ME 422 Machinery Sessional

Level - 4 Term - 1

Department of Mechanical Engineering

Bangladesh University of Engineering and Technology (BUET)
Dhaka-1000, Bangladesh

Credit Hour: 0.75 Cr. Hr.

Contact Hour: 1.5 Hrs.

ME 422 Fluid Machinery Sessional

Name of the Experiments

Exp. 1 (a) Study and performance test of a Pelton wheel.

(b) Identification of various parts of a hermetically sealed compressor.

Exp. 2 (a) Performance test of a centrifugal pump.

(b) Study of centrifugal pumps in series and parallel connections.

Exp. 3 (a) Study and performance test of a submersible pump.

(b) Dismantling and assembling of a centrifugal pump.

Exp. 4 Study and performance test of a positive displacement pump.

Experiment no. 1(a)

Name of the experiment: Study and performance test of a Pelton wheel

Experiment no. 1(a)

Name of the experiment: Study and performance test of a Pelton wheel

Objectives

- To study the working principle of a Pelton Wheel.
- To determine the performance parameters of the Pelton Wheel.
- To plot efficiency vs speed, discharge vs speed, P_{out} vs speed, efficiency vs P_{out} curve of a Pelton Wheel.
- To calculate the specific speed of a Pelton Wheel.

Apparatus:

Schematic diagram:

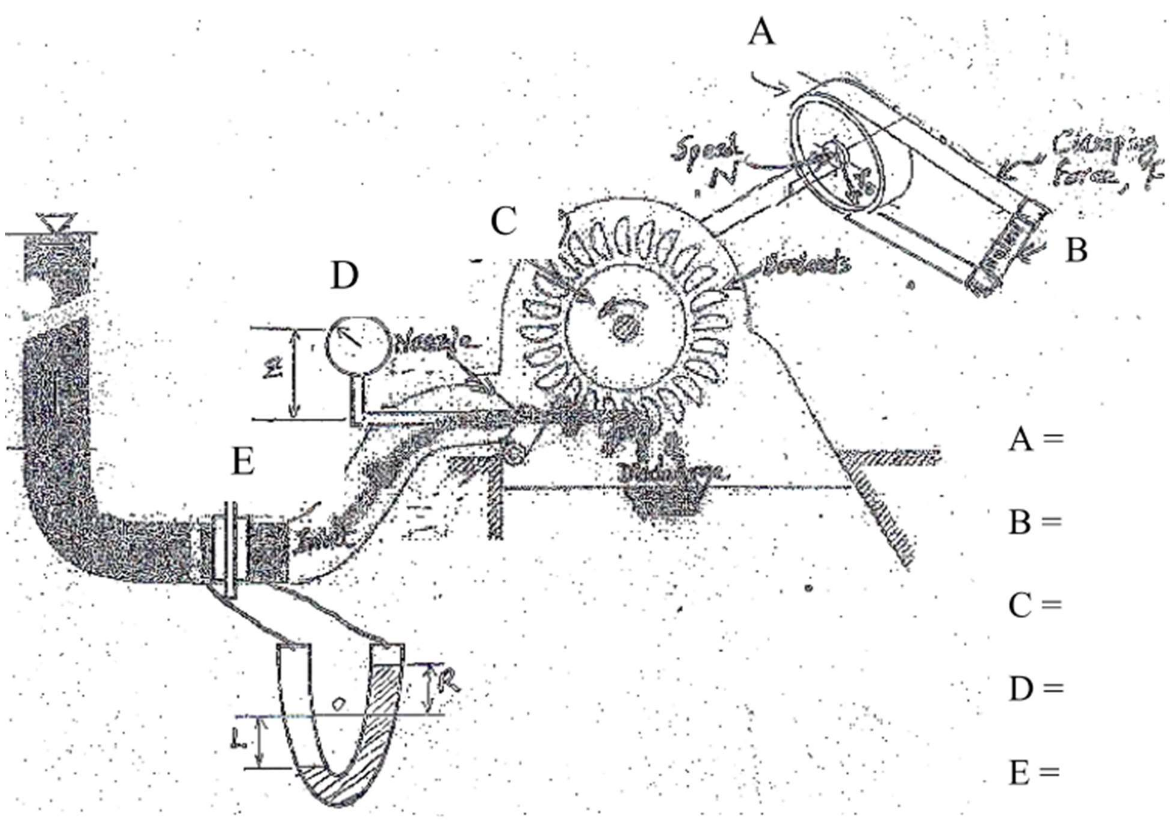

Figure 1(a): Experimental Setup of performance test of a Pelton wheel

Data from the experiment:

No. of Obs.	Manometer Reading			Spring Scale Reading (Kg)	Force, *F* (N)	Speed of the Pelton wheel (N)	
	Left (*L*) (inch)	Right (*R*) (inch)	Net Deflection (inch)			rpm	rad/s

Data obtained from calculation:

No. of Obs.	Torque (T) Nm	Power Output (P_o) Watt	Pressure Head (h) m	Discharge (Q) (Cusec × 102) m^3/hr	Efficiency (η) %

