systems, auto electrical panel , self-starter assembly, Morse test setup, battery etc., Engine is with 4 cylinder water cooled radiator is provided. Engine cooling is done by through continuous flowing water.

SPECIFICATIONS:

1 Engine coupled to hydraulic brake
2. Clutch arrangement
3. Morse test setup
4. Stand,Panel with all measurements
5. Air tank, fuel tank
6. Auto electrical with battery

DESCRIPTION OF THE APPARATUS:

Engine: Either PREMIERE / AMBASSODAR four cylinder four stroke water cooled automotive (reclaim) spark ignited with all accessories.

Make: PREMIERE

Speed: max 5000rpm

Power: 23 HP at max speed

No of cylinders: FOUR

Firing order: 1-3-4-2

Cylinder bore: 73mm

Stroke length: 70mm

Spark plug gap: 0.64mm

Other components include battery, starter motor, alternator/DC dynamo, ignition switch, solenoid, cables, accelerator assembly, radiator, valves etc.

HYDRAULIC BRAKE:

It is a reaction type hydraulic dynamometer; a stator body can swing in its axis, depending upon the torque on the shaft. The shaft is extended at both ends and supported between two bearings. Rotor is coupled at one end to the engine shaft. Water is allowed inside through stator and flows inside pockets of rotor and comes out of rotor. Any closure of valve or any restriction of flowing water, created breaking effect on the shaft, and which is reflected in opposition force of stator. Stator while reacting to proportional force pulls a spring balance, which is calibrated in kgs. Controlling all three valves enables to increase or decrease the load on the engine.

CLUTCH ARRANGEMENT:

A long lever with locking facility is provided. It helps to either couple engine to hydraulic brake or decouple both. Initially for no load do not couple these two and after increasing engine speed slowly engage same. Do not allow any water to dynamometer when engine is started. This is no load reading.

OBSERVATIONS:

1. Orifice diameter d_0 =25mm
2. Density of water ρ_w =1000kg/m^3
3. Density of air ρ_a =1.2kg/m^3
4. Density of Petrol ρ_f =0.7kg/lit
5. Acceleration due to gravity g =9.81m/sec^2
6. Torque on length R =0.3mt
7. Calorific value of Petrol C_v =43,210kJ/kg
8. Cd of orifice = 0.62
9. Cylinder bore D =73mm
10. Stroke length L =70mm

AIM:

The experiment is conducted to

a. To study and understand the performance characteristics of the engine.

b. To draw Performance curves and compare with standards.

PROCEDURE:

1. Check the lubricating oil level.
2. Check the fuel level.
3. Check and Release the load on the dynamometer if loaded.
4. Check the necessary electrical connections and switch on thePanel.
5. Provide the Battery Connections.
6. Open water valve for engine cooling and adjust flow rate , say 4to 6 LPM

CONSTANT SPEED TEST:

1. After engine picks up speed slowly, engage clutch, now engine is coupled with hydraulic dynamometer.
2. With the help of accelerator, increase engine to say 1500rpm.
3. Note down the time required for 10litres of water flow, time required for 10cc of fuel, manometer reading, spring balance reading, all temperatures.
4. For next load allow more water into dynamometer and also adjust throttle valve such that engine is loaded but with same RPM, 1500rpm.
5. Note down all readings.
6. Repeat experiment for next higher load, max 8kw.

OPERATING DYNAMOMETER:

2. Inlet water Valveno1 (V1)-If knob is rotated clockwise LOAD is reduced, that means water entry is reduced.
3. If this V1 if rotated anticlock wise LOAD increased, here water is allowed into dynamometer-MORE the water into dynamometer MORE is LOAD.
4. Drain V2 if opened completely then load is reduced, if closed by rotating clockwise then LOAD is increased.
5. Overflow valve No.3(V3)-if closed then Load is increased, If opened then LOAD is reduced.
6. In this manner load has to be increased or decreased.

