TRIBHUVAN UNIVERSITY
Institute of Engineering,
Pulchowk Campus

A
REPORT
ON

CENTRIFUGAL PUMP EXPERIMENT

LAB No: 01

EXPERIMENT DATE: 2082-02-22

SUBMITTED DATE: 2082-03-12

SUBMITTED BY:

Name: Surendra Sharma
Group: H1
Roll No: 078BCE178

03-12

SUBMITTED TO:

Department of
Civil Engineering
(Hydraulics Lab)

CENTRIFUGAL PUMP EXPERIMENT

OBJECTIVE

To determine the operating characteristics of a centrifugal pump.

APPARATUS

(a) Pump testing unit

THEORY:

(a) Mechanical power input = $\frac{2\pi NT}{60}$ watt

where, N = Revolutions per minute

T = Torque = F * torque arm radius (NM) (Newton metre)

F = Load in N. (Newton)

(b) Hydraulic power output = $\gamma Q H$ watts

where,

γ = specific weight in N/m^3 (9810) ← water

Q = Discharge in N/m^3

H = Total head in m. (suction + delivery) * 10-3

Discharge through the venturimeter is given by

$Q = 0.0938 \sqrt{H}$ liters/sec

where, H = Head of mercury in mm.

(c) Efficiency = $\frac{\text{output}}{\text{input}} \times 100\%$.

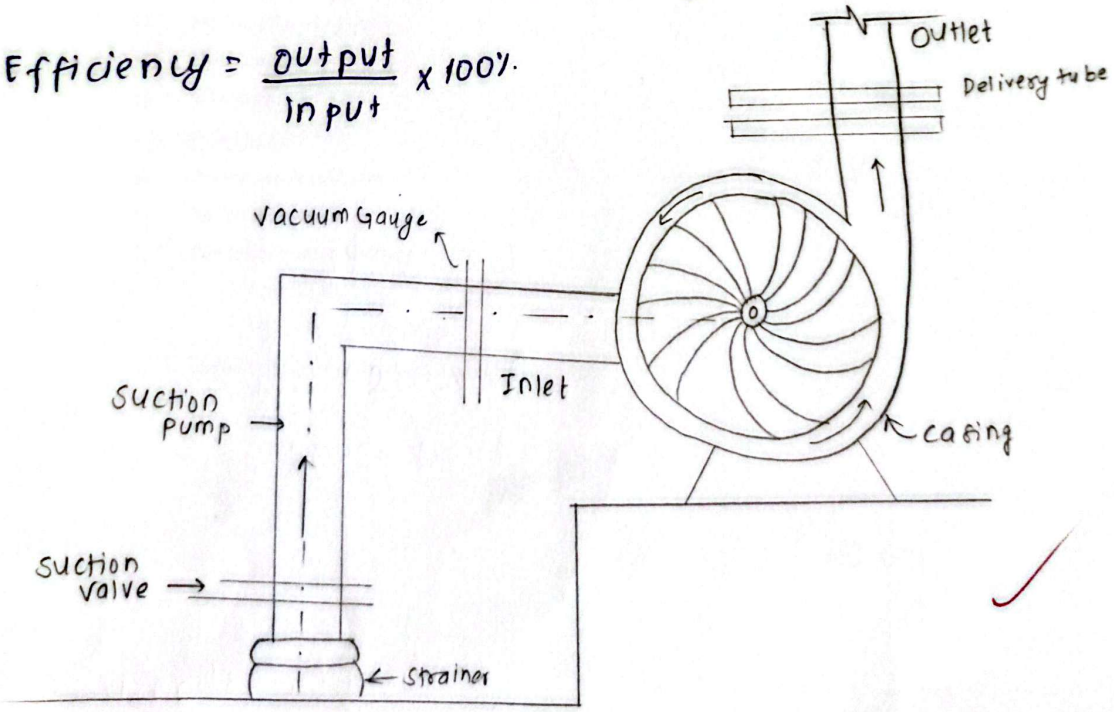


Fig: Experimental setup of centrifugal pump.

(c) adjust the flow in stages by operating the discharge valve. adjustment so speed may be necessary at each stage.

(f) Record (c) and (d) at each flow stage.

(g) Take five different reading until the mercury manometer reads 350mm of

(h) Repeat steps (a) to (g) for pump speed of 2600 revs/ min. and 2400 revs/min.

Number of observations	Pump speed rpm	Force N	Pressure		Manometer reading mm Hg
			Suction (P_2)	Delivery (P_1)	
1					240
2			0.15	0.35	225
3	2800		0.2	0.3	210
4			0.25	0.3	199
5			0.3	0.25	188
1		6	0.1	0.3	199
2			0.16	0.25	185
3	2600		0.2	0.25	170
4			0.26	0.20	156
5			0.32	0.2	144
1		5	0.1	0.2	156
2			0.16	0.2	142
3	2400		0.2	0.15	126
4			0.26	0.15	115
5			0.32	0.10	104

CALCULATION :

a) Discharge through the pump

b) Mechanical power point

c) Hydraulic power point.

d) Efficiency.

PRESENTATION :

a) Show a sample calculation

b) Present the result in a tabular form.

c) Plot pressure versus discharge

Power discharge

Efficiency versus discharge

d) Show the figure of the apparatus and simple description.

OBSERVATION & CALCULATION:-

No. of Observations	Pump Speed (rpm)	Force (N)	Pressure		Manometer Reading mm Hg	Head (m)	Discharge, Q ($\times 10^{-3}$) m^3/s	Torque (Nm)	Power		Efficiency η (%)
			Suction (P_2) (-ve)	Delivery (P_1) (+ve)					Input (W)	Output (W)	
1	2800	6	0.1	0.35	240	4.64	1.453	1.074	314.91	66.07	20.98
2		6	0.15	0.35	225	5.15	1.407	1.074	314.91	71.08	22.57
3		6	0.2	0.30	210	5.15	1.359	1.074	314.91	68.67	21.81
4		6	0.25	0.30	199	5.67	1.323	1.074	314.91	73.54	23.35
5		6	0.3	0.25	188	5.67	1.286	1.074	314.91	71.47	22.70
1	2600	6	0.1	0.30	199	4.12	1.323	1.074	292.42	53.48	18.29
2		6	0.16	0.25	185	4.22	1.276	1.074	292.42	52.85	18.07
3		6	0.2	0.25	170	4.64	1.223	1.074	292.42	55.61	19.02
4		6	0.26	0.20	156	4.74	1.172	1.074	292.42	54.45	18.62
5		6	0.32	0.20	144	5.36	1.126	1.074	292.42	59.14	20.22
1	2400	5	0.1	0.20	156	3.09	1.172	0.895	224.94	35.51	15.79
2		5	0.16	0.20	142	3.71	1.118	0.895	224.94	40.66	18.08
3		5	0.2	0.15	126	3.61	1.053	0.895	224.94	37.24	16.55
4		5	0.26	0.15	115	4.22	1.006	0.895	224.94	41.67	18.51
5		5	0.32	0.10	104	4.33	0.956	0.895	224.94	40.60	18.05

