EXPT. NO. 03

DATE : 22-05-23

EXPERIMENT OF Performance test of an Impulse Turbine (Pelton Wheel).

Introduction:

The Pelton wheel is a type of water turbine used for the conversion of hydropower into mechanical energy. It was invented by Lester Allan Pelton in the 1870s and has since become one of the most widely used and efficient designs for high-head hydroelectric applications. The Pelton wheel is specifically designed for locations where there is a high vertical distance (head) between the water source and the turbine. It is most commonly used in mountainous areas with fast-flowing water or in dams with significant water pressure. The main components of a Pelton wheel consist of a series of specially shaped buckets or cups, arranged around the rim of a wheel. These buckets are split down the middle, creating a gap that allows water to enter and exit the buckets. It is one types of hydraulic turbine. The smallest pelton wheel are only a few inches and can be used top power from mountain streams having flow of a few gallons per minute. Some of these system use household plumbing fixtures for water delivery. These small units are recommended for use with 30m (100 ft) or more of head, in order to generate significant power levels. Depending on water flow and design, it operate best with heads from 15 to 1800 m (50 to 5910 ft), there is no theoretical limit. Pelton wheel is an axial flow high head turbine with 88% overall efficiency.

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FIGURE NO.

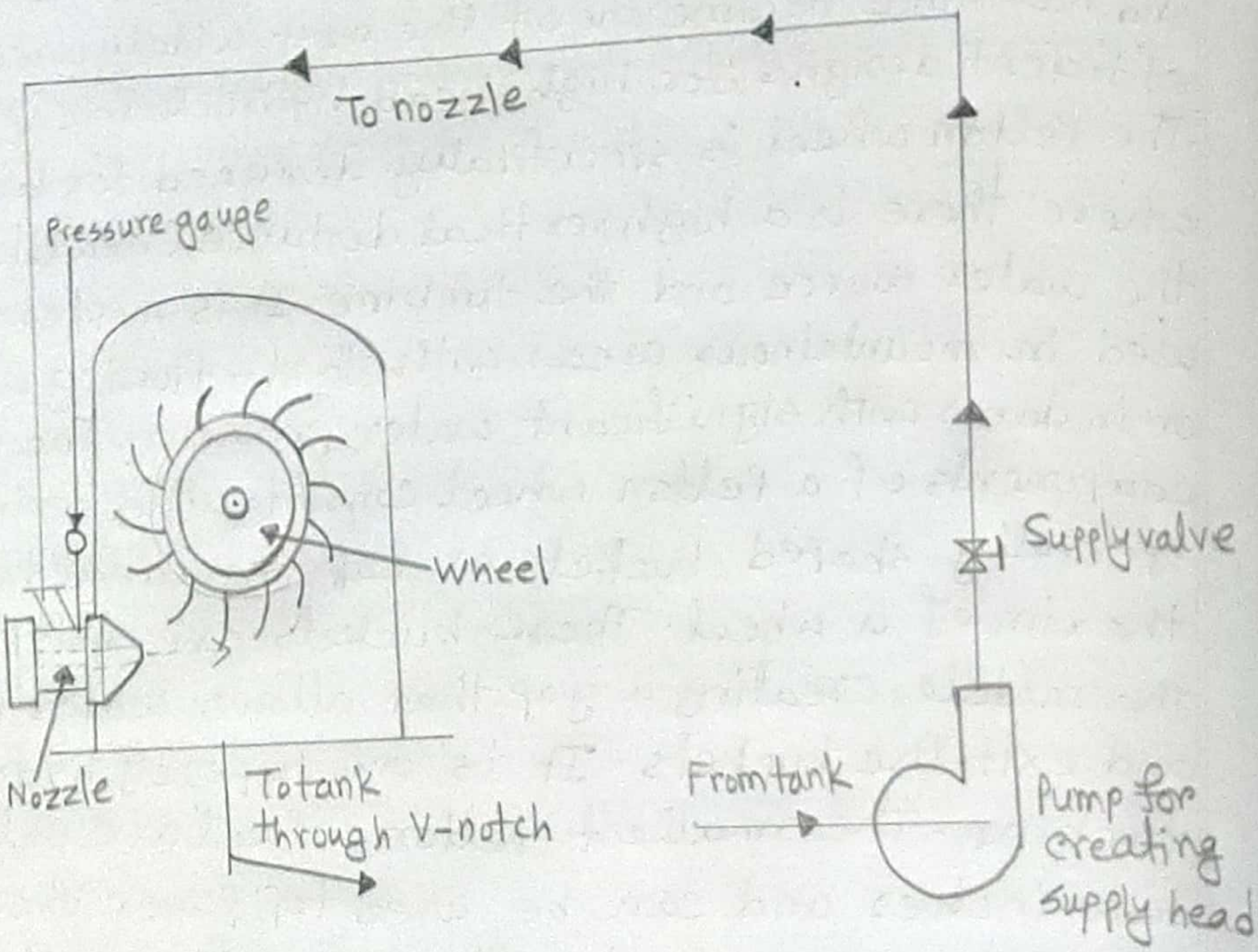

Figure 1: Pelton Wheel test set-up.

Theory:

(a) Head, $H = \Delta Z + P/\gamma + \frac{V^2}{2g}$

where, ΔZ = difference in height between the pressure gauge and nozzle.

P/γ = pressure gauge reading.

V = velocity of water in the pipe upstream of the nozzle.

However, ΔZ and $V^2/2g$ are very small compared to total head H, and are usually neglected. Thus, head $H = P/\gamma$ which is obtained directly in meters of water from gauge reading.

(b) Power

(i) Flow rate, Q is measured by means of a V-notch

$$Q = \frac{8}{15} C_d \sqrt{2g} \tan \theta/2 \, H_1^{5/2} = K H_1^{5/2}$$

H_1 = height of water surface over V-notch in m

(ii) Input hydraulic power,

$P_i = \gamma Q H$ Watt $= g Q H$ KW, where Q in m^3/sec; H in meters of water.

(iii) Output power

$$P_o = \frac{\pi D N W}{60} \text{ Watt} = \frac{\pi D N W}{60 \times 1000} \text{ KW}$$

where, D is the diameter of the brake drum in m.

N is the rpm of the wheel.

W is the net load $(W_1 - W_2)$ at the brakedrum in N.

(c) Overall efficiency, $\eta = P_o/P_i$

(d) Speed ratio, $\phi = \frac{\text{Peripheral speed of the wheel, } v}{\text{velocity of water at the nozzle tip, } V_o}$

where, $v = \frac{\pi D_m N}{60}$; D_m = mean diameter of the wheel.

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$V_o = C_v\sqrt{2gH}$; C_v = coefficient of velocity $\cong 0.99$

(e) Unit Parameters:

(i) Unit speed, $N_u = \frac{N}{\sqrt{H}}$

(ii) Unit discharge, $Q_u = \frac{Q}{\sqrt{H}}$

(iii) Unit Power, $P_u = \frac{P_o}{H^{3/2}}$

Objectives:

1. To find performance characteristics at constant head i.e. to plot
   (a) Unit discharge (Q_u) vs Unit speed (N_u).
   (b) Efficiency (η) vs Unit speed (N_u).
   (c) Unit Power (P_u) vs Unit speed (N_u).
   (d) Efficiency (η) vs speed ratio (ϕ).
2. To compare these with the theoretical curve.

Apparatus:

All are attached to the experimental set-up except tachometer and scale.

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Working Procedure:

(1) The motor was started initially to deliver water by pump.
(2) Then, the supply valve was opened, the spear was set in a desired position.
(3) After that, the brake was put in action by adding maximum tension possible.
(4) The speed, water flow rate, gauge reading and tensions in the brake drum was recorded.
(5) The speed was increased by reducing load on the brake. Care should be taken so that H must not change. If so, the supply valve was regulated to had the same H. The valves given in step (4) was recorded.
(6) Steps (4) and (5) was repeated at least five times, so that the readings could be recorded over a wide range of speed.
(7) The spear at another position was set and keeping H constant, repeated steps (3) to (6).

Data Table:

Mean diameter of the wheel, $D_m = 11.5\ cm = 0.115\ m$
Diameter of the brake drum $= 6\ cm = 0.06\ m$
Angle of V-notch, $\phi = 60°$
Co-efficient of discharge, $C_d = 0.86$
Co-efficient of velocity, $C_v = 0.99$

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Spear Position (%)	Pressure gauge reading H (m of water)	Scale reading for discharge H_1 (cm)	Tachometer reading, N (rpm)	Load for braking torque $(W_1-W_2) \times 10$ (N)
	15	3.5	1650	0.7 − 0.25
100	14	3.8	1540	1 − 0.3
	13	4	1420	1.3 − 0.4
	12	4.5	1300	1.6 − 0.5
	14	3.7	1530	0.7 − 0.2
75	13	4	1400	1 − 0.35
	12	4.6	1310	1.3 − 0.5
	11	4.8	1200	1.6 − 0.6
	13	4	1320	0.6 − 0.2
50	12	4.6	1200	0.9 − 0.3
	11	4.8	1100	1.2 − 0.4
	10	5	1000	1.5 − 0.5

Calculation:

For spear position 100%,
For observation 1,

Flow rate, $Q = \frac{8}{15} C_d \sqrt{2g} \tan\frac{\theta}{2} H_1^{5/2}$

$= \frac{8}{15} \times 0.86 \times \sqrt{2 \times 9.81} \times \tan\left(\frac{60}{2}\right) \times (0.035)^{5/2}$

$= 2.688 \times 10^{-4}\ m^3/s$

Input hydraulic power, $P_i = \gamma Q H$

$= 1000 \times 9.81 \times 2.688 \times 10^{-4} \times 15$

$= 39.554\ W$

Output power, $P_o = \frac{\pi D W N}{60}$

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$= \frac{\pi \times 0.06 \times 4.5 \times 1650}{60}$

$= 23.326 W$

Overall efficiency, $\eta = \frac{P_o}{P_i} = \frac{23.326}{39.554} \times 100 = 58.973\%$.

speed ratio, $\phi = \frac{v}{V_o}$

Here, $v = \frac{\pi D_m N}{60} = \frac{\pi \times 0.115 \times 1650}{60} = 9.935 \, m/s$

$V_o = C_v\sqrt{2gH} = 0.99 \times \sqrt{2 \times 9.81 \times 15} = 16.983 \, m/s$

$\therefore \phi = \frac{v}{V_o} = \frac{9.935}{16.983} = 0.58$

Unit speed, $N_u = \frac{N}{\sqrt{H}} = \frac{1650}{\sqrt{15}} = 426.02$

Unit Discharge, $Q_u = \frac{Q}{\sqrt{H}} = \frac{2.688 \times 10^{-4}}{\sqrt{15}} = 6.94 \times 10^{-5}$