I C Engines Performance Test For 4 Stroke S I

Engine TABULAR COLUMN:

Sl. No.	Speed, rpm	Spring balance Wkg	Manometer Reading			Time for 10 cc of fuel collected,t sec
			$h_1$cm	h_2 cm	H_w=(h1~h2)	

CALCULATIONS:

1. Area of Orifice $A_0 = (\pi/4)\, d_0^2$ sq.cm (d_0 is orifice diameter = 25mm=0.025m)
2. Head of Air $H_a = \frac{(h1-h2)x\rho w}{\rho a}$ in mts; ρ_w=1000kg/cm^3

   ρ_a=1.2kg/ cm^3, h_1 and h_2 in mts
3. Mass flow rate of Air Ma in kg/hr

   $$Ma = A_0 \times C_d \times 3600 \times \rho_a \times \sqrt{2 \times g \times Ha} \text{ kg/hr}$$
4. Total fuel consumption TFC : in kg/hr

   $$TFC = \frac{10 \times 3600 \times \rho f}{t1 \times 1000}$$
5. Brake Power BP in Kw
   a. With hydraulic brake dynamometer (reaction type)
   b. BP= [2 x π x 9.81 x N x W x R]/60,000 kW
      i. Where R= Load arm length = 0.3mts
      ii. W= load shown on spring balance,kg
      iii. N= speed in rpm
6. Specific fuel consumption: SFC in Kg/Kw-hr

   1. SFC = TFC/BP
7. Air Fuel ratio :A/F

   A/F = M_a/TFC
8. Brake Thermal efficiency
9. η_{bth} = [BP/TFC x CV]x 100%,
10. Indicated Thermal efficiency
11. η_{ith} = [IP/TFC x CV]x 100%,

GRAPHS:

Plot curves of BP vs. TFC, SFC, and A/F.

PRE LAB QUESTIONS:

7. What are the 4strokes of SI engines?

8. What is the working cycle of SI Engine?

9. List out the performance parameters?

10. Indicate the different types of loads?

11. Differentiate SFC and TFC?

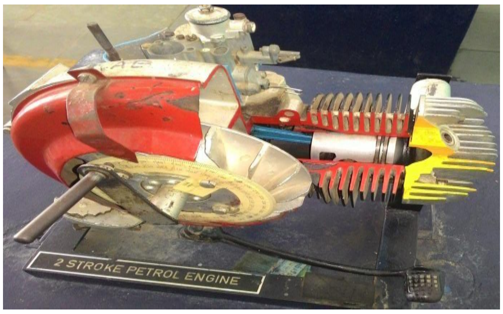
12. Concept of mass flow rate of air?

POST LAB QUESTIONS:

1. Dfifferentiate brake power and indicated power?

2. Define brake thermal efficiency?

9. Mark the openings and closings of the inlet exhaust and transverse ports.
10. Using a rope or thread and scale, find out the circumference of the flywheel.
11. Find out the arc lengths of the events IPO, IPC, EPO, EPC, TPO and TPC.
12. Let the arc length be Xcm.
    Then angle q= $360 \times X/2\pi R$ Where R is the radius of the flywheel.
13. Draw the flywheel diagram with the help of four angles calculated from lengths.



Port Timing Diagram

OBSERVATIONS:

Sl. No	Event	Position of the crank	Arc distance from nearest dead center(cm)	Angle degree
1	IPO	BTDC		
2	IPC	ATDC		
3	TPO	BBDC		
4	TPC	ABDC		
5	EPO	BBDC		
6	EPC	ABDC		

Circumference of the fly wheel= 53cm

RESULT:

Sl.no	Event	Position of the crank	Arc distance from nearest dead center (cm)	Angle degree
1	IPO	BTDC		
2	IPC	ATDC		
3	TPO	BBDC		
4	TPC	ABDC		
5	EPO	BBDC		
6	EPC	ABDC		

PRE LAB QUESTIONS

7. Differentiate valve and port?
8. Define port timing?.
9. Explain the importance of port timing?
10. Define mechanism of port operation?
11. Define the air fuel mixing process in IC engine?
12. Define crank mechanism?

POST LAB QUESTIONS

1 .What are the position of inlet port opening and closing?
4. What are the transfer port opening and closing positions?
5. Indicate the exhaust port opening and closing position?

EXPERIMENT 10

PERFORMANCE TEST ON 4-STROKE CI ENGINE

AIM: The experiment is conducted to

a) To study and understand the performance characteristics of the engine.

b) To draw Performance curves and compare with standards.

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

Electrical Loading (Water cooled)

1. The equipment consists of **KIRLOSKAR** Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled.
2. The Engine is coupled to a same capacity DC alternator with resistance heaters to dissipate the energy.
3. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
4. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
5. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
6. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of Manometer.
7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for_____cc of diesel consumption
    c. Rota meter reading.
    d. Manometer readings, in cm of water &
    e. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load and then switch of the engine.
13. Allow the water to flow for few minutes and then turn it off.