Head, $H = (P_1 - P_2) * 10.3$ m

$Q = 0.0938\sqrt{h} * 10^{-3}$ m^3/sec

↕ Manometric head in mm

Torque, T = Force * Torque arm (R)

↕ 179mm = 0.178m

Power Input $= \frac{2\pi N T}{60}$ Watt (pump speed (rpm))

Power output $= \gamma Q H$ $[\gamma = 9810 N/m^3]$

Efficiency, $\eta = \frac{P_{out}}{P_{in}} \times 100\%$

Experiment No. 1: Centrifugal Pump Experiment

Roll No.: 078BCE178 Obs No.: 14 Date: 2082/02/22

OBSERVATION

Table 1: Observation table

No. of Observations	Pump Speed (rpm) (N)	Force (Newton) (F)	Pressure		Manometer reading in mm of Hg (h)
			Delivery (P1)	Suction (P2) (-ve)	
1	2400	5	0.26	0.15	115

Totque arm radius in metre(R) = 179mm = 0.179m

SAMPLE CALCULATION

Determination of Input Power

$Torque(T) = F * R$ = 0.895 Nm

$Input\ Power = \frac{2\pi NT}{60}$ = 224.94 Watt

Determination of Output Power

$Q = 0.0938\sqrt{h}\ liters/sec$ = $1.006 \times 10^{-3}\ m^3/sec$ (*h is the manometric head in mm*)

and convert Q in m3/s

$H = (P1 - P2) * 10.3\ m$ = $(0.26 - (-0.15)) \times 10.3 = 4.22\ m$ (*H is the total head in m*)

$Output\ Power = \gamma QH\ watts$ = 41.65 W (γ=9810 N/m3)

Determination of Efficiency

$Efficiency = \frac{Output}{Input} * 100\%$ = 18.51 %

Gyoshi
02-22.

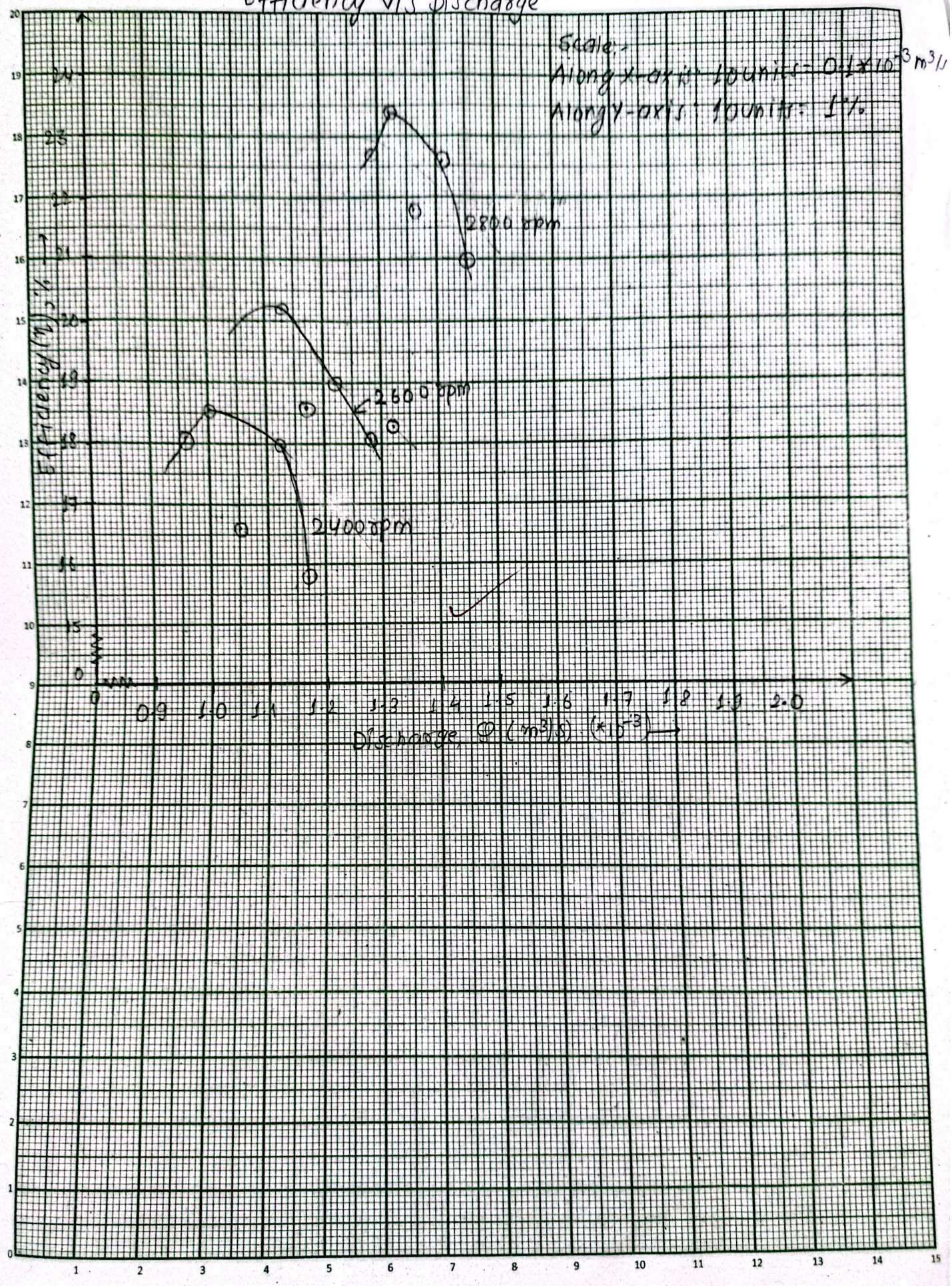
Rem $\left(\frac{178}{15}\right)$ + 1 obs

- Formula
- obs table
- NO procedure
- η vs totalhead
- η vs
- Rem mm.