Sample Calculations:

Dynamometer wheel radius, r = 4 inch = m

Pressure head correction, z = 1.1 m

Pelton wheel rotor radius, R =

Pelton wheel speed, N = rpm

$$\omega = \frac{2\pi N}{60} \text{ rad/s}$$

Torque, $T = F \times r$ Nm

Output Power, $P_o = T\omega$

Pressure head, $h = P/\gamma + z$ (m)

$= (P\times144/62.4)/3.28 + z$ (m)

Discharge, $Q = 0.024\sqrt{(L+R)}$ cusec

=

= m^3/hr

Input Hydraulic Power, $P_i = \gamma Qh$

=

Efficiency, $\eta = \dfrac{P_o}{\gamma Qh} \times 100\%$

Speed ratio, $\Phi = \dfrac{\omega R \text{ (peripheral velocity of rotor)}}{C_v\sqrt{2gh} \text{ (fluid velocity at nozzle tip)}}$

Specific speed, $N_s = \dfrac{N\sqrt{P_{out}}}{H^{\frac{5}{4}}}$; where N (rpm), P_{out} (kW), H (m)

- **Plot the characteristic curve of the Pelton Wheel.**

Discussion:

Experiment No. 1(b)

Name of the experiment: Identification of various components of a hermetically sealed compressor

Experiment No. 1(b)

Name of the experiment: Identification of various components of a hermetically sealed compressor

Introduction

A compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Compressors are similar to pumps in the aspect that both increase the pressure on a fluid, and both can transport the fluid through pipe. Compressors can be of positive displacement or rotodynamic type.

The compressor in this experiment is a positive displacement type reciprocating compressor. This type of compressor is typically used in household refrigerators. The intake gas enters the suction manifold, then flows into the compression cylinder where it gets compressed by a piston driven in a reciprocating motion via a crankshaft and is then discharged. The compressor is generally driven by an electric motor. In a Hermetically Sealed Compressor, the motor compressor assembly is packed in an air-tight compartment.

Figure 1(b): Various components of a Hermetically Sealed Compressor

1. Housing with connectors and baseplates.	2. Top cover	3. Blocks with a stator bracket	4. Stators (with screws)
5. Rotors	6. Valve units (screws, cylinder cover, gaskets, valve plate)	7. Crankshafts with grommet	8. Connecting rods with a piston
9. Oil pickup tubes	10. Springs with suspensions	11. Internal discharge tubes (screw, washer, gasket)	12. Start equipment (PTC device, cover, cord relief)

Objectives

1. To observe different components of a hermetically sealed compressor.
2. To understand the working principle of these parts and identify them.

Report Writing:

1. Identify and write down the functions of the various components of the Hermetically Sealed Compressor shown in the lab.
2. Differentiate between components of Figure 1(b) and the Hermetically Sealed Compressor shown in the lab.
3. Find out any missing components of Hermetically Sealed Compressor that you think should be there in lab.

Experiment no. 2(a)

Name of the experiment: Performance test of a centrifugal pump

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Name of the experiment: Performance test of a centrifugal pump

Objectives:

To study the performance characteristics of the pump at constant speed when varying the flowrate.

Apparatus:

Schematic diagram:

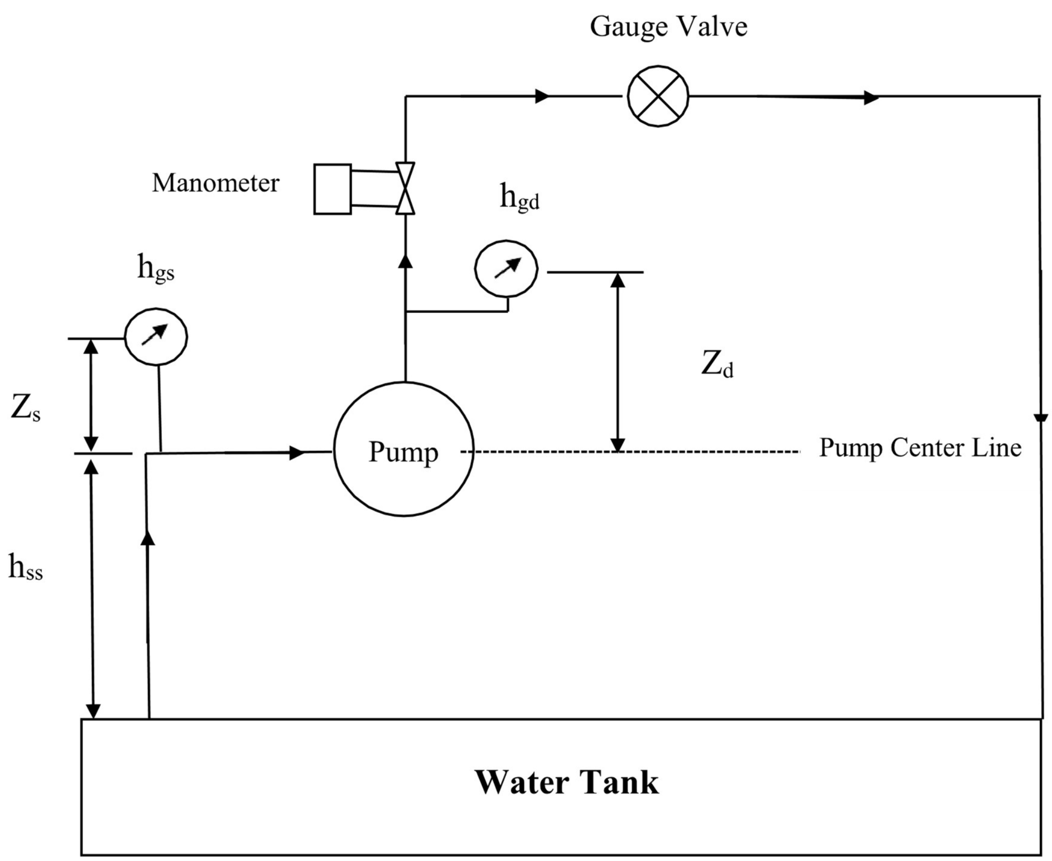

Figure 2(a): Schematic Diagram of Centrifugal Pump Test

Data Collection:

Operating speed, N = rpm

Suction pipe dia. d_s = m

Delivery pipe dia. d_d = m

No of Obs.	Suction Pressure, $h_{g,s}$		Delivery Pressure, $h_{g,d}$		Total Head (m of H_2O)	Manometer reading			Flow rate, Q (m^3/s)
	inch Hg	m of H_2O	Kg/cm^2	m of H_2O		Left, L (cm)	Right, R (cm)	Net deflection, ΔH (m)	

Calculation:

Manometer Net Deflection, $\Delta H = L + R =$ (cm)

$=$ (m)

Flow rate, $Q = 0.015 \times \sqrt{\Delta H}$ (m^3/s) $=$

Here,

Pressure gauge reading in suction side, $h_{g,\,s}$ =

Pressure gauge reading in delivery side, $h_{g,\,d}$ =

h_s = vertical distance of the pressure gauge in the suction side from the pump horizontal centerline = Z_S = m

h_d = vertical distance of the pressure gauge in the delivery side from the pump horizontal centerline = Z_d = m

Velocity at the suction side, $v_s = \dfrac{Q}{\dfrac{\pi d_s^2}{4}}$

Velocity at the delivery side, $v_d = \dfrac{Q}{\dfrac{\pi d_d^2}{4}}$

Total Head, $H_t = \left(h_{g,d} + \dfrac{v_d^2}{2g} + h_d\right) - \left(h_{g,s} + \dfrac{v_s^2}{2g} + h_s\right)$

Input Power, P_i =

Output Power, $P_o = Q\gamma H_t$

Efficiency, $\eta = \dfrac{P_o}{P_i} \times 100\%$

Calculation Table:

Obs. No.	N (rpm)	Total head, H (m)	Discharge, Q (m^3/s)	Input power, P_i (Watt)	Output power, P_o (Watt)	Efficiency, η

Discussions:

(Discuss the experimental pump characteristic curve. Also, compare it with ideal pump characteristic curve. Discuss the possible source of deviations in your results.)

Experiment no. 2(b)

Name of the experiment: Study of centrifugal pumps in series and parallel connection

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Name of the experiment: Study of centrifugal pumps in series and parallel connection

Objective:

To study the flow rate and head characteristics of two centrifugal pumps in series and parallel connections.

Apparatus:

Schematic diagram (connection circuit):

Pump 2 off and Pump 1 running	**Pump 1 off and Pump 2 running**
Both pumps in series connection	**Both pumps in parallel connection**

Data collection:

For pump 2 off pump 1 running:

No of Obs.	Suction Pressure, $P_{s,1}$		Delivery Pressure, $P_{d,1}$		Total Head (m of H_2O)	Manometer reading			Flow rate, Q (m^3/s)
	inch Hg	m of H_2O	Kg/cm^2	m of H_2O		Left, L (cm)	Right, R (cm)	Net Deflection, ΔH (m)	

For pump 2 off pump 1 running:

No of Obs.	Suction Pressure, $P_{s,2}$		Delivery Pressure, $P_{d,2}$		Total Head (m of H_2O)	Manometer reading			Flow rate, Q (m^3/s)
	inch Hg	m of H_2O	Kg/cm^2	m of H_2O		Left, L (cm)	Right, R (cm)	Net Deflection, ΔH (m)	

For pumps is series connection:

No of Obs.	Suction Pressure, $P_{s,3}$		Delivery Pressure, $P_{d,3}$		Total Head (m of H_2O)	Manometer reading			Flow rate, Q (m^3/s)
	inch Hg	m of H_2O	Kg/cm^2	m of H_2O		Left, L (cm)	Right, R (cm)	Net Deflection, ΔH (m)	

For pumps is parallel connection:

No of Obs.	Suction Pressure, $P_{s,4}$		Delivery Pressure, $P_{d,4}$		Total Head (m of H_2O)	Manometer reading			Flow rate, Q (m^3/s)
	inch Hg	m of H_2O	Kg/cm^2	m of H_2O		Left, L (cm)	Right, R (cm)	Net Deflection, ΔH (m)	