Diesel Engine

TABULAR COLUMN:

Sl. No.	Speed, rpm	Spring balance W kg	Manometer Reading			Time for 10 cc of fuel collected, t sec	Voltmeter reading	Ammeter reading
			h_1 cm	h_2 cm	h_w = (h1~h2)			

CALCULATIONS:

1. Mass of fuel consumed, mf

$M_{f=}$ (X_{cc} x Specific gravity of the fuel) 1000 x t kg/sec
Where,
S_g of Diesel is = 0.827
Xcc is the volume of fuel consumed = 10ml
t is time taken in seconds

2. Heat Input, H_I

$H_I = m_f$ x Calorific Value of Fuel kW

Where, Calorific value of diesel =44631.96 kj/kg

3. Output Or Brake Power, Bp

BP=(Vx I)/1000KW
Where,
V= Voltmeter reading in volts
I= Ammeter reading in Amps

Tabular column for temperatures

SNO	T1	T2	T3	T4	T5	T6

Heat Balance Sheet Calculations:

A. Credit side:

Heat Input: H_i

$H_i = \frac{TFC \times CV}{60}$ kJ/min

B. Debit Side:

e. Heat converted into useful work Hb

H_b = BP x 60 kJ/min

f. Heat carried away by engine cooling water Hw

$H_w = \frac{1 x Cpw \times (T3 - T2)}{t2}$ x60kJ/min

g. Heat carried away by exhaust gases

$H_e = [M_e \times C_{pg} \times (T4\text{-}T1)]$ kJ/min

M_e= mass flow rate of exhaust gas in Kg/min

C_{pg}= specific heat of exhaust gas 1.005kJ/KgK

M_e= Ma+ TFC in Kg/hr.

h. Un accountable losses:

Hu= $[H_i]-\{H_b+H_w+H_e\}$ kJ/min

HEAT BALANCE SHEET:

Credit Side (Input)				**Debit Side(Out Put)**			
Sl. No.	Particulars	Heat, Kj/Min	%	Sl. No.	Particulars	Heat, Kj/Min	%
	Hi				Hb		
					Hw		
					He		
					Hu		
Total:			100				100

PRE LAB QUESTIONS:

1. What are the 4strokes of CI engines?
2. What is the working cycle of CI Engine?
3. List out the performance parameters?
4. Indicate the different types of loads?
5. Differentiate SFC and TFC?
6. Describe different heat losses in CI engines?

POST LAB QUESTIONS:

1. Dfifferentiate brake power and indicated power?
2. Define brake thermal efficiency?
3. Explain the heat balancing of Diesel engine?

EXPERIMENT NO: 11
PERFORMANCE TEST ON AIR COMPRESSOR UNIT

AIM: The experiment is conducted at various pressures to

a. Determine the Volumetric efficiency.
b. Determine the Isothermal efficiency.

INTRODUCTION:

A COMPRESSOR is a device, which sucks in air at atmospheric pressure & increases its pressure by compressing it. If the air is compressed in a single cylinder it is called as a Single Stage Compressor. If the air is compressed in two or more cylinders it is called as a Multi Stage Compressor.

In a Two Stage Compressor the air is sucked from atmosphere & compressed in the first cylinder called the low-pressure cylinder. The compressed air then passes through an inter cooler where its temperature is reduced. The air is then passed into the second cylinder where it is further compressed. The air further goes to the air reservoir where it is stored.

DESCRIPTION OF THE APPARATUS:

1. Consists of Two Stage Reciprocating air compressor of 3hp capacity. The compressor is fitted with similar capacity Motor as a driver and 160lt capacity reservoir tank.
2. Air tank with orifice plate assembly is provided to measure the volume of air taken and is done using the Manometer provided.
3. Compressed air is stored in an air reservoir, which is provided with a pressure gauge and automatic cut-off.
4. Necessary Pressure and Temperature tapings are made on the compressor for making different measurements
5. Temperature is read using the Digital temperature indicator and speed by Digital RPM indicator.