+ 2600, 2400, 2200

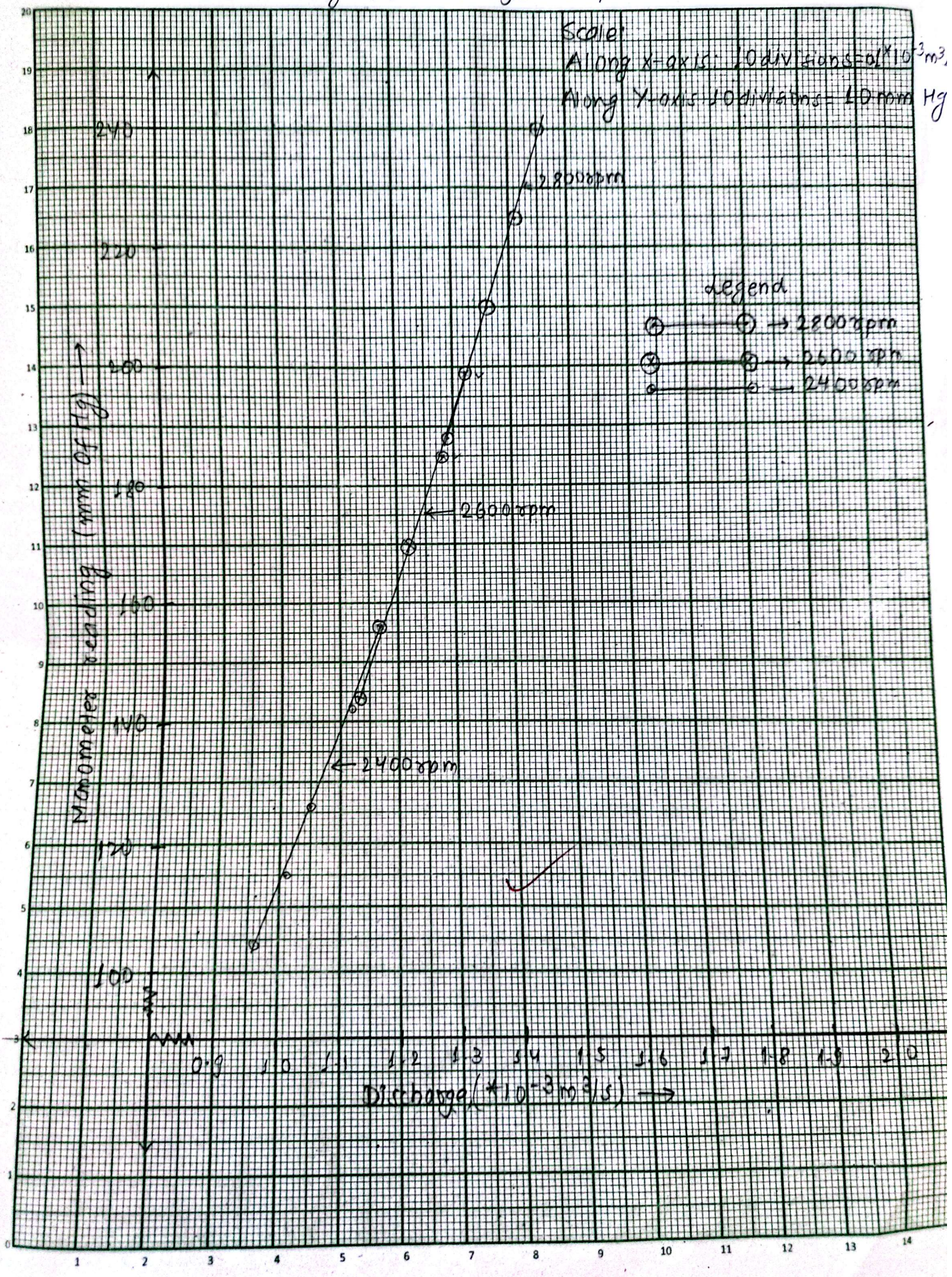
078BEE178

Efficiency V/S Discharge

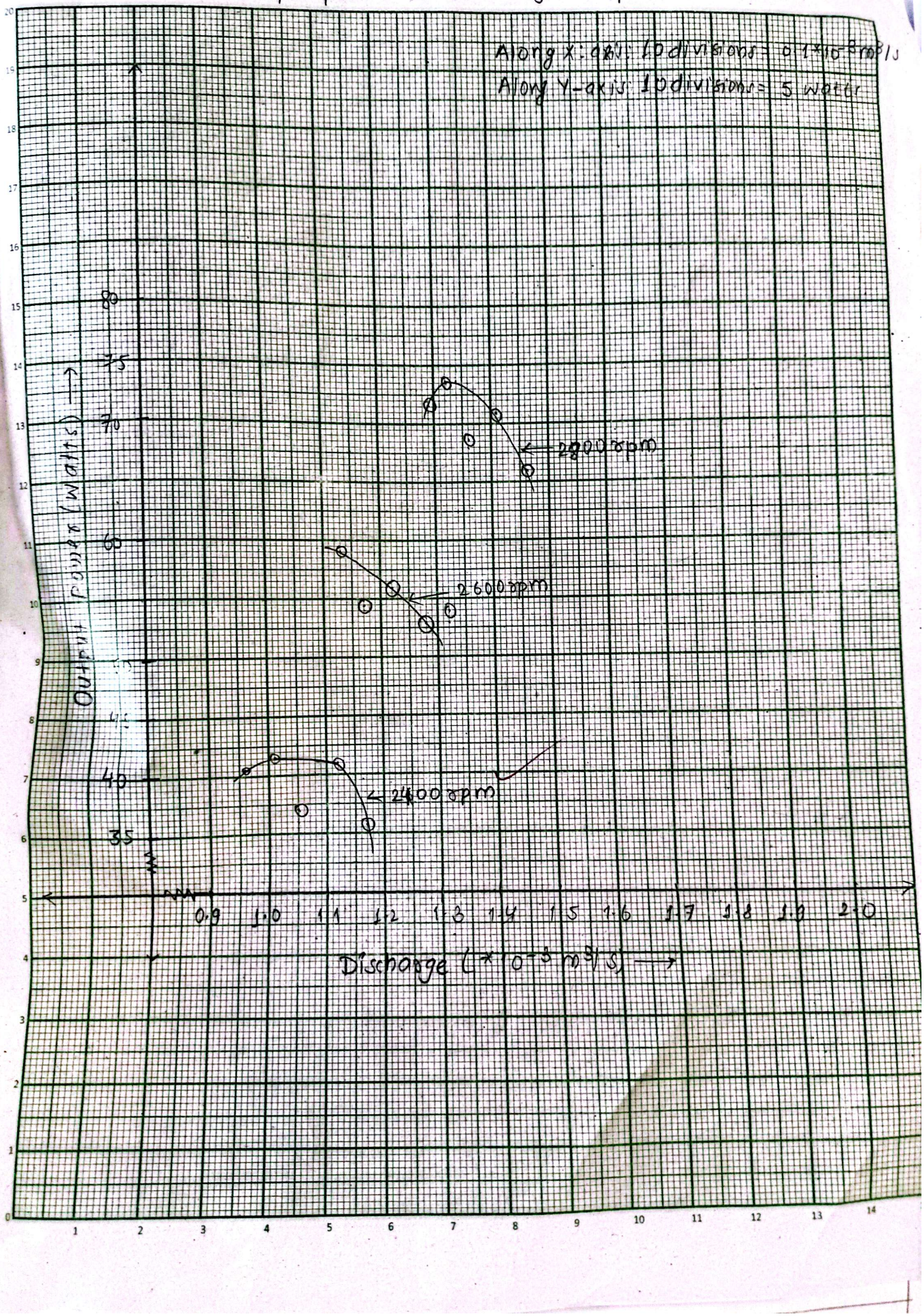


Manometer Reading V/S Discharge Graph

078BCE178



Output power Vs Discharge Graph. 078BCE178



Sample calculation:

Pump speed (N) = 2400 rpm

Force (F) = 5N

Suction Head (P_2) = 0.32 m

Delivery Head (P_1) = 0.10m

Manometer Reading (h) = 104 mm of Hg

Torque arm radius (R) = 0.179m

So,

Head, $H = (P_1 - P_2) * 10.3 = (0.10 - (-0.32)) * 10.3 = 4.33$ m

Discharge, $Q = 0.0938\sqrt{104} * 10^{-3} = 0.956 * 10^{-3}$ m³/sec.