Calculation:

1. Suction pressure, P_s = (inch Hg)

   = (m of H_2O)

2. Delivery pressure, P_d = (kg/cm^2)

   = (m of H_2O)

3. Total head = $P_d - P_s$ = (m of H_2O)

4. Manometer net deflection, $\Delta H = L + R$ = (cm)

   = (m)

5. Flow rate, $Q = 0.015 \times \sqrt{\Delta H}$ (m^3/s) =

Discussion:

Experiment No. 3(a)

Name of the Experiment: Study and performance test of a submersible pump

Experiment No. 3(a)
Name of the Experiment: Study and performance test of a submersible pump

Objectives:

- To study the working principle of a submersible pump.
- To determine the performance parameters of a submersible pump.
- To plot the characteristic curve of a submersible pump and find its duty point.
- To calculate the specific speed of a submersible pump.

Apparatus:

Schematic diagram:

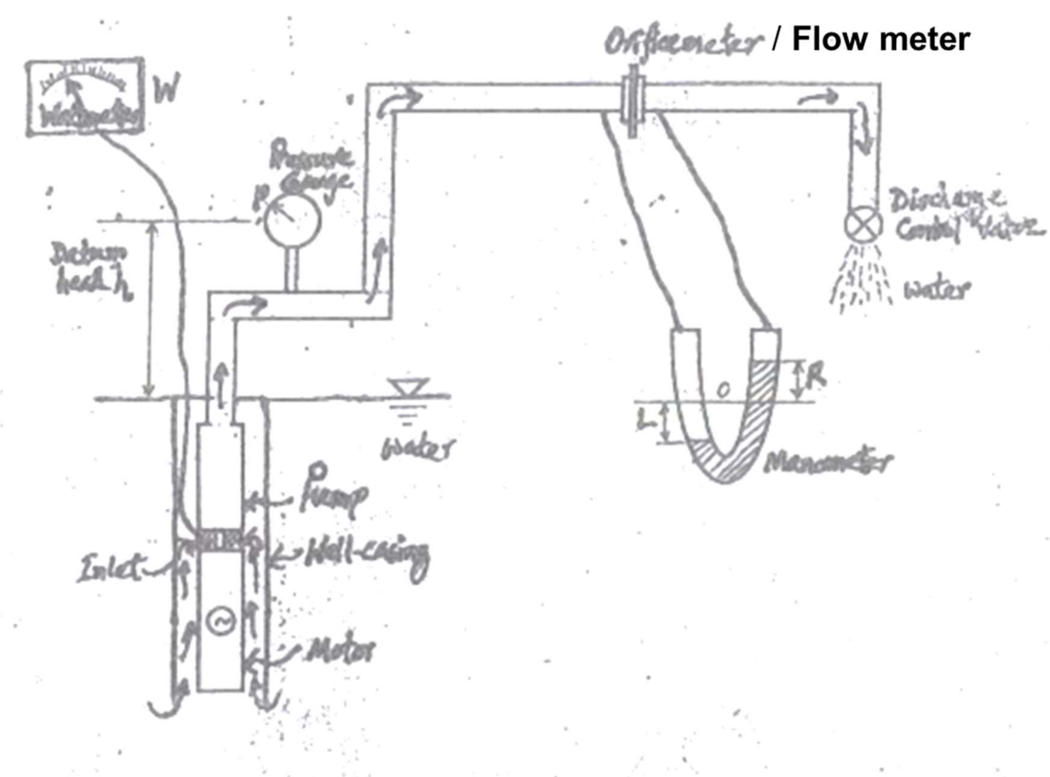


Figure 3(a): Schematic diagram of a submersible pump test

Experimental measurement data:

Datum Head of the PG (Pressure Gauge), H_0 = (m)
PG calibration Equation:
Flowmeter calibration equation:
Wattmeter calibration equation:

No. of Obs.	Flow meter reading		Pressure gauge reading (Psi)	Input power, P_{in} Wattmeter reading (kW)
	Vol (lit)	Time (s)		

Calculated data:

No. of Obs.	Flow rate/discharge, Q		Head, H (m)	Input power, P_{in} (kW)	Output power, P_{out} (kW)	Overall efficiency, η (%)
	lit/min (lpm)	m^3/s (cumec)				

Sample calculation:

1. Discharge, Q = vol/time = lit/s

   = lit/min

   Actual discharge, Q = lit/min [use calibration equation]

   Actual discharge, Q = m^3/s

2. Head, $H = \frac{p}{\gamma} + H_0$ = m of Water [use calibration equation]

3. Input Power, P_{in} = kW [from Wattmeter]

   Actual Input Power, P_{in} = kW [use calibration equation]

4. Output power, P_{out} = γQH kW

5. Overall efficiency, η = $\frac{P_{out}}{P_{in}} \times 100$ %

6. Specific speed (at best efficiency point), $N_s = \frac{N\sqrt{Q}}{H^{3/4}}$

Graphical presentation:

Plot the characteristics curve of a submersible pump (H, P_{in}, η vs. Q) and find its duty point at maximum efficiency, η_{max}.