PROCEDURE:

1. Check the necessary electrical connections and also for the direction of the motor.
2. Check the lubricating oil level in the compressor.
3. Start the compressor by switching on the motor.
4. The slow increase of the pressure inside the air reservoir in observed.
5. Maintain the required pressure by slowly operating the discharge valve (open/close). (Note there may be slight variations in the pressure readings since it is a dynamic process and the reservoir will be filled continuously till the cut-off.)
6. Now note down the following readings in the respective units,
   Speed of the compressor. Manometer readings.
   Delivery pressure. Temperatures.
   Energy meter reading.
7. Repeat the experiment for different delivery pressures.

8. Once the set of readings are taken switch of the compressor.
9. The air stored in the tank is discharged. Be careful while doing so, because the compressed air passing through the small area also acts as a air jet which may damage you or your surroundings.
10. Repeat the above two steps after every experiment.

Volumetric Efficiency of a Reciprocating Air Compressor OBSERVATIONS:

Sl. No.	Compressor Speed, rpm	Delivery Pressure, 'P' kg/cm^2	Manometer Reading			Time for 'n' revolutions of energy meter, 'T' sec
			h_1 cm	h_2 cm	$h_w = (h1 \sim h2)$	

CALCULATIONS:

1. Air head causing flow,ha

Manometer Head Ha =(h_1-h_2) x $\frac{\rho w}{\rho a}$ m

ρ_w=1000kg/m^3

ρ_a=1.293 kg/m^3, h_1 and h_2 in m

2. Actual vol. of air compressed at RTP,

Where,

$h_a$is air head causing the flow in **m** of air.

C_d = coefficient of discharge of orifice = 0.62

a = Area of orifice = $\frac{\pi}{4}$ d ^{2}

Where,

d = diameter of orifice = 0.02m

3. Theoretical volume of air compressed Q_{th},

Where,

D is the diameter of the LP cylinder = 0.07m.

L is Stroke Length = 0.085m

Is speed of the compressor in rpm

4. Input Power, **IP**

3600*n*η_m /(KxT)… ...kW

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant revs/kW-hr

T = time for 5 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 75%

5. Isothermal Work done,**WD**

WD = ρa x QalnrkW

Where,

ρ_a= is the density of the air = 1.293 kg/m^3 Q_a

= Actual volume of air compressed.

r = Compression ratio

r = Delivery gauge pressure + Atmospheric pressure

Atmospheric pressure

Where Atmospheric pressure = 101.325 kPa

NOTE: To convert delivery pressure fromkg/cm[to kPa multiply by 98.1

6. Volumetric efficiency, ηvol

η_{vol} = Qa/Qth x 100

7. Isothermal efficiency, ηiso

$$\eta_{iso} = \frac{\text{Isothermal work done}}{\text{IP}} \times 100$$

TABULATIONS:

S. No	Head of Air h_a, m	Actual volume of air compressed Q_a, m^3/s	Theoretical vol of air compressed Q_{th}, m^3/s	Isothermal work done Kw	Iso thermal efficiency η_{iso}, %	Volumetric Efficiency η_{vol},%

GRAPHS TO BE PLOTTED:

1. Delivery Pressure vs. ηvol
2. Delivery Pressure vs. ηiso

PRECAUTIONS:

1. Do not run the blower if supply voltage is less than 380V
2. Check the direction of the motor, if the motor runs in opposite direction change the phase line of the motor to run in appropriate direction.
3. Do not forget to give electrical earth and neutral connections correctly.

RESULT:

PRE LAB QUESTIONS:

1. What is the principle of compressor?
2. Differentiate various types of compressors?
3. Explain concept of multi staging?

POST LAB QUESTIONS?

1. Differentiate single stage and multistage compressor?
2. Define isothermal work done?
3. What is isothermal efficiency?

EXPERIMENT NO: 12

PERFORMANCE TEST ON VARIABLE COMPRESSION RATIO (VCR) ENGINE

AIM: The experiment is conducted to

a) To study and understand the performance characteristics of the engine.
b) To draw Performance curves and compare with standards.

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

Electrical Loading (Water cooled)

1. The equipment consists of **KIRLOSKAR** Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled.
2. The Engine is coupled to a same capacity DC alternator with resistance heaters to dissipate the energy.
3. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
4. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
5. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
6. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of Manometer.
7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for_____cc of diesel consumption
    c. Rota meter reading.
    d. Manometer readings, in cm of water &
    e. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load and then switch of the engine.
13. Allow the water to flow for few minutes and then turn it off.