Unit power, $P_u = \frac{P_o}{H^{3/2}} = \frac{23.326}{15^{3/2}} = 0.401$

Similarly, for observation 2,

$Q = 3.302 \times 10^{-4} \, m^3/s$; $P_i = 45.349 W$; $P_o = 33.866 W$

$\eta = 74.679\%$; $v = 9.273 \, m/s$; $V_o = 16.407 \, m/s$

$\phi = 0.56$; $N_u = 411.6$; $Q_u = 8.825 \times 10^{-5}$; $P_u = 0.646$

For observation 3,

$Q = 3.753 \times 10^{-4} \, m^3/s$; $P_i = 47.868 W$; $P_o = 40.149 W$

$\eta = 83.875\%$; $v = 8.550 \, m/s$, $V_o = 15.810 \, m/s$; $\phi = 0.54$;

$N_u = 393.83$; $Q_u = 1.041 \times 10^{-4}$; $P_u = 0.856$

For observation 4,

$Q = 5.038 \times 10^{-4} \, m^3/s$; $P_i = 59.315 W$; $P_o = 44.925 W$

$\eta = 75.739\%$; $v = 7.828 \, m/s$; $V_o = 15.190 \, m/s$; $\phi = 0.51$

$N_u = 375.27$; $Q_u = 1.454 \times 10^{-4}$; $P_u = 1.081$

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For spear position 75%, for observation -1,

$Q = 3.088 \times 10^{-4} \, m^3/s$; $P_i = 42.421 W$; $P_o = 24.033 W$

$\eta = 56.653\%$; $v = 9.213 \, m/s$; $V_o = 16.407 \, m/s$; $\phi = 0.56$

$N_u = 408.90$; $Q_u = 8.253 \times 10^{-5}$; $P_u = 0.458$

For observation 2,

$Q = 3.753 \times 10^{-4} m^3/s$; $P_i = 47.868 W$; $P_o = 28.588 W$; $\eta = 59.723\%$; $v = 8.429 m/s$; $V_o = 15.810 m/s$; $\varphi = 0.53$; $N_u = 388.29$; $Q_u = 1.041 \times 10^{-4}$; $P_u = 0.609$

For observation 3,

$Q = 5.323 \times 10^{-4} m^3/s$; $P_i = 62.665 W$; $P_o = 32.923 W$; $\eta = 52.539\%$; $v = 7.888 m/s$; $V_o = 15.190 m/s$; $\varphi = 0.51$; $N_u = 378.16$; $Q_u = 1.536 \times 10^{-4}$; $P_u = 0.792$

For observation 4,

$Q = 5.921 \times 10^{-4} m^3/s$; $P_i = 63.893 W$; $P_o = 37.699 W$; $\eta = 59.003\%$; $v = 7.225 m/s$; $V_o = 14.543 m/s$; $\varphi = 0.49$; $N_u = 361.81$; $Q_u = 1.785 \times 10^{-4}$; $P_u = 1.033$

For spear position 50%, For observation 1,

$Q = 3.753 \times 10^{-4} m^3/s$; $P_i = 47.868 W$; $P_o = 16.587 W$; $\eta = 34.652\%$; $v = 7.948 m/s$; $V_o = 15.810 m/s$; $\varphi = 0.50$; $N_u = 366.10$; $Q_u = 1.041 \times 10^{-4}$; $P_u = 0.353$

For observation 2,

$Q = 5.323 \times 10^{-4} m^3/s$; $P_i = 62.665 W$; $P_o = 22.619 W$; $\eta = 36.095\%$; $v = 7.225 m/s$; $V_o = 15.191 m/s$; $\varphi = 0.47$; $N_u = 346.41$; $Q_u = 1.536 \times 10^{-4}$; $P_u = 0.544$

For observation 3,

$Q = 5.921 \times 10^{-4} m^3/s$; $P_i = 63.892 W$; $P_o = 27.646 W$; $\eta = 43.269\%$; $v = 6.623 m/s$; $V_o = 14.543 m/s$; $\varphi = 0.45$; $N_u = 331.66$; $Q_u = 1.785 \times 10^{-4}$; $P_u = 0.757$

For observation 4,

$Q = 6.557 \times 10^{-4} m^3/s$; $P_i = 64.325 W$; $P_o = 31.415 W$; $\eta = 48.839\%$; $v = 6.021 m/s$; $V_o = 13.867 m/s$; $\varphi = 0.43$; $N_u = 316.23$; $Q_u = 2.073 \times 10^{-4}$; $P_u = 0.993$

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For Figure 2,
Along x axis, 10 unit = 40
Along Y axis, 10 unit = 0.50

For Figure 3,
Along x axis, 10 unit = 0.05
Along Y axis, 10 unit = 20%.

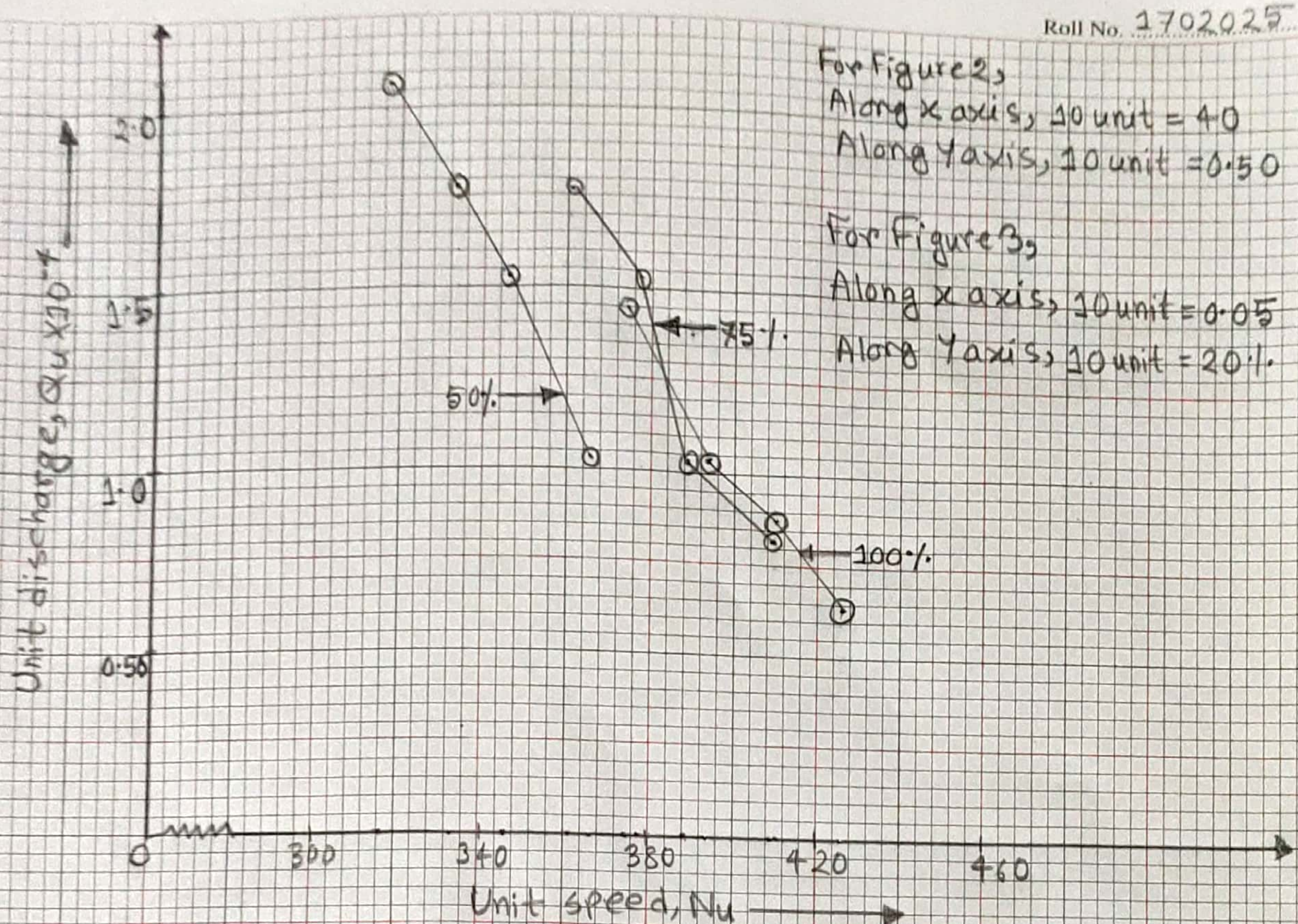

Figure 2: Unit discharge vs unit speed curve.

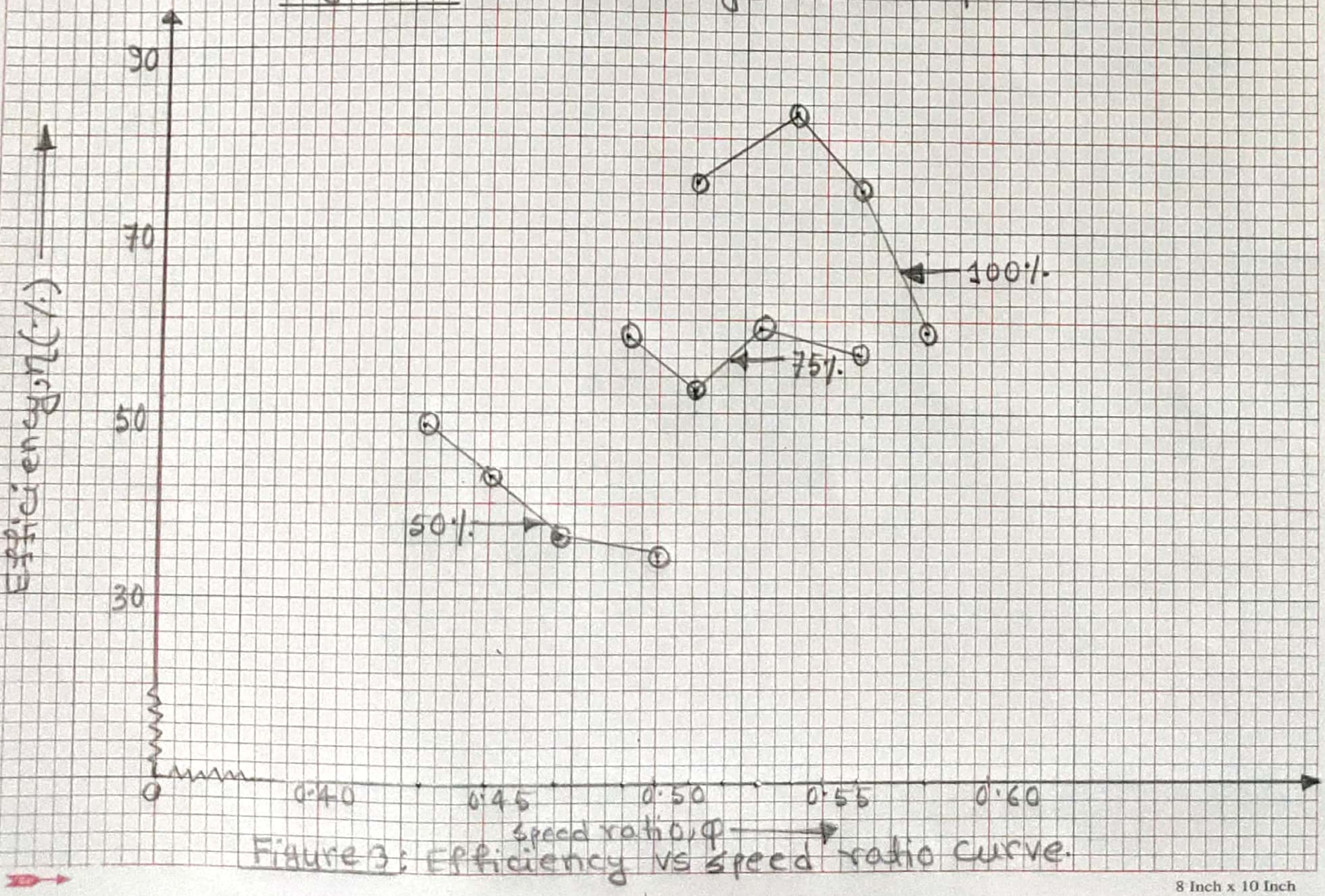

Figure 3: Efficiency vs speed ratio curve.