Experiment No. 3(b)

Name of the Experiment: Dismantling and assembling of a centrifugal pump

Experiment No. 3(b)
Name of the Experiment: Dismantling and assembling of a centrifugal pump

Introduction:

Centrifugal pumps are devices that are used to transport fluids by the conversion of rotational kinetic energy to the hydraulic energy of the fluid flow. The kinetic energy typically comes from an electric motor. Centrifugal pumps are used in more industrial applications than any other kind of pumps.

Working principle:

Fluid enters the pump axially through the suction pipe to the eye of impeller (low pressure area) which rotates at high speed. As the impeller blades rotate, they transfer momentum to incoming fluid. The fluid accelerates radially outward, and a vacuum is created at the impellers eye that continuously draws more fluid into the pump. As the fluid’s velocity increases its kinetic energy increases. Fluid of high kinetic energy is centrifugally forced out of the impeller area and enters the volute. In the volute, the fluid flows through a continuously increasing cross sectional area, where the kinetic energy is converted into fluid pressure according to Bernoulli’s principle. The main parts of a centrifugal pump include the suction pipe, impeller, volute casing, shaft, packing seals, bearing etc. The impeller may be open, semi open, or closed type depending on the fluid to be handled.

Activities:

1. Dismantle a centrifugal pump using the tools provided.
2. Identify and observe each of the components.
3. Take photographs of various components and attach them with the report.
4. Study the components and energy flow sequence.
5. Assemble all components to form the pump again.

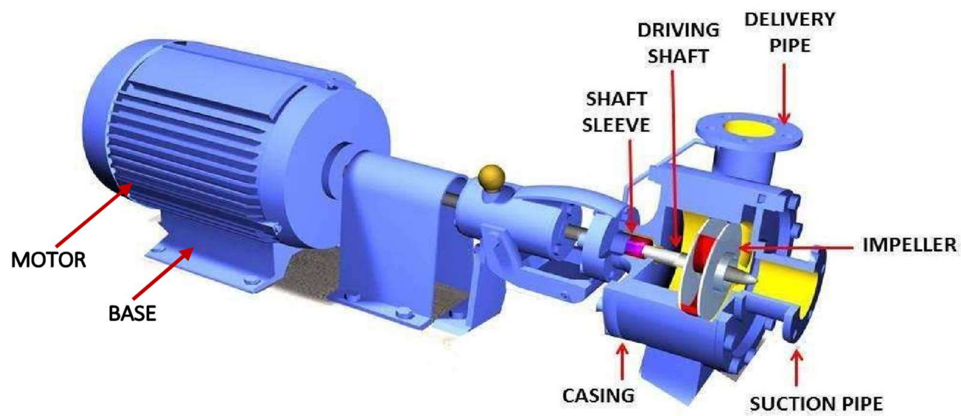
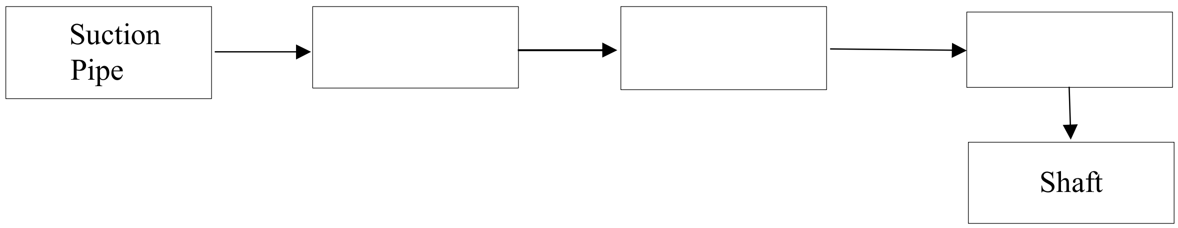
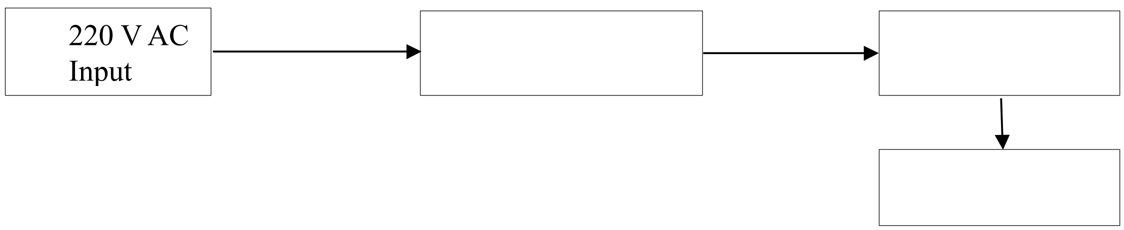


Figure 3 (b): Centrifugal pump and its components.