Torque (T) = $F * R = 5 * 0.179 = 0.895$ Nm

Input power (Pin) = $\frac{2\pi NT}{60} = \frac{2\pi * 2400 * 0.895}{60} = 224.94$ watts

Output power (P_{out}) = $\gamma QH = 9810 * 0.956 * 10^{-3} * 4.33 = 40.60$ watts

Efficiency (η) = $\frac{P_{out}}{P_{in}} * 100\% = \frac{40.60}{224.94} * 100\% = 18.05\%$

COMMENTS

This lab includes determining operating characteristics of a centrifugal pump. The performance characteristics is represented by Efficiency ~ Discharge and output power ~ Discharge curve. Looking at the efficiency (average about 19.51% ≈ 20%) the pump is one of the low efficiency device. The pump, when speed is changed from maximum efficiency, the best efficiency shifts. when speed is increased, the curve shifts towards higher flow rate while it shifts over lower flow rate at decreased speed. The Efficiency ~ Discharge graph, peaks at mid-values and decreases at low and High flow rates. In the Hydraulic power output ~ Discharge curve, the power is decreasing at higher flow rates. The curves are not smooth which may be due to several error like calibration error, viewing error, etc. The Manometer reading ~ Discharge graph showed increasing manometer reading with discharge and speed.

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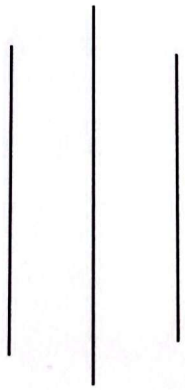
A
REPORT
ON

RECIPROCATING PUMP



LAB No: 02

EXPERIMENT DATE: 2082-03-12

SUBMITTED DATE: 2082-03-19

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03-22

SUBMITTED BY:

Name: Surendra Sharma
Group: H1
Roll No: 078BCE178

SUBMITTED TO:

Department of
Civil Engineering.

RECIPROCATING PUMP EXPERIMENT

OBJECTIVES

To determine the operating characteristics of a reciprocating pump.

SCOPE:

The adaptability of a reciprocating pump for different heads can be known from the characteristics of the pump. The relationship between the efficiency and speed or head will help us in selecting speed or head at which the pump has to be run for maximum efficiency.

APPARATUS:

(a) Reciprocating pump set
(b) Stop watch

THEORY:

(a) Mechanical power input = $\frac{2\pi NT}{60}$ watt

where, N = Speed in RPM

Torque, T = F * Torque arm Radius

F = Load in N.

(b) Hydraulic power output = $\gamma Q H$

where, γ = Specific weight in N/m^3

$Q = \frac{V}{T}$ or 1 Kg/1000 litres = 1 m^3/sec

Q_a = Discharge in m^3/sec.

$H = (P_1 - P_2) * 10.3$ m. [1 bar = 10.3 m].

P_1 = Delivery pressure

P_2 = Suction pressure

H = Head in m of water.

(c) Efficiency = $\frac{\text{Output}}{\text{Input}} \times 100\%$.

(d) Record the suction and delivery pressures.

(e) Measure discharge through the pump by timing the mass collected in the calibrated tank with the help of a stop watch.

(f) Increase the delivery pressure by closing the delivery valve in stages of Bar until the pressure of 4 bar is reached. It might be essential to adjust the speed to keep it at 20 rev/min. at each stage.

(g) At each stage take observations (e) to (a)

(h) Repeat the observations for 15 rev/ min. and 10 rev/ min.

OBSERVATION:

Torque arm radius = 15cm

Number of observations	Motor speed rev/sec.	Pump speed rev/min.	Load F E	Pressure		Mass of water collected kg	Time sec.
				Delivery pd (P_1) bar	Suction Ps (P_2) Bar		
1							
2							
3	20						
4							
5							
1		14.5	4.8	0.5	-0.05	6	19.35
2		14.5	5.25	1	-0.1	6	21.37
3	15	14.5	6	1.75	-0.125	6	22.11
4		13.5	6.5	1.5	-0.15	6	23.40
5		12.5	7	2	-0.2	6	26.70
1							
2							
3	10						
4							
5							

CALCULATION:

a) Discharge through the pump.

b) Mechanical power point.

c) Hydraulic power point.

d) Efficiency.

PRESENTATION:

a) Show a sample calculation

b) Present the result in a tabular form.

Experiment No. 2: Reciprocating Pump Experiment

Roll No.: 078BCE178 Obs No.: 4 Date: 2082/03/12

OBSERVATION

Table 1: Observation table

No. of Observations	Pump Speed (rpm) (N)	Force (Newton) (F)	Pressure (Bar)		Mass of water collected kg (V)	Time sec (t)
			Delivery (P1)	Suction (P2) (-ve)		
1	19.5×60	6.5	1.5	−0.15	6	23.40

Torque arm radius in metre(R) = 15 cm

SAMPLE CALCULATION

Determination of Input Mechanical Power

$Torque(T) = F * R$ = 6.5×0.15 = 0.975 Nm

$Input\ Power = \frac{2\pi NT}{60}$ = 82.70 Watt

Determination of Output hydraulic Power

$Q = \frac{V}{t}\ liters/sec$ = 0.256 litres/sec convert Q in m3/s

$H = (P1 - P2) * 10.3\ m$ = 16.995m H is total head in m

$Output\ Power = \gamma QH\ watts$ = 42.68 watts $\gamma = 9810\ N/m3$

Determination of Efficiency

$Efficiency = \frac{Output}{Input} * 100\%$ = $\frac{42.68}{82.70} \times 100$ = 51.61%