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For Figure 4,
Along x axis, 10 unit = 40
Along Y axis, 10 unit = 0.20
For figure 5,
Along x axis, 10 unit = 40
Along Y axis, 10 unit = 20%.

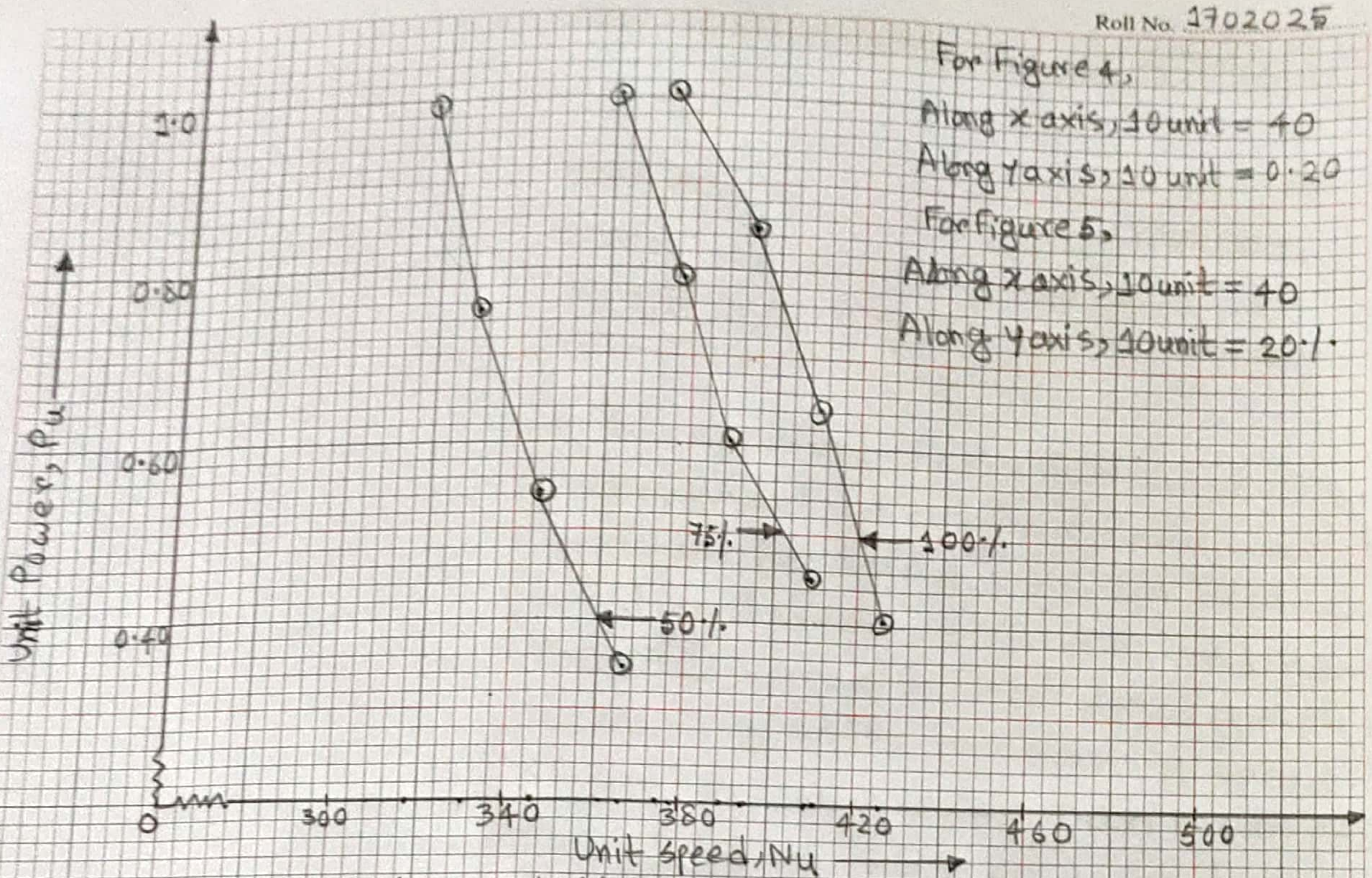

Figure 4: Unit Power vs Unit Speed Curve.

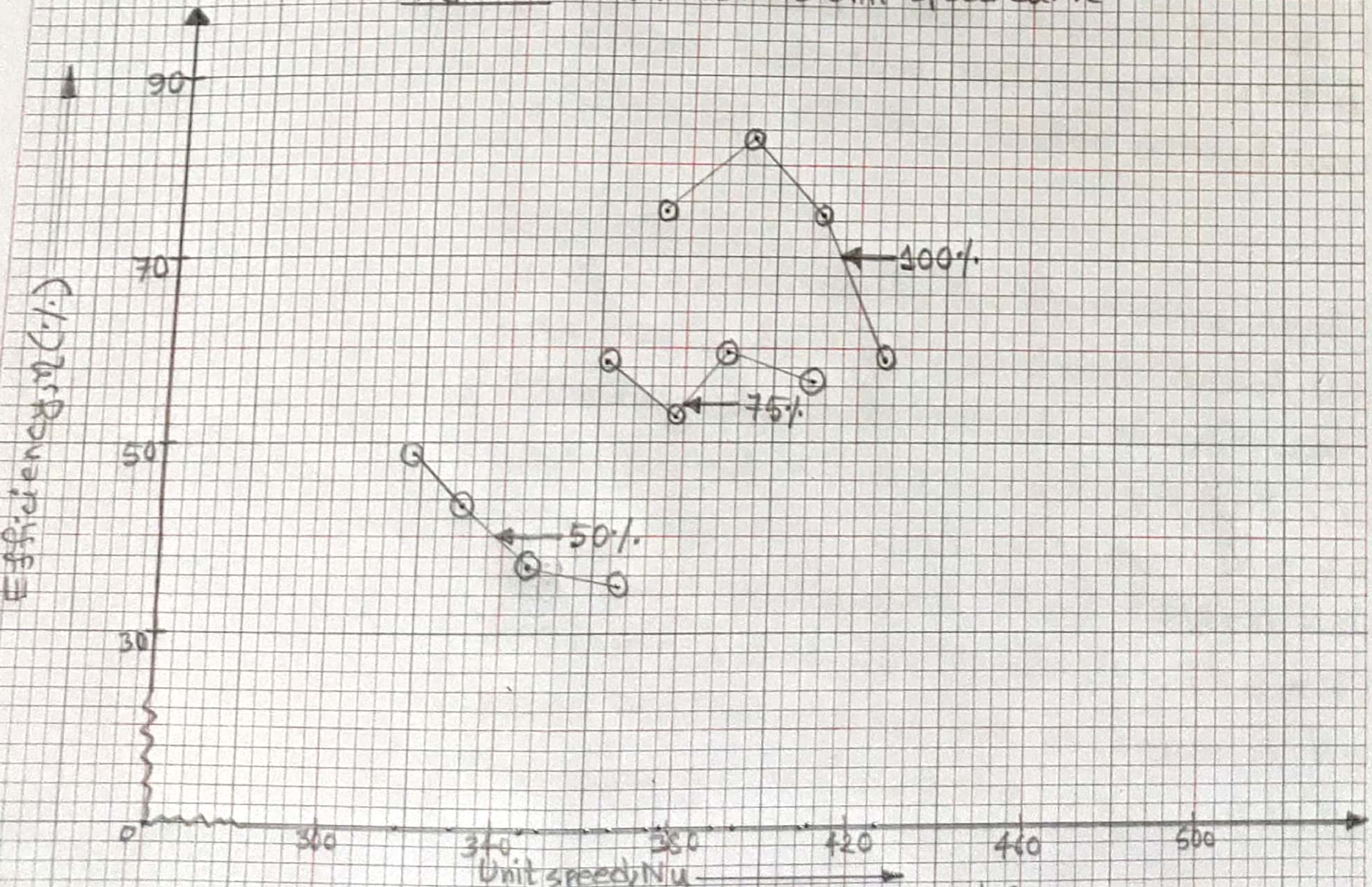

Figure 5: Efficiency vs Unit speed Curve.

8 Inch x 10 Inch

Discussions:

In this experiment, performance characteristics of Pelton Wheel at constant head was obtained under various operating condition such as unit Power output, rotational speed, flow rate and head of water. From the efficiency vs unit speed graph, efficiency was decreasing with increasing speed. From unit power vs unit speed graph, maximum power output was obtained at 75% spear position. From unit discharge vs unit speed graph, it was shown that 50% spear position had the maximum unit discharge. Overall efficiency of the pelton wheel was quite satisfactory.

Conclusions:

In this experiment, Performance test of a Pelton wheel was evaluated at constant head under different operating characteristics. Maximum efficiency was found 83.875% at 393.83 rpm when the spear position was at 100%. The performance test was indicated that Pelton wheel had suitability for high head application. The efficiency and power output could be increased by optimizing the design of nozzle and turbine blades.

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EXPT. NO. 02

DATE : 08-05-23

EXPERIMENT OF Performance test of Centrifugal pump connected in Series/Parallel.

Introduction:

Two or more similar impellers installed on the same shaft or on other shafts make up a multi-stage centrifugal pump. A multi-stage pump serves several crucial purposes so that it is designed to generate high-pressure fluid flow by converting mechanical energy into hydraulic energy. The important functions performed by a multi-stage pump are:

(a) To produce heads greater than that permissible with a single impeller discharge remaining constant. The task can be achieved by "series arrangement" where in the impellers are mounted on shafts and enclosed in the same casing.