Pump Components Sequence:



Energy Conversion Sequence:



Question and answer:

1. Where are the gaskets placed?

2. Why gland packing seals are used?

Experiment No. 4

Name of the Experiment: Study and performance test of a positive displacement pump

Experiment No. 4

Name of the Experiment: Study and performance test of a positive displacement pump

Objective:

To find the pump performance for a range of delivery pressures (varied load) at a constant speed.

Apparatus:

Experimental Setup:

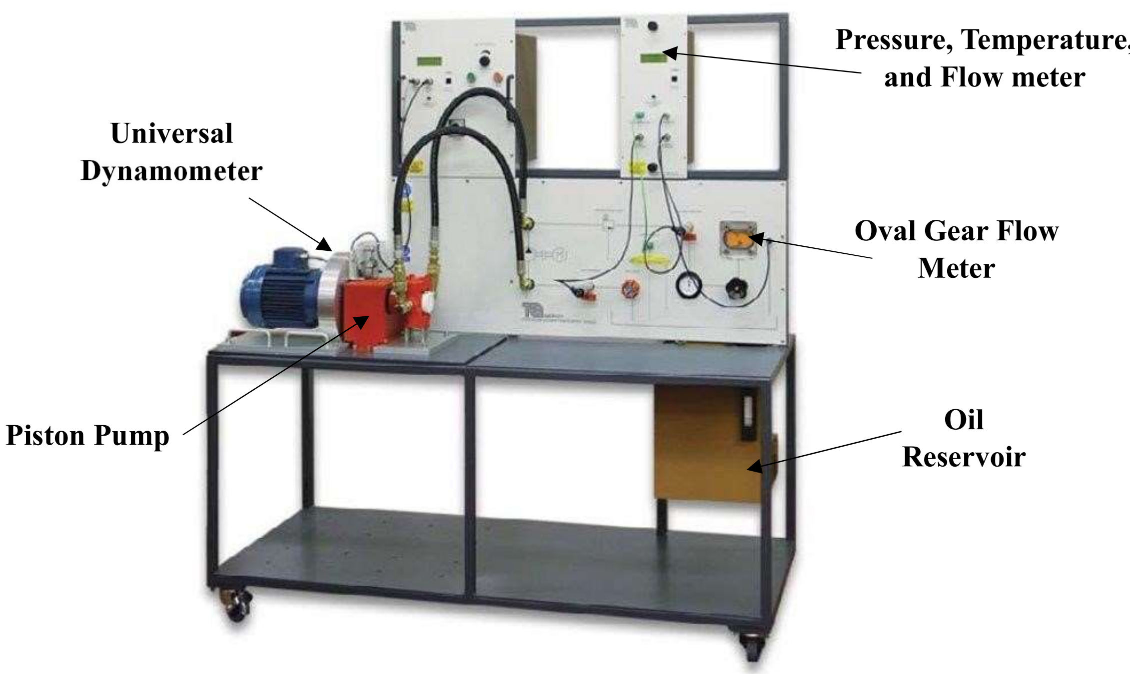


Figure 4(a): Positive displacement pump module

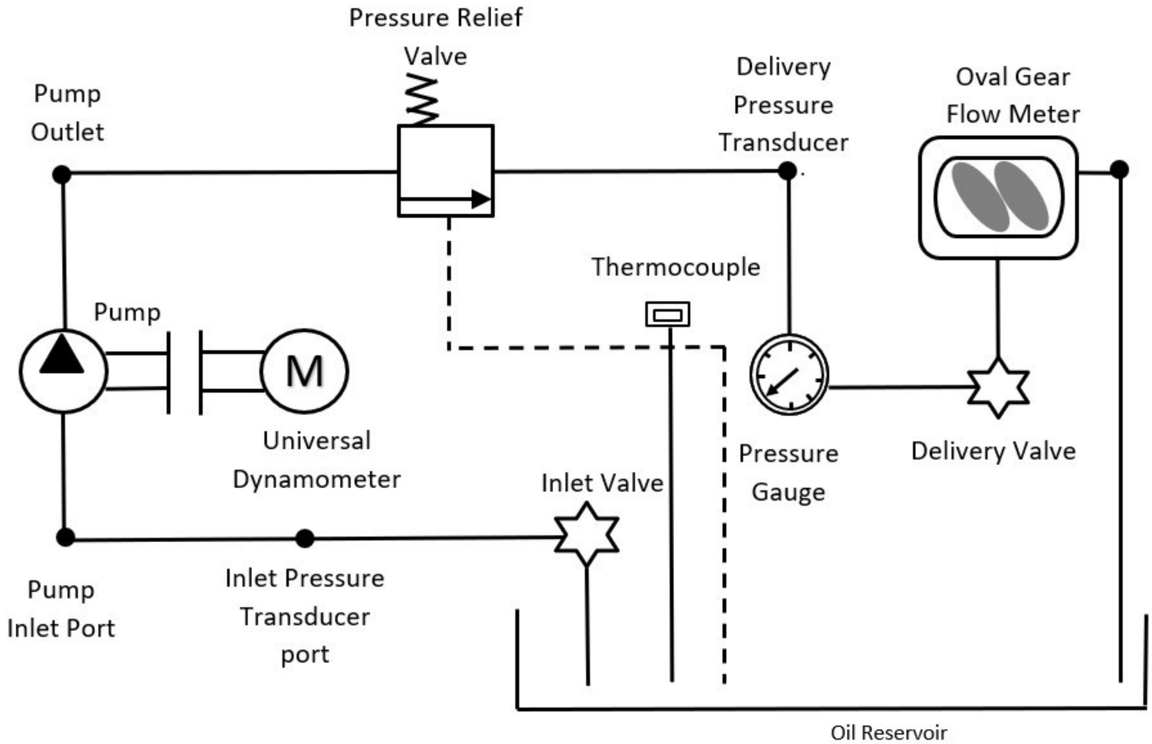
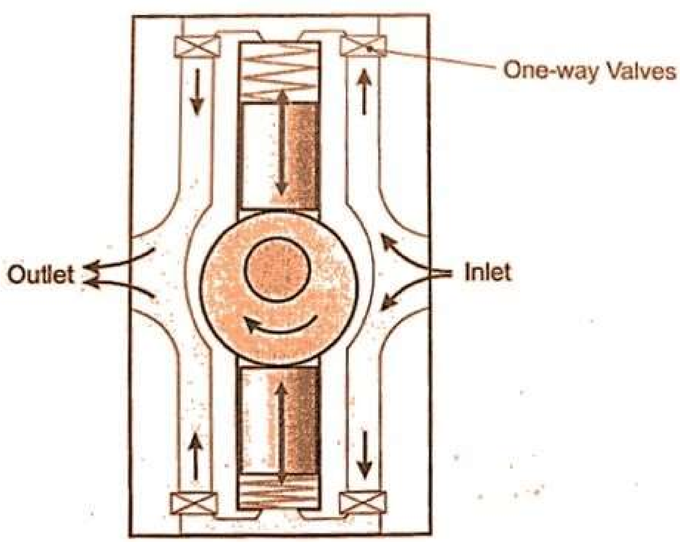