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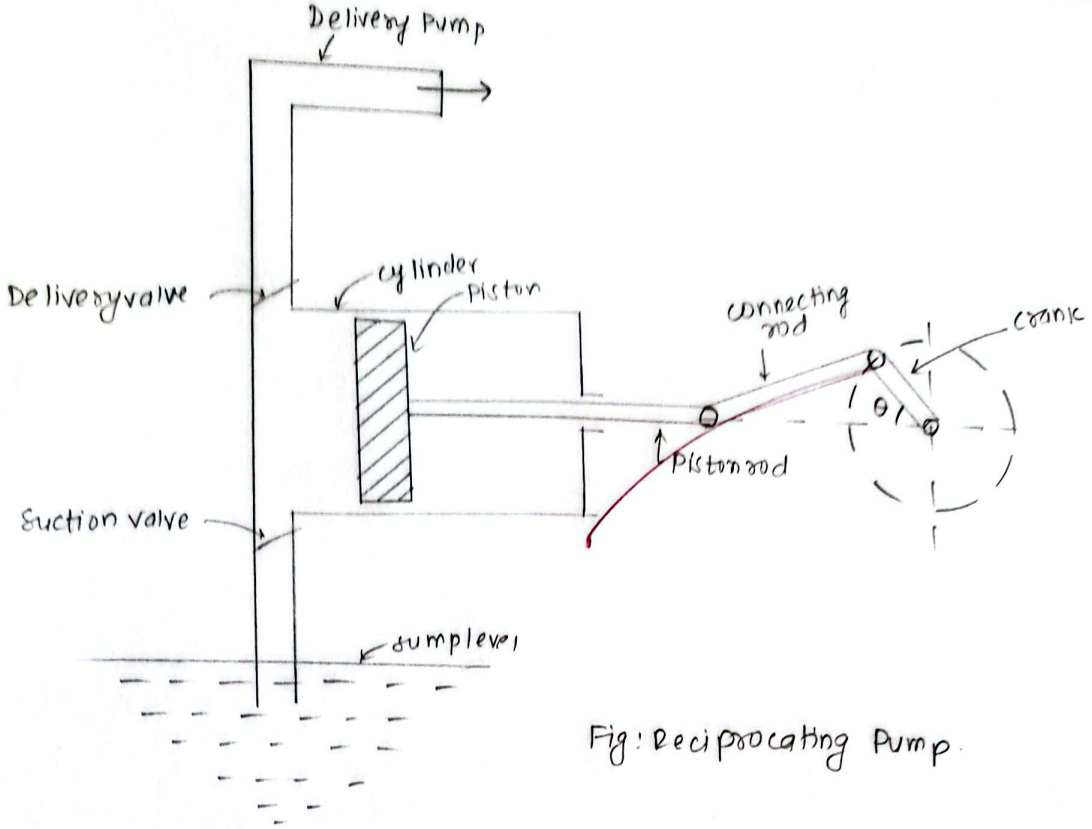


Fig: Reciprocating Pump

OBSERVATION AND CALCULATION:-

Torque arm radius = 15cm

NO. of observations	Motor speed (rev/min)	Pump Speed (rev/min) (rpm)	Load F, (N)	Pressure		Mass of water kg	Time (sec)	Head (m)	(*10-3) Discharge Q, m^3/s	Torque T, (Nm)	Power (watts)		Efficiency η, %
				Delivery (P_1), bar	Suction (P_2), bar						Hydraulic output	Mechanical Input	
1	15	14.5*60 = 870	4.5	0.5	-0.05	6	19.35	5.67	0.310	0.675	17.23	61.50	28.02
2	15	14.5*60 = 870	5.25	1	-0.1	6	21.37	11.33	0.281	0.788	31.21	71.75	43.50
3	15	14.5*60 = 870	6	1.75	-0.125	6	22.11	19.31	0.271	0.900	51.41	82.00	62.70
4	15	13.5*60 = 810	6.5	1.5	-0.15	6	23.10	16.98	0.256	0.975	42.68	82.70	51.69
5	15	12.5*60 = 750	7	2	-0.2	6	26.70	22.66	0.225	1.050	49.95	82.47	60.57

Sample Calculation:-

Observation NO.5:

Pump speed (N) = 12.5*60 = 750 rev/min = 750 rpm

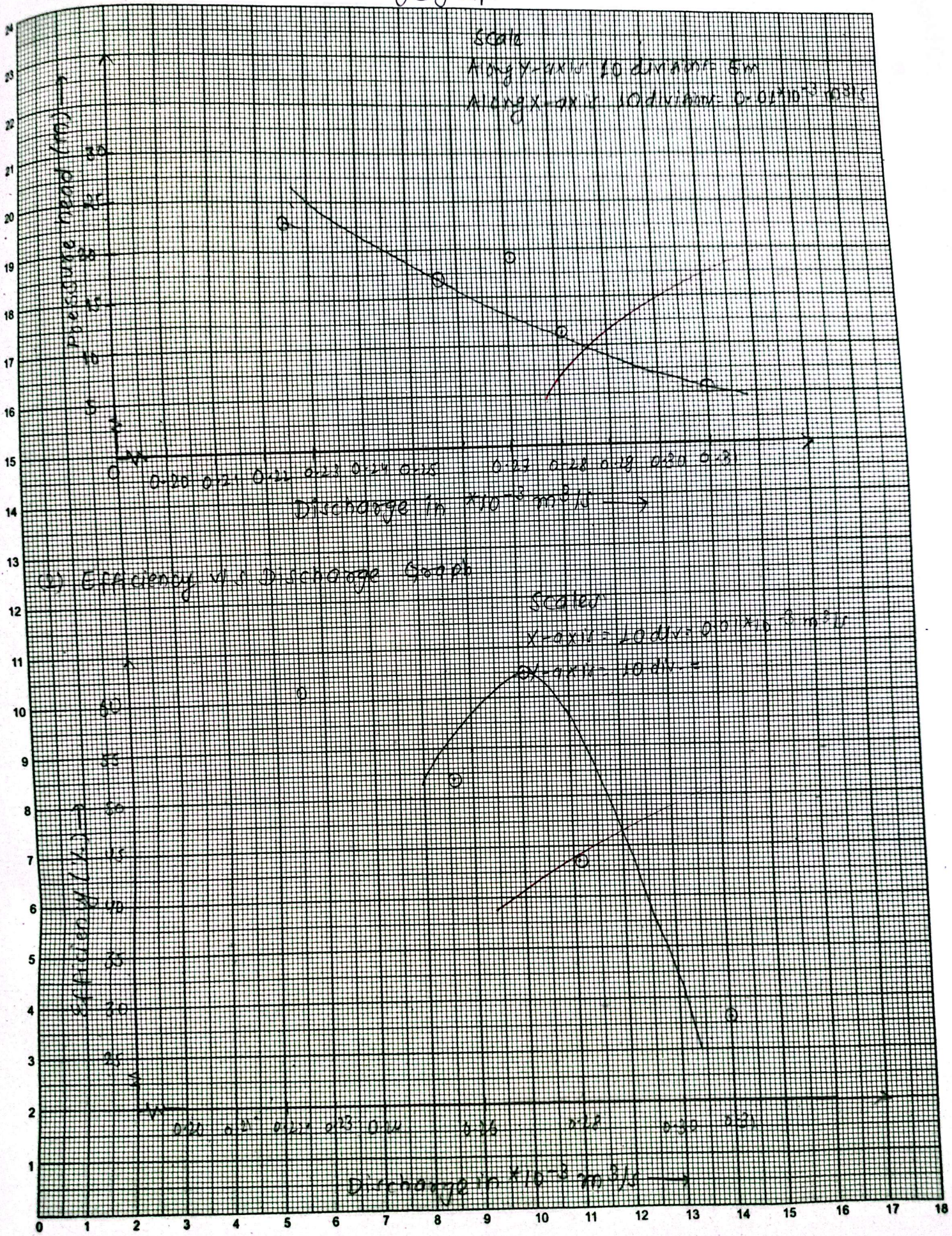
Delivery pressure (P_1) = 2 bar

Suction pressure (P_2) = -0.2 bar

Force (F) = 7N

Mass of water collected (V) = 6kg = 6 litre = $6*10^{-3}$ m^3

(1) Pressure Head V/s discharge graph



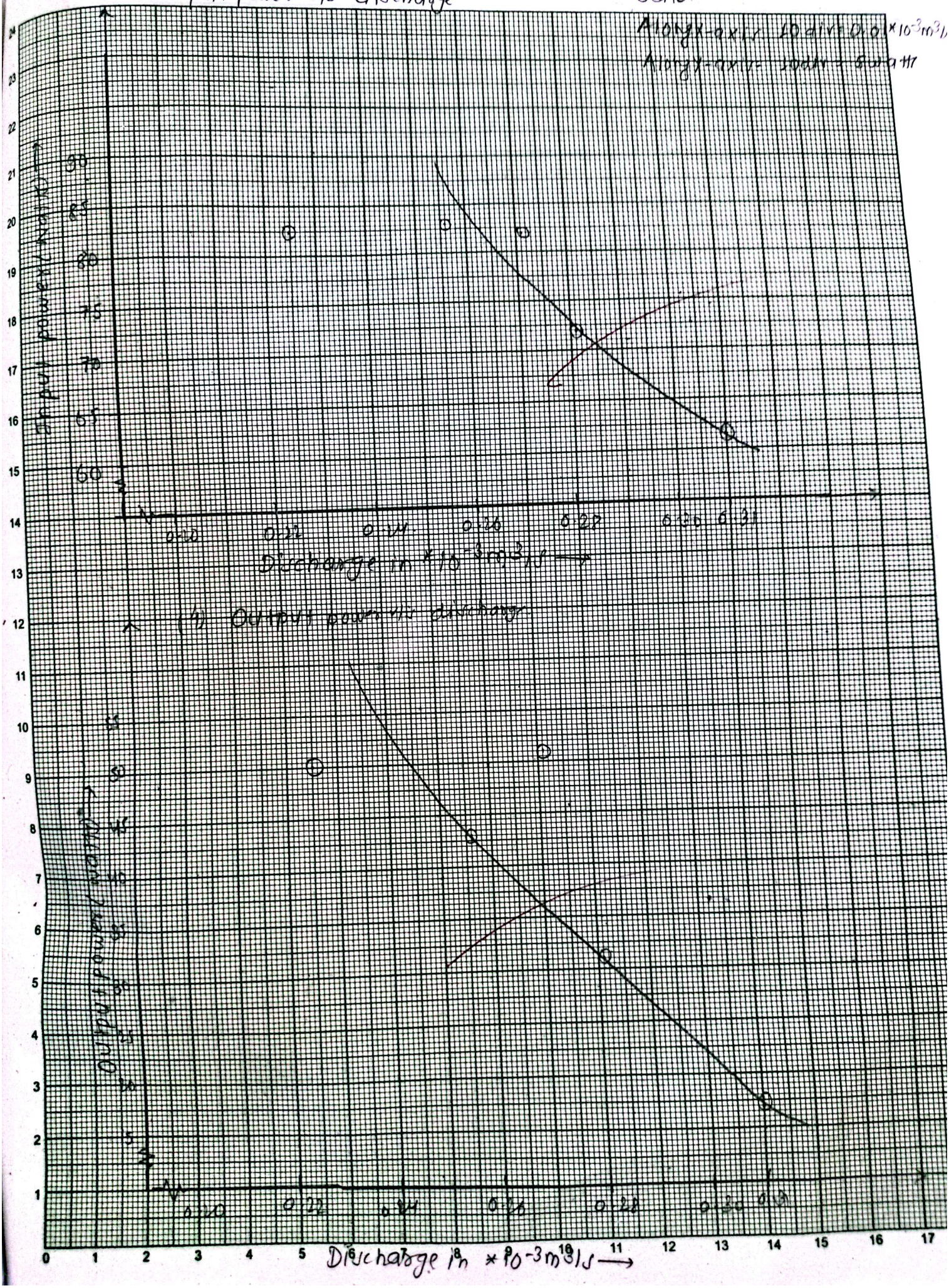
(2) Efficiency V/s Discharge Graph

(3) Input power v/s discharge

Scale:

Along x-axis 10 div = 0.01 × 10^{-3} m^3/s

Along y-axis 1 div = 5 watt



Time = 26.70sec

Then, Torque = F * l = 7*0.15 = 1.050Nm

$$\text{Input power} = \frac{2\pi NT}{60} = \frac{2\pi * 750 * 1.050}{60} = 82.47 \text{watts}.$$

$$Q = \frac{M}{t} = \frac{V}{t} = \frac{6*10^{-3}}{26.70} = 0.225*10^{-3} \, m^3/sec.$$

Head, $H = (P_1 - P_2) * 10.3 \, m = (2 - (-0.2)) * 10.3 = 22.66 m.$

Then,

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} * 100\% = \frac{49.95}{82.47} * 100\% = 60.57\%$$

COMMENTS.

The reciprocating pump reciprocates piston back and forth to positively displace fluid. The pump works majorly on suction stroke and delivery stroke. The performance characteristics of reciprocating pump is represented by Efficiency ~ Discharge, Pressure ~ Discharge and Power ~ Discharge curves. The pressure head ~ Discharge have inverse relation which was proved by graph as well. When efficiency was plotted against discharge, the efficiency seemed to decrease with increase in discharge. However efficiency ~ discharge relation is bell shaped with best efficiency point somewhere in mid-part. Both the input and output power decreased with increase in discharge. At higher discharges, the mechanical and hydraulic losses increases and thus power and efficiency have decreased.

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A
REPORT
ON

FRANCIS TURBINE
AND
PELTON TURBINE

LAB No: 03/04

EXPERIMENT DATE: 2082-03-19

SUBMITTED DATE: 2082-04-18

SUBMITTED BY:

Name: Surendra Sharma
Group: H1
Roll No: 078BCE178

SUBMITTED TO:

Department of
Civil Engineering

FRANCIS TURBINE EXPERIMENT

OBJECTIVE:

To determine the performance of a small scale Francis turbine.

APPARATUS

(a) Francis turbine set
(b) Tachometer

THEORY:

(a) Hydraulic Power Input $= \gamma Q H$

where, γ = specific weight in N/m^3
Q = Discharge in m^3/s
H = Effective head in $m = (P_i - P_o)$
where, P_i = Inlet pressure
P_o = Draft tube pressure.

(b) Mechanical Power Output $= \frac{2\pi NT}{60}$

where, N = Speed in RPM
T = Torque in Nm

(c) Efficiency $= \frac{\text{Output}}{\text{Input}} * 100\%$.