(b) To discharge a large quantity of liquid, head remaining same. This task is accomplished by "Parallel arrangement" where in impellers are mounted on separate shafts.

Pumps in series: For obtaining a high head, a number of impellers are mounted in series or on the same shaft. The series arrangement is employed for delivering a relatively small quantity of liquid against very high heads.

Pumps in Parallel: When a large quantity of liquid is required to be pumped against a relatively small head (which is impossible for a single pump to accomplish), two or more pumps are employed which are so arranged that each of these pumps working separately lifts the liquid from a common sump and delivers it to a common collecting pipe through which it is carried to required height. This arrangement is known as pump in parallel (since each pumps delivers the liquid against the

FIGURE NO. ....

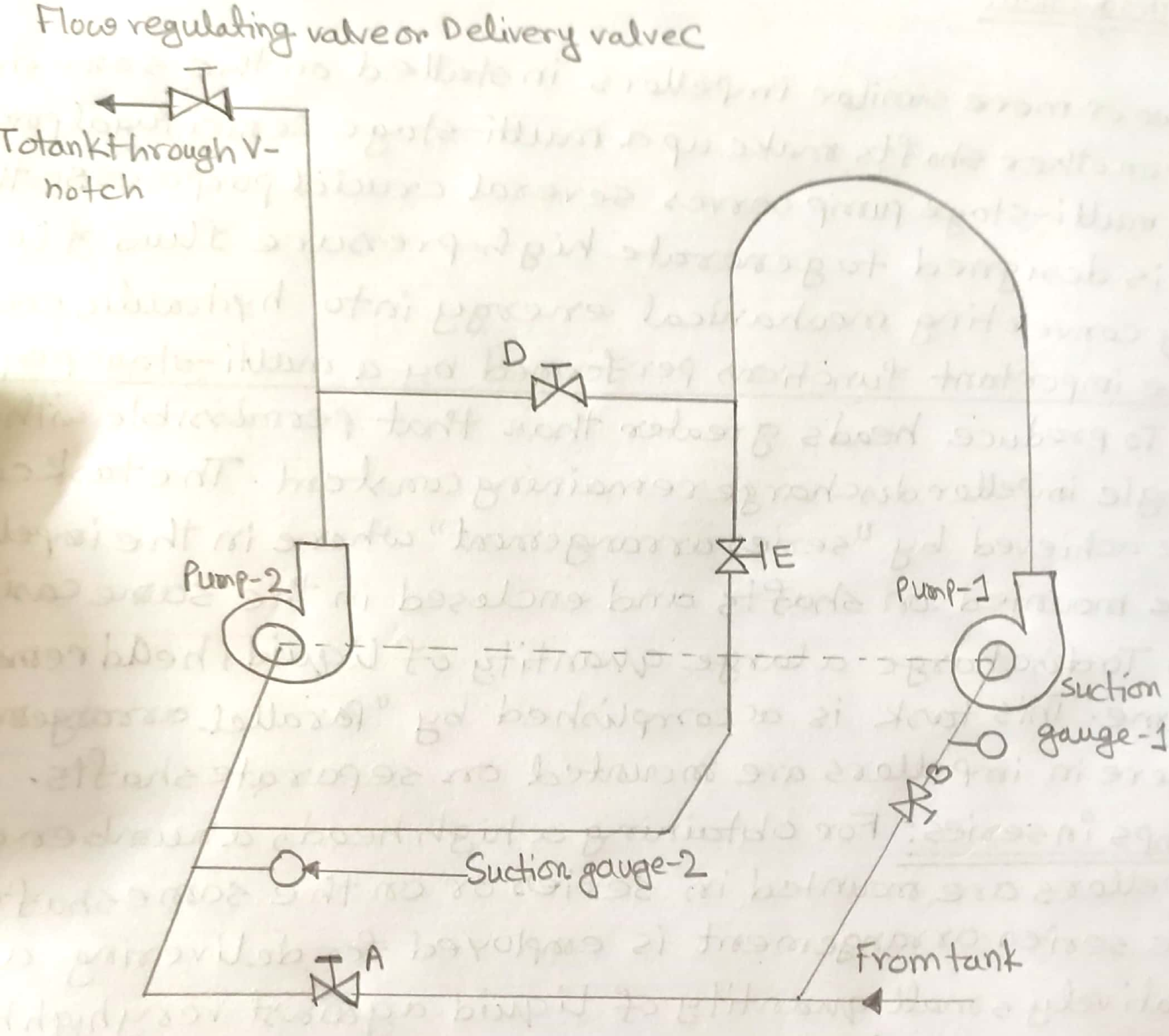

Figure 1: Set up for Series/ Parallel Pump testing.

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same head).
If Q is the discharge capacity of one pump and there are n identical pumps arranged in parallel, then total discharge will be, $Q_{total} = nQ$.

Objectives:

1. To determine the head/discharge characteristics for two pumps operating in series at the same speed and to compare the result with the individual pump characteristics.
2. To determine the head/discharge characteristics for two pumps operating in parallel at the same speed and to compare the result with the individual pump characteristics.

Apparatus:

1. Valves
2. Hydraulic bench
3. Pressure gauge
4. Pumps
5. Connecting pipes

Experimental Set-up:

Let, Discharge of pump-1 $= Q_1$
Head of pump-1 $= H_1$
Discharge of pump-2 $= Q_1$
Head of pump-2 $= H_2$

Total Head = H

Total discharge = Q

For series Connection: Discharge is same.

$\therefore Q_1 = Q_2 = Q$

Head, $H = H_1 + H_2$

For parallel Connection: Head is same.

$H_1 = H_2 = H$ and discharge, $Q = Q_1 + Q_2$

Flowrate is obtained directly from the graduated V-notch in (Litres/min) and Pressure head is obtained directly from pressure gauge in bar.

Working Procedure:

(a) For Series Connection –

(i) The pump was connected in series. This was done by fully opening valves B, C, E and closing valves A, D.

(ii) Pump-1 and Pump-2 was then started.

(iii) After that, the pump was set at desired speed.

(iv) Then, the suction pressure from gauge-1, the delivery pressure from pump-2 and the common flow rate was recorded.

(v) The delivery valve was controlled and repeated step (iv) several times keeping speed constant.

(vi) Pump-2 was stopped, closed valves A, E, opened valves B, C, D and record pressure readings from suction pressure gauge-2 and pump-2 for corresponding discharge tabulated above speed should be as before.

(b) For Parallel Connection –

(i) The pump was connected in parallel, this was done by

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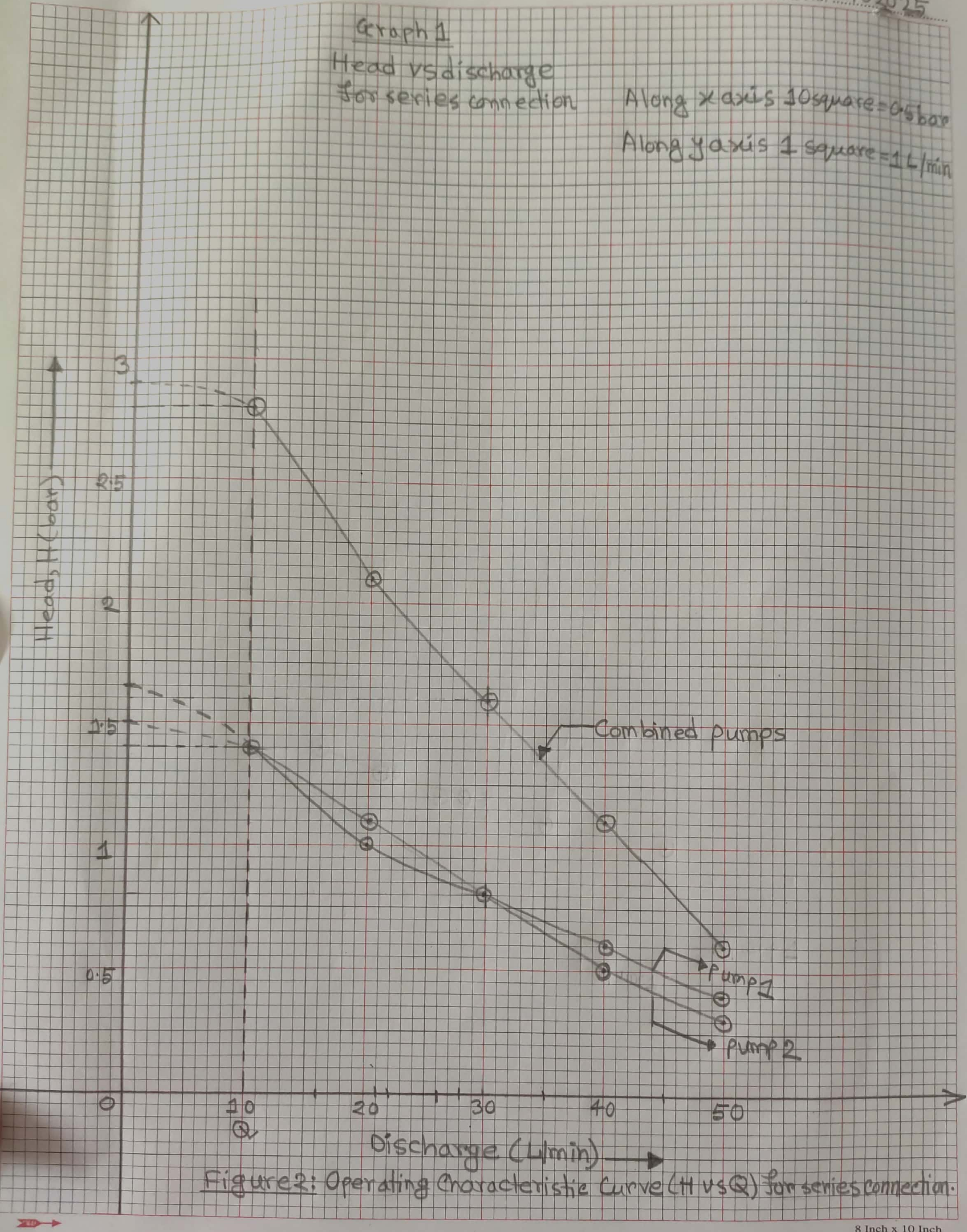

Figure 2: Operating Characteristic Curve (H vs Q) for series connection.

8 Inch x 10 Inch

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fully opening valves A, B, C, D and closing it.
(ii) Then, pump-1 and pump-2 was started.
(iii) Afterwards, the pumps was set at the speed same as series connection.
(iv) The suction pressure was recorded from gauge-1 and gauge-2, delivery pressure from pump-2 and combined discharge.
(v) Delivery valve was controlled and repeated step (iv) several times keeping speed constant.

Data:

For series Connection:-

Table 1: Data Table for series connection.