Figure 4(b): Schematic diagram of piston pump setup



Piston Pump Working Action

Piston Pump (TQ MFP103a)

Figure 4(c): Piston pump

Experiment: 4(a)

Experiment Name: Effect of delivery pressure at constant speed

Experiment: 4(a)

Experiment Name: Effect of delivery pressure at constant speed

Objective:

To find the pump performance for a range of delivery pressures (varied load) at a constant speed.

Procedure:

- Fit the pump according to the instructions (i.e., video).
- Fully open inlet and delivery valves.
- Use button on the pressure display to zero all the pressure readings.
- Zero the torque reading of the MFP100 Universal Dynamometer.
- Press the start button on the Motor Drive and run the speed to 1600 rpm (+/- 5 rpm) for at least five minutes and monitor the oil temperature until it stabilizes. Check that any air bubbles have moved away from the flowmeter.
- Record the speed and oil temperature.
- Slowly shut the delivery valve and maintain the speed until the delivery pressure reaches 2 bar. Allow a few seconds for conditions to stabilize. Record the indicated flow and pressures.
- Continue increasing the delivery pressure in 1 bar steps (while keeping the speed constant) to a maximum of 15 bar. At each step, allow a few seconds for conditions to stabilize and record the indicated flow and pressures.
- (Optional) Repeat the test at two other lower speeds (1200 rpm and 800 rpm are recommended)

Data from experiment:

Swept Volume, V_s = 0.00715 L/rev

Speed, N_P = rpm,

Expected Flow = L/min

Oil Temperature, T_1 = (at Start), (at end)

Data Table:

Obs. No	Delivery Pressure P_2 (bar)	Inlet Pressure P_1 (bar)	Pressure Difference ΔP, (Bar)	Pressure Difference ΔP, (Pa)	Flow Rate Q_v, (L/min)	Shaft Power W_D, (W)	Hydraulic Power W_P, (W)	Overall Efficiency η_P, (%)	Volumetric Efficiency η_v, (%)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

Calculation:

1. Mechanical Power (into the pump), W_D =

2. Hydraulic Power (from the pump), $W_P = (P_2 - P_1)\ Q_v$ =

3. Overall Pump Efficiency, η_P =

4. Swept Volume V_S =

5. Expected Volume Flow rate = $V_S \times N_p$ =

6. Volumetric Efficiency, $\eta_V = Q_v /(V_S \times N_p) \times 100$ =

Discussion:

- Compare the Flow rate, Shaft power, Volumetric efficiency, and Overall efficiency with Pressure difference.
- Create one chart with two vertical axes, one for flow rate and other one for volumetric efficiency, overall efficiency, and shaft power.
- Discuss the individual parameters behavior with the change of pressure difference.
- If the test is run at other speeds, repeat the above discussions, and compare them.

Experiment: 4(b)

Experiment Name: Effect of speed at constant speed delivery pressure

Experiment: 4(b)

Experiment Name: Effect of speed at constant speed delivery pressure

Objective:

To find the pump performance for a range of speeds at a constant delivery pressure (load).