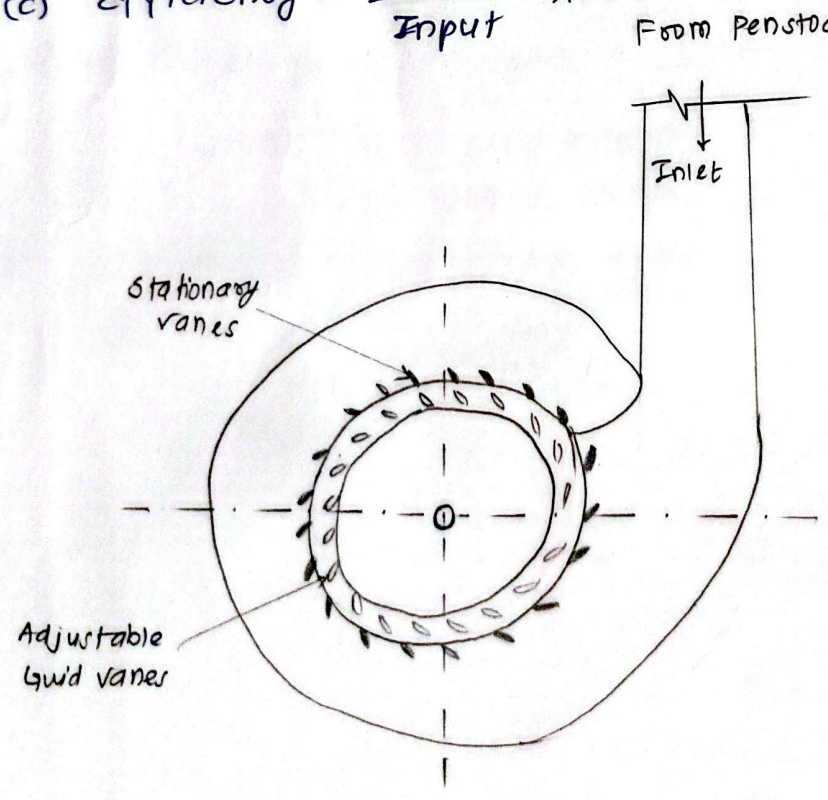

Fig: Francis Turbine

PELTON WHEEL EXPERIMENT

OBJECTIVE:-

To determine the performance characteristics of a model Pelton wheel.

SCOPE:-

It is used to generating electricity in high head hydro power projects. It is necessary to operate the turbine at maximum efficiency which can be achieved by having the head constant or speed constant. The study of performance characteristic enables one to understand the operating condition for which maximum efficiency is obtained.

APPARATUS:-

Pelton wheel model with supply system.

THEORY

(a) Hydraulic power input = $\gamma Q H$ watts

where, γ = specific weight in N/m^3.

Q = Discharge in m^3/s

H = Head in meter

(b) Mechanical power output = $\frac{2\pi NT}{60}$ watts

where, N = speed in rpm

T = Torque in Nm

(c) Efficiency = output/Input * 100%

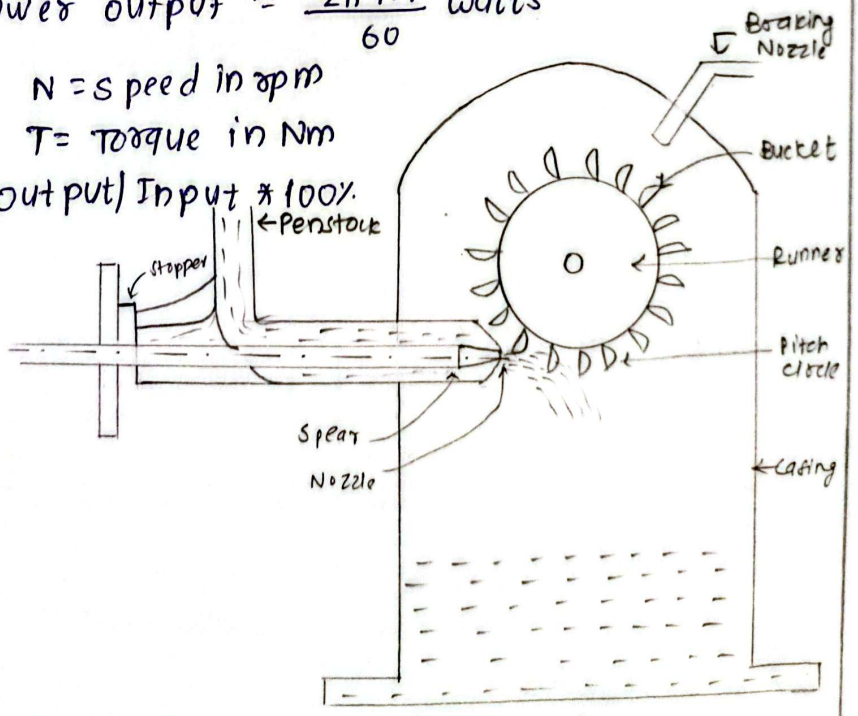

Fig: Schematic Diagram of Pelton Turbine.

Inlet Pressure = 20 meter head

Lever Area = 25cm or 0.25m

Number of observations	Veo Notch reading mm	Speed rpm	Brake Load N
1	94.5	1208	0
2		1129	5
3		1064	10
4		961	15
5		840	20
6		718	~~25~~ 27
7		655	30
8		569	35
9		458	40
10		336	45
		0	50

$C_d = 0.6$

CALCULATION :

a) Actual discharge Q.

b) Hydraulic power input.

c) Mechanical power input.

d) Efficiency for each reading.

e) Show the sketch or figure of the apparatus and simple description

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PRESENTATION :

a) Show a sample calculation.

b) Present the result in a tabular form.

Number of observation	Discharge Q m^3/s	Hydraulic power input		Mechanical Power output				Efficiency %
		Head m of water	Power QH watt	Speed N	Load	Torque T Nm	Power	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

c) Plot output power versus speed and efficiency of the turbine versus speed.

COMMENTS: Comment on the characteristics, maximum operation efficiency and suitability of Pelton wheel in hydro power projects in Nepal.

Experiment No. 3: Pelton Wheel Experiment

Roll No.: 078BCE178 Obs No.: 8 Date: 2082/03/17

OBSERVATION

Table 1: Observation table

No. of Observations	Speed (rpm) (N)	Brake Load (Newton) (F)	V-Notch Reading m (h)
1	559	35	0.0945

Head of water in m (H)= 20 m

Totque arm radius in metre(R) = 0.25m

SAMPLE CALCULATION

Determination of Input Hydraulic Power

$Discharge(Q), m3/s = \frac{8}{15} * Cd * \sqrt{2g} * h^{\frac{5}{2}} =$ $3.891 * 10^{-3}\ m^3/s$ $Take\ Cd = 0.6$

$Input\ Power = \gamma QH\ watts =$ 763.44watts $\gamma = 9810\ N/m3$

Determination of Output Mechanical Power

$T = F * R =$ 35*0.25 = 8.75 Nm

$Output\ Power = \frac{2\pi NT}{60} watts =$ 512.21 watts

Determination of Efficiency

$Efficiency = \frac{Output}{Input} * 100\% =$ $\frac{512.21}{763.44} * 100 = 67.09\%$