SL. NO.	Discharge (Litres/min)	Head generated by pump-1, H_1 (bar)	Head generated by pump-2, H_2 (bar)	Head generated by combined (series), H (bar)	Summation of separate heads (H_1+H_2) bar
01	10	1.4	1.4	2.8	2.8
02	20	1.1	1.0	2.1	2.1
03	30	0.8	0.8	1.6	1.6
04	40	0.6	0.5	1.1	1.1
05	50	0.4	0.3	0.6	0.7

For parallel connection:-

Table 2: Data Table for Parallel Connection.

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Graph 2

Head vs discharge
for parallel connection

Along x axis 10 square = 0.5 bar
Along y axis 1 square = 1 L/min

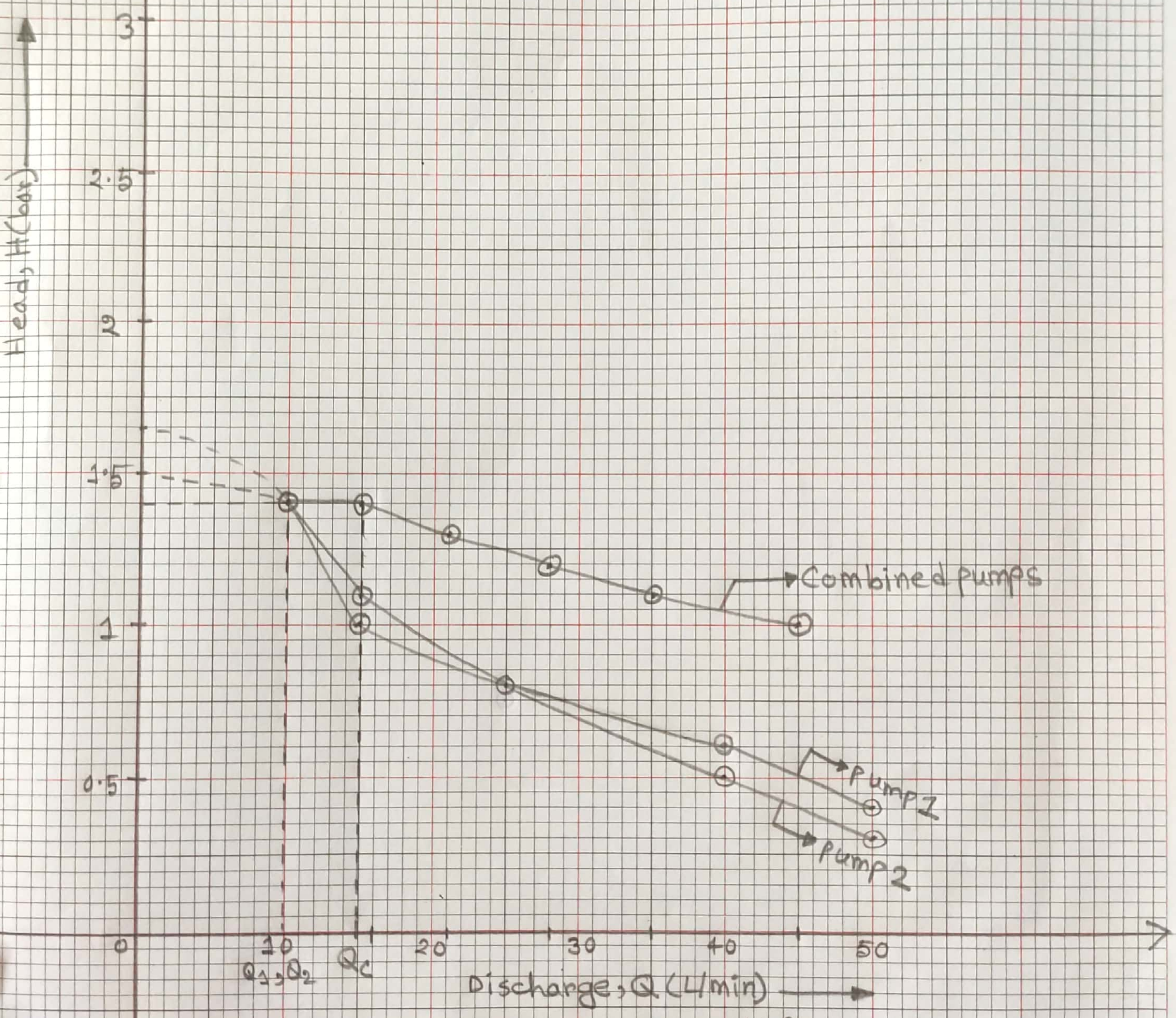

Figure 3: Performance curves for centrifugal pumps (H vs Q) in parallel

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SL NO.	Head (bar)	Discharge (litres/min)
01	1	45
02	1.1	35
03	1.2	28
04	1.3	21
05	1.4	16

Discussions:

In this experiment, centrifugal pumps were connected in series and parallel to determine the head/discharge characteristics at same speed. When the pumps were connected in series, the graph was shown that head was decreased when the discharge was increased. The combined pumps had lower head (H_c) than pump-I and pump-2. When the pumps were connected in parallel, the combined pumps discharge was compared to the individual pumps and which was lower than individuals. At some point, the individual pumps and combined pumps were given the different value which was decreased discharge with respect to increase the head.

Conclusions:

In this experiment, Centrifugal pumps performance test were obtained and it was seen that $H_c < (H_1 + H_2)$ when the pumps were connected in series. For parallel connection, $Q_c < (Q_1 + Q_2)$ which was obtained from the graph. For both connections, valves were opened/closed at different condition. The speed was constantly maintaining at same value in this whole experiment.

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DEPARTMENT OF
CE/EEE/ME/CSE/ETE/IPE/URP/GCE/MTE/ARCH/CFPE/MSE/ECE/BCE ENGINEERING

Expt. No 04

Name of Expt. Determination of calorific value by Bomb Calorimeter

SUBJECT: Thermodynamics Sessional	SUBMITTED BY:
COURSE NO: ME 2102	NAME: Md. Taslim Alam Rafi
DATE OF EXP.: 09-11-2020	CLASS: 2nd year odd semester
DATE OF SUB.:	ROLL NO: 1802161
GROUP:	SESSION: 2018-19

Name of the experiment:

Determination of calorific value of given fuel by bomb calorimeter.

Objectives:

i. To know the calorific value of a given fuel (Diesel).
ii. To know the functions of a bomb calorimeter.
iii. To know the applications of a bomb calorimeter.

Theory:

The calorific value or heat value of a solid or liquid fuel may be defined as the amount of heat given out by the complete combustion of 1 kg of fuel. It is expressed in terms of kJ/kg of fuel. There are two types of calorific values: Higher calorific value, Lower calorific value. The method of determining higher calorific value by Dulong's formula gives approximate result only. The most satisfactory method of obtaining the calorific value of fuel is by actual experiment. In all these experimental methods, a known mass of fuel is burnt in a suitable calorimeter and the heat so evolved is found by measuring the rise in temperature of the surrounding water. The calorimeter used for finding the calorific value of fuels are known as fuel calorimeter. Bomb calorimeter is one kind of fuel calorimeter. It is used for finding the higher calorific value of solid and liquid fuels. In this calorimeter the fuel is burnt at a constant volume and under a high pressure in a closed vessel called bomb. The bomb is made mainly of acid-resisting stainless steel, machined from the solid metal, which is capable of withstanding high pressure, heat and corrosion. The cover or head of the bomb carries the oxygen valve for admitting oxygen and a release valve for exhaust gases. A cradle or carrier ring, carried by the ignition rods, supports the silica crucible, which in turn holds the sample of fuel under test. There is an ignition wire of platinum or nichrome which dips into the crucible. It is connected to a battery, kept outside, and can be sufficiently heated by passing current through it so as to ignite the fuel.

The bomb is completely immersed in a measured quantity of water. The heat, liberated by the combustion of fuel, is absorbed by this water, the bomb and copper vessel. The rise in the temperature of water is measured by a precise thermometer, known as Beckmann thermometer which reads upto 0.01°c.

Theoretical higher calorific value of a fuel

$$= \frac{(m_w + m_e) \times C_w (t_2 - t_1)}{m_f} \quad \text{------} \quad (1)$$

Where, m_w = Mass of water filled in the calorimeter in kg.
m_e = Water equivalent of apparatus in kg.
C_w = Calorific value of water.
m_f = Mass of fuel burnt in the bomb in kg.
t_1 = Initial temperature of water and apparatus in °C.
t_2 = Final temperature of water and apparatus in °C.

And experimental higher calorific value is,

$$H.C.V. = \frac{w \times (t_2 - t_1)}{m_f} \quad \text{.........} (2)$$

Apparatus :

1. Bomb calorimeter - parts of a bomb calorimeter is,
   i. Small cup, contain the sample
   ii. Oxygen
   iii. A stainless steel bomb
   iv. Water
   v. Stirrer
   vi. Thermometer
   vii. The dewar - Prevents heat flow
   viii. Ignition circuit.
2. Fuel - Diesel
3. Power source.