Fig: Variable Compression Ratio Engine

TABULAR COLUMN:

Sl. No.	Speed, rpm	Spring balance W kg	Manometer Reading			Time for 10 cc of fuel collected, t sec	Voltmeter reading	Ammeter reading
			h_1 cm	h_2 cm	h_w = (h1~h2)			

CALCULATIONS:

1. Mass of fuel consumed, mf

   $M_{f=}$ (X_{cc} x Specific gravity of the fuel) 1000 x t kg/sec

   Where,
   S_g of Diesel is = 0.827
   Xcc is the volume of fuel consumed = 10ml
   t is time taken in seconds
2. Heat Input, H_I
   $H_I = m_f$ x Calorific Value of Fuel kW

   Where, Calorific value of diesel =44631.96 kj/kg

3. Output Or Brake Power, Bp
   BP=(Vx I)/1000KW
   Where,
   V= Voltmeter reading in volts
   I= Ammeter reading in Amps
4. Specific Fuel Consumption,Sfc
   SFC= m_fx 3600/BP kg/KW-hr

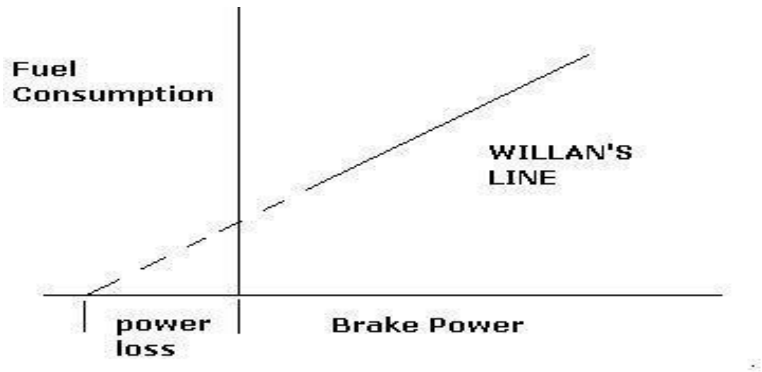
5. Brake Thermal Efficiencyη_{bth}%
   η_{bth}% = (3600x 100)/ (SFCx CV)

6. Mechanical Efficiencyη_{mech}%
   η_{mech}% = (BP/IP)x 100

Determine the IP = Indicated power, using WILLAN'S LINE method and yhe procedure is as below:

- Draw the graph of Fuel consumption Vs. Brake power.
- Extend the line obtained tillit cuts the brake power axis.
- The point where it cuts the brake power axis till the zero point will give the power losses(Friction Power loss)
- With this IP can be found using the relation:

IP = BP+ FP



7. Calculation Of Head Of Air, Ha

   Ha= h_w x(ρ_w/ρ_a)

   Where;

   ρ_w =1000 kg/m³

   ρ_a= 1.2 kg/m³

   h_w is the head in water column in 'm' of water

8. Volumetric Efficiency , η_{vol}%

$$\eta_{vol}\% = (Q_a/Q_{th})x100$$

where,

Qa = actual volume of air taken = $C_d x a x \sqrt{2gHa}$

Where C_d= Coefficient of discharge of orifice=0.62

a=area of the orifice= [(π(0.02)²)/4]

H_a =head in air column, m of air.

Q_{th}= theoretical volume of air taken

$Q_{th} = \frac{L\ xAxN}{60x2}$ [A= $(\pi\ xD^2)/4$

Where D= Bore diameter of the engine = 0.08m

L= Length of the stroke =0.110m

N is speed of the engine in rpm

TABULATIONS:

Sl. No	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency

CALCULATIONS:

2. FRICTION POWER, FP

$$FP = (V*I) / 1000 \text{ KW}$$

Where,

V= voltmeter reading on motoring side

I = ammeter reading on motoring side

Graphs to be plotted: 1) SFC v/s BP 2) ηbth v/s BP 3)η_{mech} v/s BP 4) η_{vol} v/s BP

RESULT:

PRE LAB QUESTIONS:

1. What are the 4strokes of CI engines?
2. What is the working cycle of CI Engine?
3. List out the performance parameters?
4. Indicate the different types of loads?
5. Differentiate SFC and TFC?
6. Concept of mass flow rate of air?

POST LAB QUESTIONS:

2. Differentiate brake power and indicated power?
3. Define brake thermal efficiency?
4. Indicate mechanical efficiency in terms of BP and IP?
5. Determine frictional power by using Wilson's line?