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OBSERVATIONS & CALCULATIONS:-

Inlet pressure(H)=2om head

Lever arm radius (R) = 0.25m

$C_d = 0.6$

No. of obs.	Speed(N), rpm	Brake Load(F), Newton	Veo Notch reading (m), h	Discharge (Q), m^3/s ($\times 10^{-3}$)	Input power, (P_{in}) watts	Torque, T, Nm	Power output(P_{out}) watts	Efficiency (η), %
1	1208	0	0.0945	3.891	763.44	0	0	0.00
2	1129	5	0.0945	3.891	763.44	1.25	147.79	19.36
3	1064	10	0.0945	3.891	763.44	2.5	278.55	36.49
4	961	15	0.0945	3.891	763.44	3.75	377.38	49.43
5	840	20	0.0945	3.891	763.44	5	439.82	57.61
6	718	27	0.0945	3.891	763.44	6.75	507.52	66.48
7	655	30	0.0945	3.891	763.44	7.5	514.44	67.38
8	559	35	0.0945	3.891	763.44	8.75	512.21	67.09
9	458	40	0.0945	3.891	763.44	10	479.62	62.82
10	336	45	0.0945	3.891	763.44	11.25	395.84	51.85
11	0	50	0.0945	3.891	763.44	12.5	0.00	0.00

Sample calculation (observation No. 9)

Speed (N) = 458rpm

Brake load (F) = 40N

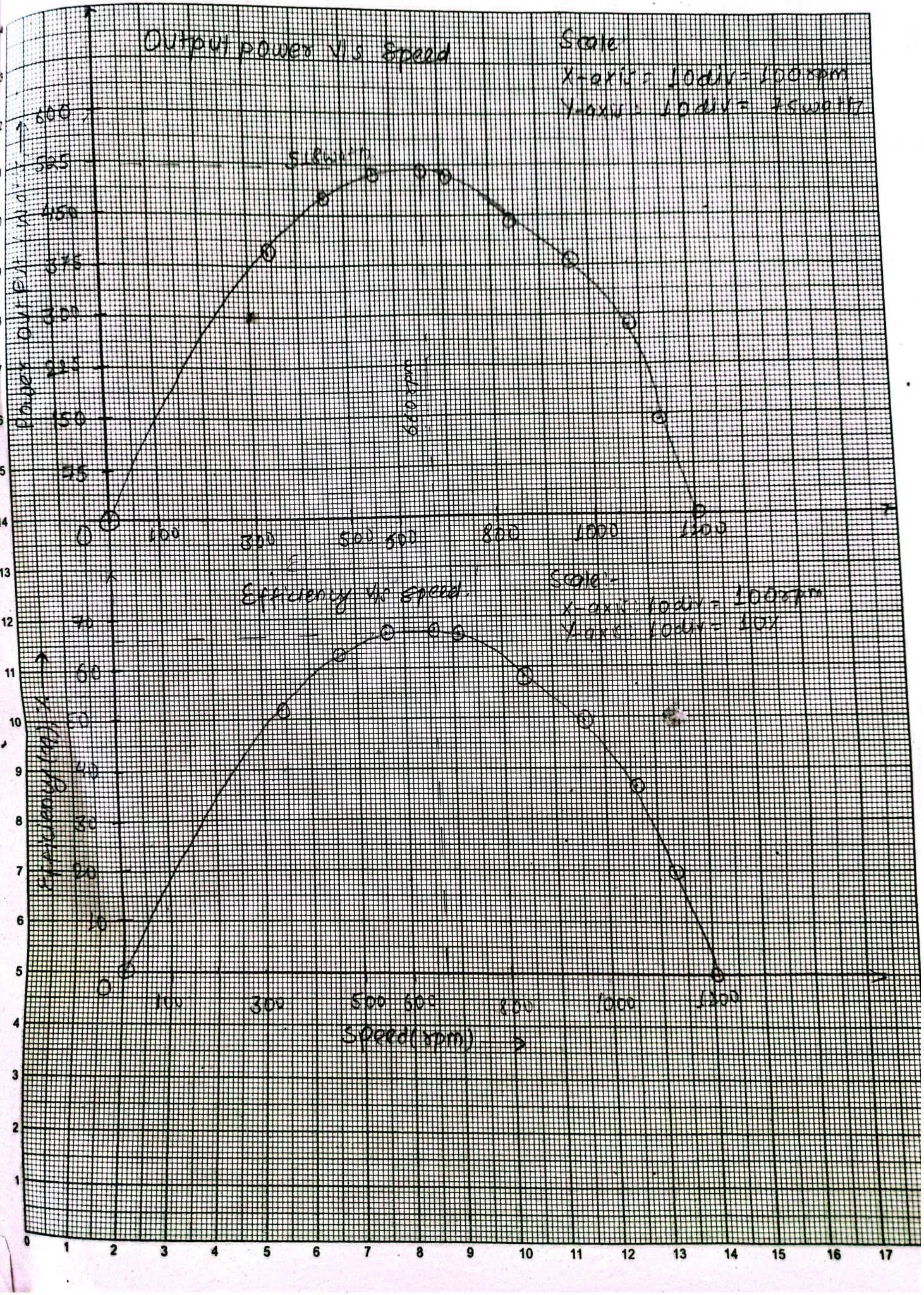
Veo Notch reading (h) = 0.0945 m = 94.5 mm

$$\text{Discharge } (Q) = \frac{8}{15} * C_d * \sqrt{2g} * h^{5/2}$$

$$= \frac{8}{15} * 0.6 * \sqrt{2*9.81} * (0.0945)^{5/2}$$

$$= 3.891 * 10^{-3} \, m^3/sec$$

(078BCE178)


Output power Vs Speed
Scale
X-axis = 1 div = 100 rpm
Y-axis = 1 div = 75 watts
Output power (watts)
600
525
450
375
300
225
150
75
0
100
300
500
600
800
1000
1200
Efficiency Vs Speed
Scale:-
X-axis: 1 div = 100 rpm
Y-axis: 1 div = 10%
Efficiency (%)
70
60
50
40
30
20
10
0
100
300
500
600
800
1000
1200
Speed (rpm)

Input power (P_{in}) = $\rho g H = 9810 * 3.891 * 10^{-3} * 20 = 763.44$ watts

Torque, $T = F * R = 40 * 0.25 = 10$ Nm

Output power (P_{out}) = $\frac{2\pi NT}{60} = \frac{2\pi * 458 * 10}{60} = 479.62$ watts

Efficiency, $\eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{479.62}{763.44} \times 100\% = 62.82\%$

COMMENTS

In this experiment, we evaluated the performance of a Pelton Turbine by calculating output power and efficiency under varying speed and loading conditions. Graph of output power v/s. speed and efficiency of turbine v/s speed were plotted to analyse the turbine's behaviour, showing optimal efficiency at a specific value. There might have been some error during experiment due to old devices with improper maintenance, improper calibration and error during data recording.