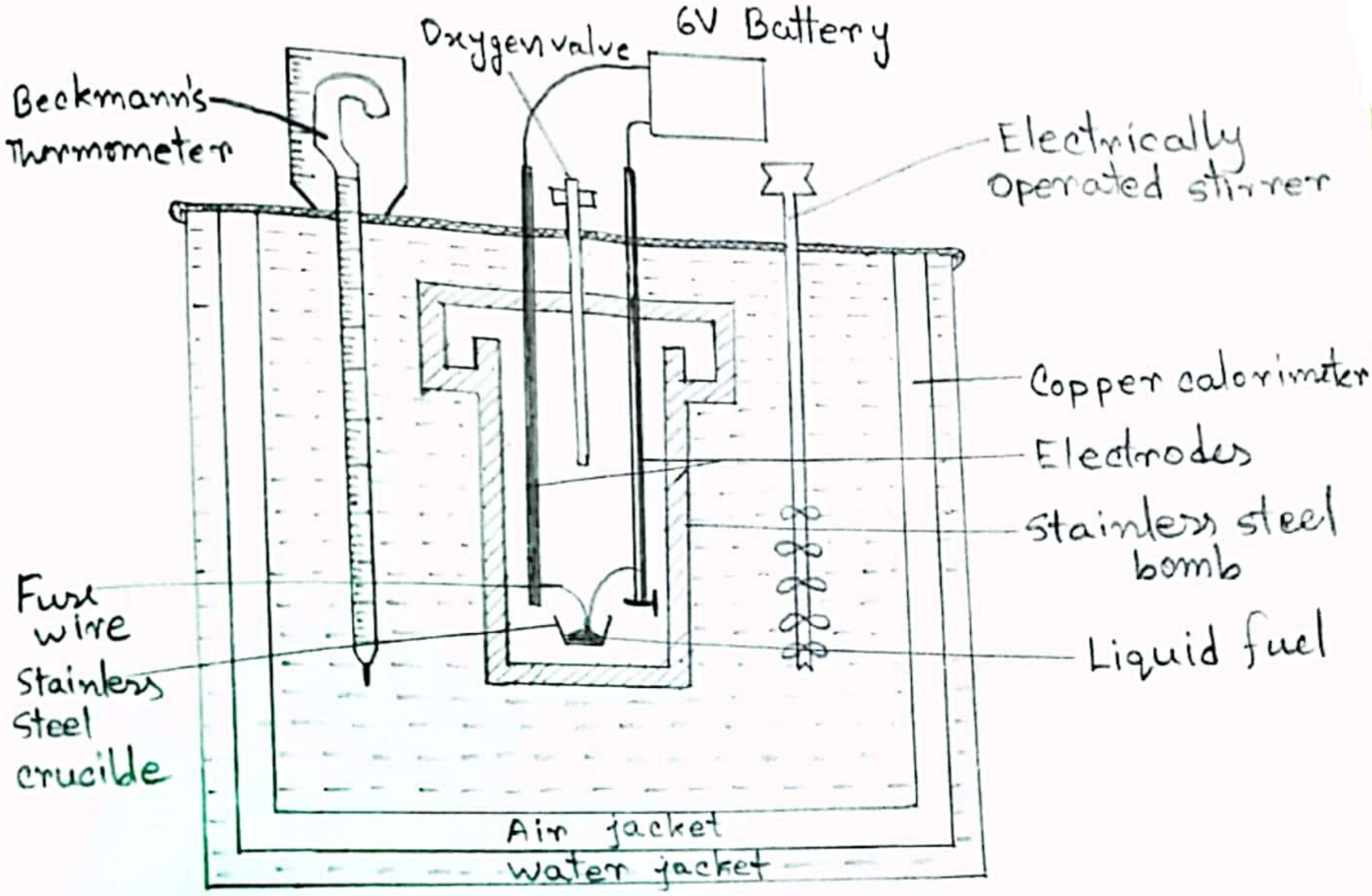


Figure: Bomb Calorimeter

Working Procedure :

i. Firstly, a small amount of diesel was taken in the small cap and the ignition wires were immersed into the fuel.

ii. Then it was put in a tight vessel with a tight screw cap. And the vessel was put into a cylindrical drum filled with water.

iii. Then the outer cylinder was also tightened so that no heat transfer with the environment takes place.

iv. After that oxygen was filled through a hoss pipe to the fuel containing vessel at high pressure.

v. Then the temperature of water was taken using thermometer.

vi. After the electric ignition, again the temperature of water was noted quickly.

Data :

$m_f = 1 \times 10^{-3}$ kg

$m_w = 2$ kg

$m_e = 0.39$ kg

$t_1 = 19°C$

$t_2 = 23.5°C$

Length of fuse wire = 10 cm

Pressure of oxygen = 35 PSI

Calorific value of water, $C_w = 4.2$ kJ/kgK

Calculations :

$$\text{Theoretical H.C.V} = \frac{(m_w + m_e) \times C_w \times (t_2 - t_1)}{m_f}$$

$$= \frac{(2 + 0.39) \times 4.2 \times 4.5}{1 \times 10^{-3}}$$

$$= 45171 \text{ kj/kg}$$

$$\text{Experimental H.C.V} = \frac{w \times (t_2 - t_1)}{m_f}$$

$$= \frac{2426 \times 4.5}{1 \times 10^{-3}} = 1091.7 \text{ cal/gm}$$

$$= 45851.4 \text{ kJ/kg}$$

$$\text{Error} = \frac{45851.4 - 45171}{45171} \times 100$$

$$= 1.5\ \%$$

Result :

Theoretical H.C.V = 45171 kJ/kg
Experimental H.C.V = 45851.4 kJ/kg
Error = 1.5 %

Discussion :

Determination of calorific value using bomb calorimeter was done to know the process of a bomb calorimeter. After getting a result from that experiment error was noticed. The error was neglegible. The error was occured as in application. complete combustion of any fuel is not possible, also the heat insulation is not possible fully. In the end, some heat would cross the boundary of the drum. Thus the error is inevitable.

Precautions:

(I) The cap of the fuel containing vessel must be tightly fitted.
(II) Do not put a sample in the bomb that will react explosively.
(III) Do not overcharge the bomb with oxygen.
(IV) Make sure the bomb is completely submerged and electrodes attached before firing.
(V) The ignition circuit wires must not contact the body of the fuel containing cup.
(VI) The fan or impellar should be rotated properly to mixup the heat with water properly.

Conclusion:

It is necessary to measure the calorific value of a fuel before using it in any heat engine. A good fuel gives a good performance of a heat engine. A fuel ~~is~~ good or bad is determined by its calorific value. A good fuel always have a higher calorific value. This higher calorific value of any fuel can be measured by this experiment.

Title:

Determination of calorific value of given fuel by bomb calorimeter.

Objectives:

i. To know the calorific value of given fuel.

ii. To know the function of bomb-calorimeter

iii. To know the applications of bomb-calorimeter

Theory:

The calorific value of a fuel is defined as the heat generated by burning 1 kg of fuel completely. Calorimeter is a device which is used to calculate the calorific value of solid, liquid and gaseous fuel.

A bomb calorimeter is a type of constant volume calorimeter used in measuring of heat of combustion of particular reaction. It consists of stainless steel of the boundary. The fuel is placed on the crucible and is fully submerged under water. Then it's fully covered by stainless steel. The oxygen is admitted through the oxygen value till 30 atmosphere. The fuel is ignited using a battery. The temperature reading are taken using Becumann thermometer.

Data:

Higher calorific value, H.C.V. = $\frac{(m_w + m_e) C_w (t_2 - t_1)}{m_f}$ kJ/kg

m_f = Mass of fuel sample burnt inside the bomb calorimeter in kg (diesel) = 1 g

m_w = Mass of water filled in the calorimeter in kg = 2 kg

m_e = mass of the equivalent of apparatus in kg = 0.30 gm

t_1 = Initial temerature of water and apparatus in °C = 30°C

t_2 = Final temperature of water & apparatus in °C. = 34.5°C

Length of fuse wire = 10 cm

Pressure of oxygen = 35 PSI

Calculations:

$$\text{Theoritical H.C.V.} = \frac{(m_w + m_e) \times C_w \times (t_2 - t_1)}{m_f} \text{ kJ/kg}$$

$$= \frac{(2 + 0.390) \times 4.2 \times (34.5 - 30)}{10^{-3}}$$

$$= 45171 \text{ kJ/kg}$$

$$\text{Experimental H.C.V.} = \frac{W \times (t_2 - t_1)}{m_f} \text{ cal/gm}$$

$$= \frac{2426 \times (34.5 - 30)}{1} \text{ cal/gm}$$

$$= 10917 \text{ cal/gm}$$

$$= \frac{10917 \times 4.2 \times 1000}{1000} \text{ kJ/kg}$$

$$= 45851.4 \text{ kJ/kg}$$

$$\text{Error:} \quad \frac{45171 - 45851.4}{45171} \times 100\% = -1.506\%$$

Result:

Theoritical Higher calorific value of diesel is 45171 kJ/kg and experimental H.C.V. of diesel is 45851.4 kJ/kg

Discussion:

Calorific value is the total quantity of heat liberated by combustion of unit mass as unit volume of given fuel. There were some difference between theoritical and experimental value due to some technical difficulties. Calorific value is an excellent characteristics of fuel: The higher calorific value, the higher amount of heat we will get.

Conclusion:

Using bomb calorimeter we have measured the calorific value of diesel. The theoritical value is 45171 kJ/kg. In the experiment we got 45851.4 kJ/kg

Title: Study and performance test of a four stroke diesel engine.

Objectives:

(i) To perform a load test on four stroke diesel engine to study its performance.

(ii) To plot the following engine performance graph based on the experiment.

(iii) To know the actual efficiency of diesel engine.

Theory:

Diesel engine is an internal combustion engine in which heat is produced by the compression of air and fuel in the cylinder.

The four stroke diesel engine is an internal combustion engine in which the piston completes four seperate strokes while turning a crank-shaft. A stroke refers to the full travel of the piston along the cylinder, in either direction.

Data table:

No. of Observation	Speed of the engine in RPM N	Fuel consumption time for 10 cc. t (sec)	Brake Load W (lb)	Diameter of the flywheel L (inch)
1	966.6	87	4.1	13
2	966.6	80	5.6	13
3	966.6	73	7.1	13
4	966.6	66	8.6	13
5	966.6	59	10.1	13

Calculation:

Diameter of the flywheel (L) in meter = 0.332 m

Brake load in Newton:

$W_1 = 18.23$

$W_2 = \cancel{2.54}\ 24.89$

$W_3 = 31.56$

$W_4 = 38.23$

$W_5 = 44.90$

Fuel density = 0.86 gm/cc

$$\text{Brake power (BP)} = \frac{2\pi N W L}{60}$$

$$BP_1 = \frac{18{\cdot}23 \times 2\pi \times 966{\cdot}6 \times 0{\cdot}332}{60}$$

$$= 612{\cdot}63 \text{ W}$$

$$BP_2 = \frac{2\pi \times 966{\cdot}6 \times 24{\cdot}89 \times 0{\cdot}332}{60}$$

$$= 836{\cdot}45 \text{ W}$$

$$BP_3 = \frac{2\pi \times 966{\cdot}6 \times \overset{31{\cdot}56}{\cancel{24{\cdot}89}} \times 0{\cdot}332}{60}$$

$$= 1060{\cdot}6 \text{ W}$$

$$BP_4 = \frac{2\pi \times 966{\cdot}6 \times 38{\cdot}23 \times 0{\cdot}332}{60}$$