Procedure:

- Fit the pump according to the instructions (i.e., video).
- Fully open inlet and delivery valves and use button on the pressure display to zero all the pressure readings.
- Zero the torque reading of the MFP100 Universal Dynamometer.
- Press the start button on the Motor Drive and run the speed to 1600 rpm (+/- 5 rpm) for at least five minutes and monitor the oil temperature until it stabilizes.
- Wait for any trapped air bubbles to move from the flowmeter.
- Slowly shut the delivery valve and maintain the speed until the delivery pressure reaches 15 bar.
- Allow a few seconds for conditions to stabilize. Record the speed, oil temperature, the indicated flow (from display) and pressures.
- Reduce the speed by 100 rpm while adjusting the delivery pressure to keep it constant at 15 bar. Allow the conditions to stabilize and record the indicated flow and pressures.
- Continue decreasing the speed in 100 rpm steps (while keeping the pressure constant) until you reach 800 rpm. At each step, record the indicated flow and pressure.
- (Optional) Repeat the test at two other fixed delivery pressures (10 bar and 5 bar are recommended).

Data from experiment:

Swept Volume, V_s = 0.00715 L/rev

Delivery Pressure, P_2 = bar

Oil Temperature, T_1 = (at start), (at end)

Data Table:

Obs. No	Speed, N_P (rpm)	Inlet Pressure P_1, (bar)	Pressure Difference ΔP, (Pa)	Flow rate Q_v, (L/min)	Expected Flow, (L/min)	Shaft Power W_D, (W)	Hydraulic Power W_P, (W)	Overall Efficiency η_P, (%)	Volumetric Efficiency η_v, (%)
1									
2									
3									
4									
5									
6									
7									
8									
9									

Calculation:

1. Mechanical Power (into the pump), W_D =

2. Hydraulic Power (from the pump), $W_P = (P_2 - P_1)\ Q_v$ =

3. Overall Pump Efficiency, η_P =

4. Swept Volume V_S =

5. Expected Volume Flow rate = $V_S \times N_p$ =

6. Volumetric Efficiency, $\eta_V = Q_v / (V_S \times N_p) \times 100$ =

Discussion:

- Compare the Flow rate, Shaft power, Volumetric efficiency, and Overall efficiency with Pump speed.
- Create one chart with two vertical axes, one for flow rate and other one for volumetric efficiency, overall efficiency, and shaft power.
- Discuss the individual parameters behavior with the change of pump speed.
- If the test is run at other delivery pressures, repeat the above discussions, and compare them.

Experiment: 4(c)

Experiment Name: Effect of inlet pressure on pump performance

Experiment: 4(c)

Experiment Name: Effect of inlet pressure on pump performance

Objective:

To show how reduced inlet pressures affect pump performance and cause cavitation.

Procedure:

- Fit the pump according to the instructions (i.e., video).
- Fully open inlet and delivery valves.
- Use button on the pressure display to zero all the pressure readings.
- Zero the torque reading of the MFP100 Universal Dynamometer.
- Press the start button on the Motor Drive and run the speed to 1600 rpm (+/- 5 rpm) for at least five minutes and monitor the oil temperature until it stabilizes.
- Wait for any trapped air bubbles to move from the flowmeter.
- Slowly shut the delivery valve and maintain the speed until the delivery pressure reaches 2 bar.
- While keeping the speed and delivery pressure constant, use the inlet valve to reduce the inlet pressure to the nearest 0.1 bar.
- Allow a few seconds for conditions to stabilize, then record the speed, the oil temperature, the indicated flow, and pressures.
- Continue decreasing the inlet pressure in 0.1 bar steps (while keeping the delivery pressure and speed constant) until you can hear a change in sound from the pump (cavitation). At each step, record the indicated flow and pressures.

Data from experiment:

Swept Volume, V_s = 0.00715 L/rev,

Pump Speed, N_P = rpm,

Expected Flow = L/min

Delivery Pressure, P_2 = bar

Oil Temperature, T_1 = (at Start), (at end)

Data Table:

Obs. No	Inlet Pressure P_1, (bar)	Pressure Difference ΔP, (Pa)	Flow rate Q_v, (L/min)	Shaft Power W_D, (W)	Hydraulic Power W_P, (W)	Overall Efficiency η_P, (%)	Volumetric Efficiency η_v, (%)
1							
2							
3							
4							
5							
6							
7							
8							

Calculation:

1. Mechanical Power (into the pump), W_D =

2. Hydraulic Power (from the pump), $W_P = (P_2 - P_1)\ Q_v$ =

3. Overall Pump Efficiency, η_P =

4. Swept Volume V_S =

5. Expected Volume Flow rate = $V_S \times N_p$ =

6. Volumetric Efficiency, $\eta_V = Q_v / (V_S \times N_p) \times 100$ =

Discussion:

- Compare the Flow rate, Shaft power, Volumetric efficiency and Overall efficiency with inlet pressure.
- Create one chart with two vertical axes, one for flow rate and other one for volumetric efficiency, overall efficiency and shaft power.
- Discuss the individual parameters behavior with the change of pump speed.
- Comment on how low the inlet pressures (that can cause cavitation) affect the performance of the pump.