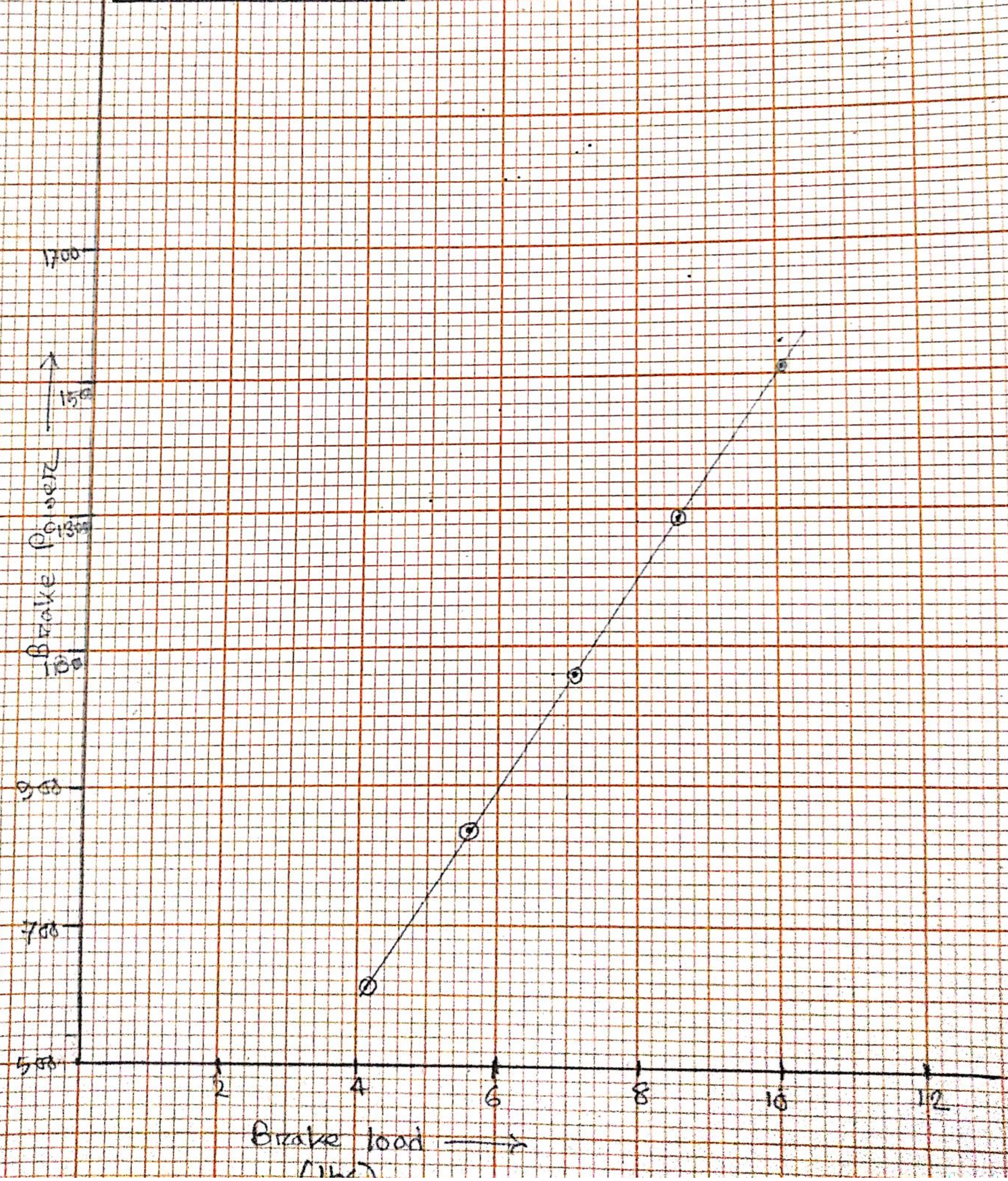
$$= 1284{\cdot}75 \text{ W}$$

$$BP_5 = \frac{2\pi \times 966{\cdot}6 \times 44{\cdot}9 \times 0{\cdot}332}{60}$$

$$= 1508{\cdot}90 \text{ W}$$

Brake load Vs Brake power graph

Along x axis, 1 small square = 0.2 unit
Along y axis, 1 small square = 20 unit



mass of 10 cc Diesel ~~fuel~~ $= \frac{10}{1000} \times 0.86$ kg

$= 8.6 \times 10^{-3}$ kg

Fuel consumption rate $(mf) = \dfrac{\text{mass of 10 cc fuel}}{\text{Consumption time for 10 cc fuel}}$

$$mf_1 = \frac{8.6 \times 10^{-3}}{87/3600} = 0.356 \text{ kg/hr}$$

$$mf_2 = \frac{8.6 \times 10^{-3}}{80/3600} = 0.387 \text{ kg/hr}$$

$$mf_3 = \frac{8.6 \times 10^{-3}}{\cancel{80}78/3600} = 0.424 \text{ kg/hr}$$

$$mf_4 = \frac{8.6 \times 10^{-3}}{66/3600} = 0.469 \text{ kg/hr}$$

$$mf_5 = \frac{8.6 \times 10^{-3}}{59/3600} = 0.525 \text{ kg/hr}$$

Specific fuel consumption $= \dfrac{m_f}{B.P.}$

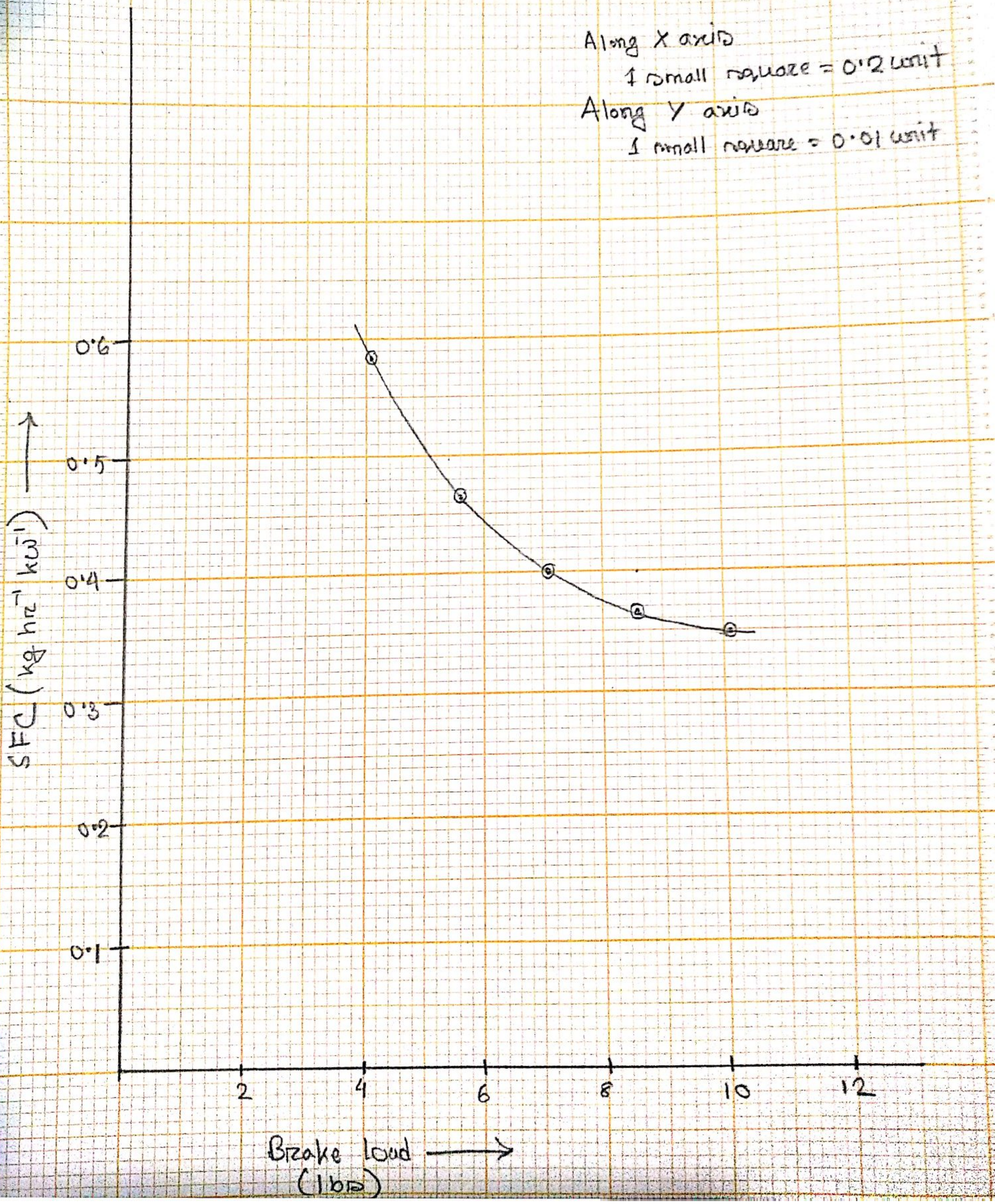
$$SFC_1 = \frac{mf_1}{BP_1} = \frac{0.356}{0.613} = 0.581 \text{ kg hr}^{-1}\text{kW}^{-1}$$

$$SFC_2 = \frac{mf_2}{BP_2} = \frac{0.387}{0.836} = 0.463 \text{ kg hr}^{-1}\text{kW}^{-1}$$

$$SFC_3 = \frac{mf_3}{BP_3} = \frac{0.424}{1.061} = 0.399 \text{ kg hr}^{-1}\text{kW}^{-1}$$

$$SFC_4 = \frac{mf_4}{BP_4} = \frac{0.469}{1.285} = 0.365 \text{ kg hr}^{-1}\text{kW}^{-1}$$

$$SFC_5 = \frac{mf_5}{BP_5} = \frac{0.525}{1.509} = 0.348 \text{ kg hr}^{-1}\text{kW}^{-1}$$



Along X axis
1 small square = 0·2 unit
Along Y axis
1 small square = 0·01 unit
0·6
0·5
0·4
0·3
0·2
0·1
SFC (kg hr⁻¹ kW⁻¹)
2
4
6
8
10
12
Brake load
(lbs)

$$\text{Thermal efficiency} = \frac{\text{Brake Power} \times 3600}{mf \times \text{calorific value of fuel}}$$

$$\eta_1 = \frac{BP_1 \times 3600}{\cancel{0.356}\, mf_1 \times 44500} = \frac{0.613 \times 3600}{0.356 \times 44500}$$

$$= 0.139$$

$$\eta_2 = \frac{0.836 \times 3600}{0.387 \times 44500} = 0.175$$

$$\eta_3 = \frac{1.061 \times 3600}{0.424 \times 44500} = 0.202$$

$$\eta_4 = \frac{1.285 \times 3600}{0.469 \times 44500} = 0.222$$

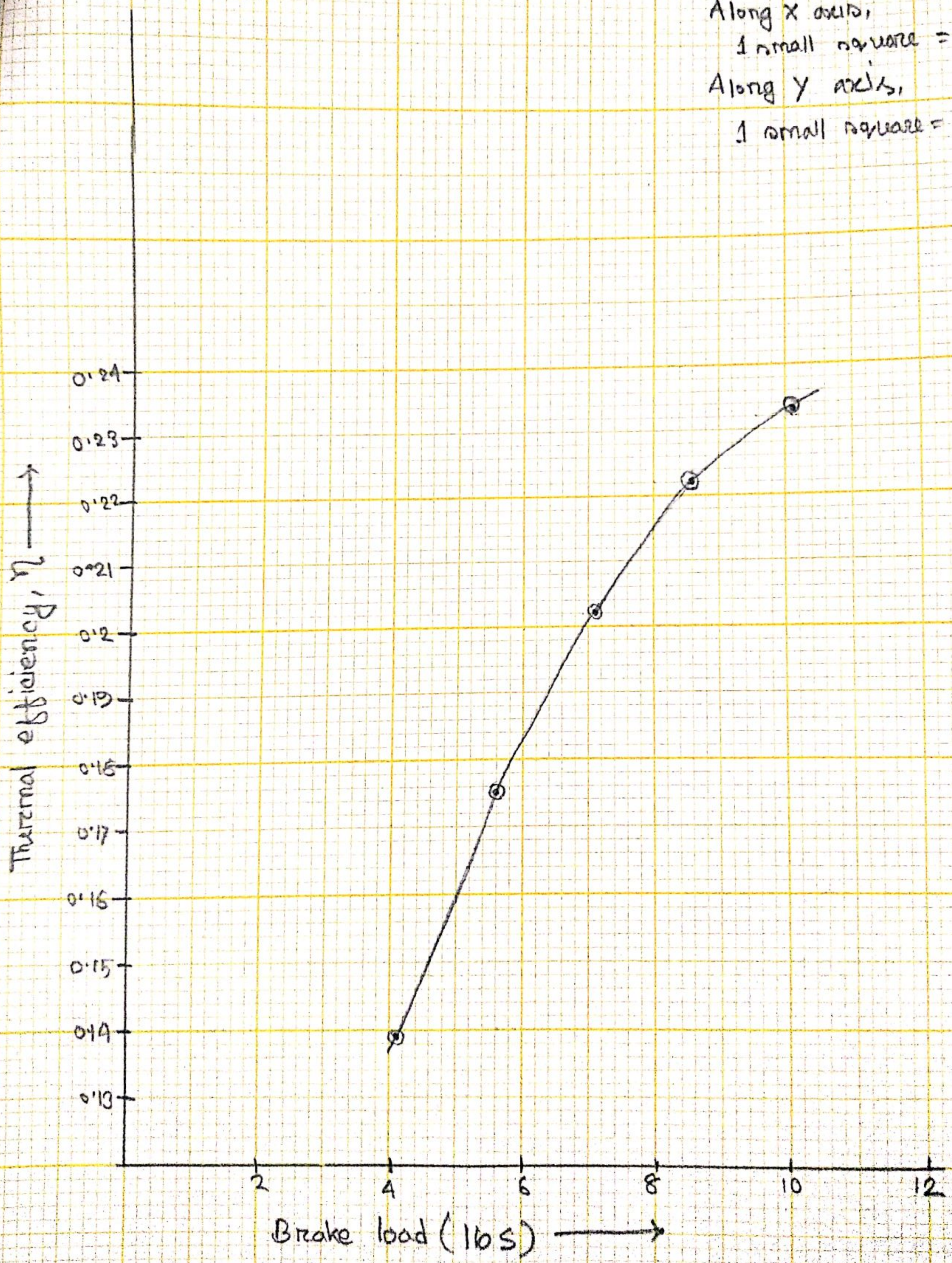
$$\eta_5 = \frac{1.509 \times 3600}{0.525 \times 44500} = 0.233$$

$$\text{mean efficiency}, \eta = \frac{0.139 + 0.175 + 0.202 + 0.222 + 0.233}{5}$$

$$= 0.1942$$

$$= 19.42\,\%$$

Along X axis,
1 small square = 0·2 unit
Along Y axis,
1 small square = 0·002 unit



Discussion:

In mechanical engineering, diesel engine is one of the most vital and widely used machine. Performance of an engine is denoted by the ~~ef~~ thermal efficiency of that engine. In this experiment the brake power and fuel consumption rate was measured in order to calculate the thermal efficiency.

conclusion:

Diesel engine is used in heavy duty work and where efficiency is important. So, performance test of a four stroke diesel engine is an important experiment ~~whi~~ to learn which can applied in practical life.

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Expt. No 05

Name of Expt Study of a refrigeration system

SUBJECT: Thermodynamics Sessional	**SUBMITTED BY:**
COURSE NO: ME - 2102	**NAME:** Md. Taslim Alam Rafi
DATE OF EXP.: 09-11-2020	**CLASS:** 2nd year odd semester
DATE OF SUB.:	**ROLL NO:** 1802161
GROUP:	**SESSION:** 2018-19

Name of the experiment:

Study of a Refrigeration system.

Objectives:

i. To know the main parts of a vapour compression refrigeration system.
ii. To know the working principle of a refrigeration cycle.
iii. To know the application of a refrigeration system.

Theory:

Refrigeration is the transportation of heat from one location to another location to lower the temperature in an controlled environment. A vapour compression refrigeration system is an improved type of air refrigeration system in which a suitable working substance, termed as refrigerant, is used. In this system the refrigerant undergoes phase changes. It condenses and evaporates at temperature and pressures close to the atmospheric conditions. The refrigerants usually used for this purpose are amonia, carbon dioxide and sulphur dioxide. The refrigerant used, doesnt leave the system, but is circulated throughout the system alternately condensing and evaporating. In evaporating the refrigerant absorbs its latent heat from the brine which is used for circulating it around the cold chamber. While condensing it gives out its latent heat to the circulating water of the cooler. The vapour compression refrigeration system is, therefore, a latent heat pump, as it pumps its latent heat from the brine and delivers to the cooler.

Main Components :

i. Compressor
ii. Condenser
iii. Receiver
iv. Expansion valve
v. Evaporator

Study of main components :

i. Compressor : It is a mechanical device that compresses gaseous fluid from low temperature and pressure to high temperature and pressure.

ii. Condenser : It is a set of pipes immersed into cooler environment. It's purpose is to condense the vapour refrigerant to liquid.

iii. Receiver : Here all the refrigerant gets stock.

iv. Expansion valve : It expands the refrigerants volume to reduce pressure. It akts like a throttle valve.

v. Evaporator : The space from where the refrigerant absorb latent heat and vaporizes. It is the desired space for this system.

Working Principle :

i. The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to a high pressure and temperature. This high pressure and temperature vapour refrigerant is discharged

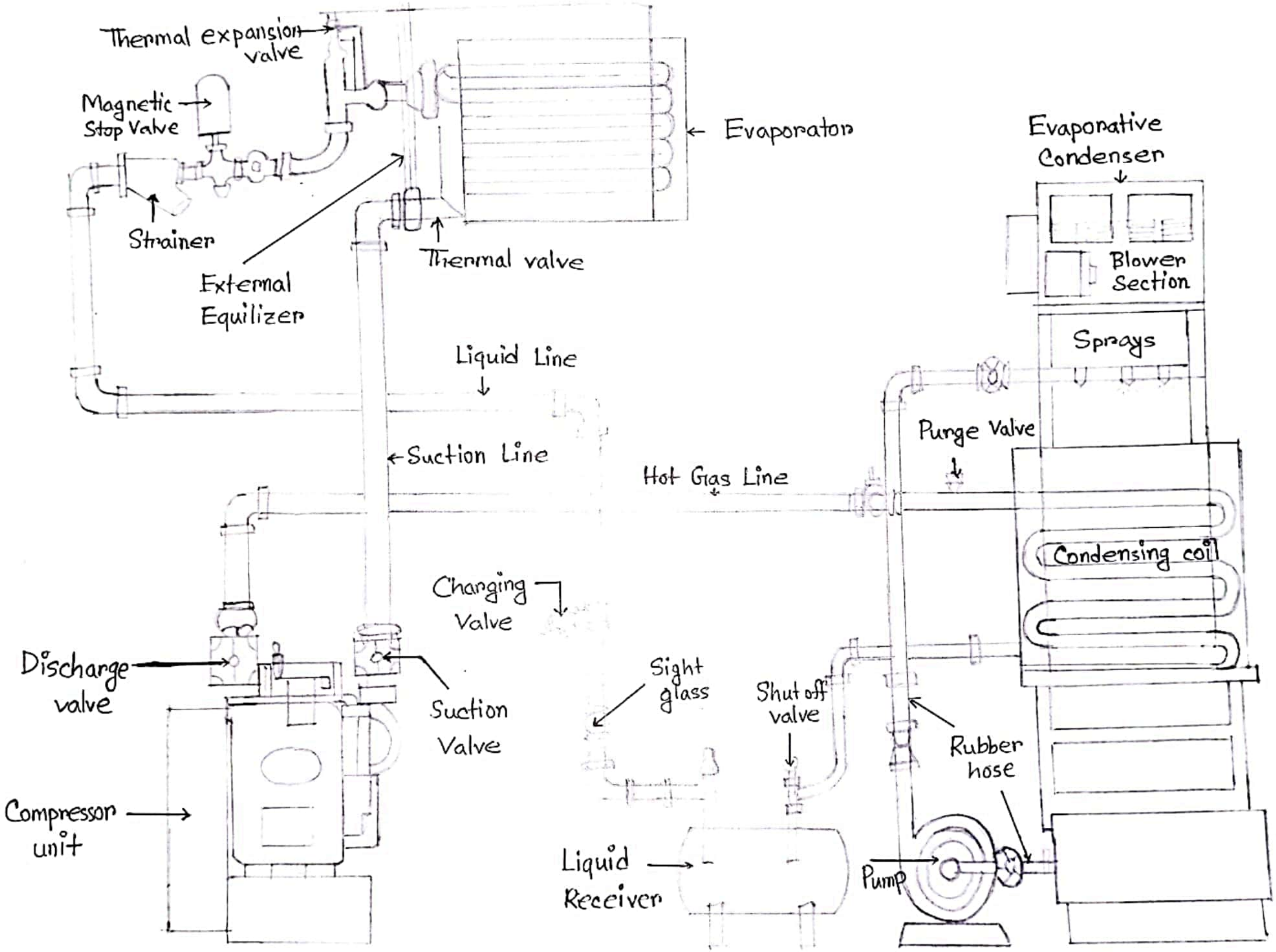

Fig. Vapour Compression Refrigeration System into the condenser through the delivery or discharge valve.

ii. The refrigerant, while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water.

iii. The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve.

iv. Some of the liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporised in the evaporator at the low pressure and temperature.

v. In evaporating, the liquid vapour refrigerants absorbs its latent heat of vaporisation from the medium which is to be cooled.

Discussion :

The vapour compression refrigeration system has smaller size for the given capacity of refrigerant. Though its initial cost is high, the running cost is less. It can be employed over a large range of temperatures. The coefficient of performance is quite high. In any compression refrigeration system, there are two different pressure conditions. One is called high pressure side and another is called low pressure side. The high pressure side includes the discharge line, receiver and expansion valve. The low pressure side includes the evaporator, piping from the expansion valve to the evaporator and the suction line.

Precautions:

(i) The pipeline containing high pressurized fluid must be sufficiently able to keep its pressure all together.

(ii) A proper refrigerant is essential for this refrigeration system. For household uses, toxic and flammable refrigerant should be avoided.

(iii) Leakage of the refrigerant is the major problem in vapour compression system. So any kind of fault in desigining a refrigeration system must be avoided.

(iv) The refrigerant must not be corrosive to the device.

Conclusion:

A vapour compression refrigerant system is an improved type of air refrigeration system. Nowadays it is used for all purpose refrigeration. It is generally used for all industrial purposes from a small domestic refrigerator to a big air conditioning plant. The continuous improvements made it possible to have vapour-compression refrigeration systems that were relatively efficient, reliable, small and inexpensive.