Date: 8-02-2021

Expt No. 4

Experiment - 4

19JE0411

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Name of the experiment: Performance test of centrifugal pump

Objective: To predict the behaviour and performance of centrifugal pump at different flow rates, head and speed

Theory:

A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips

Formulas to be used:

Weight of water = density of water × discharge × g

Manometric head = 10 × delivery pressure gauge reading
($1 Kg/cm^2$ is equivalent to 10m of water head)

Power output = Weight of water lifted × Manometric head

Efficiency (η) = Power output / Power Input

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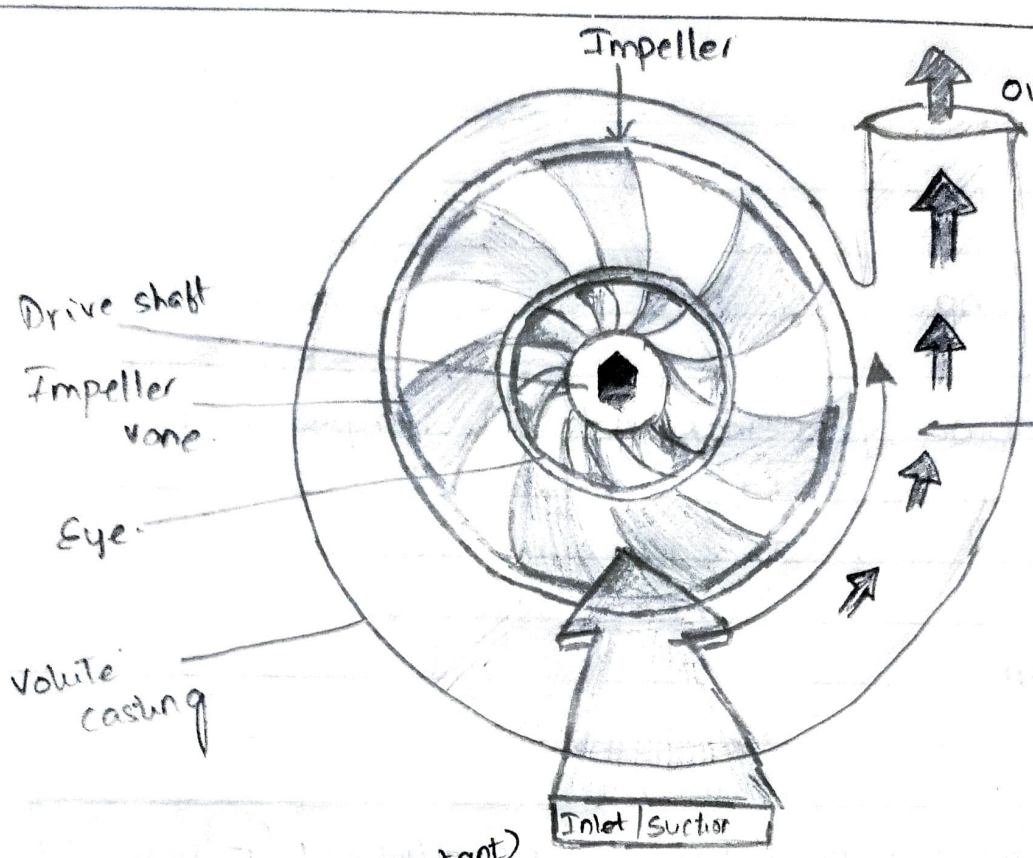
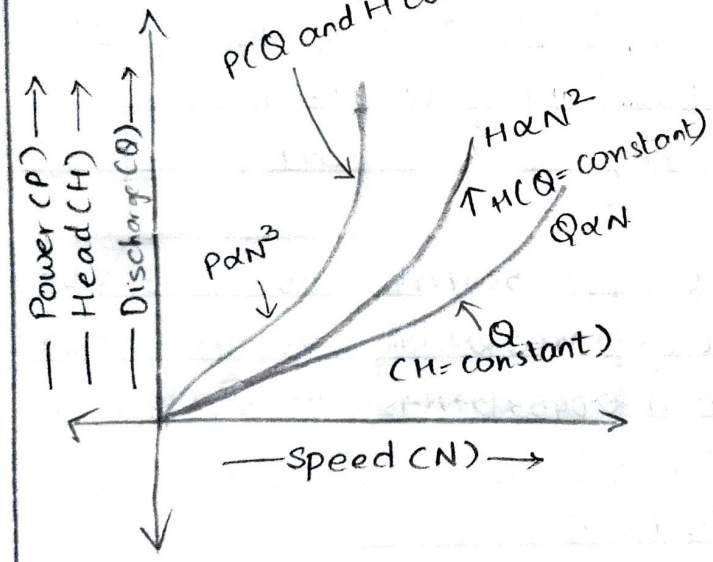
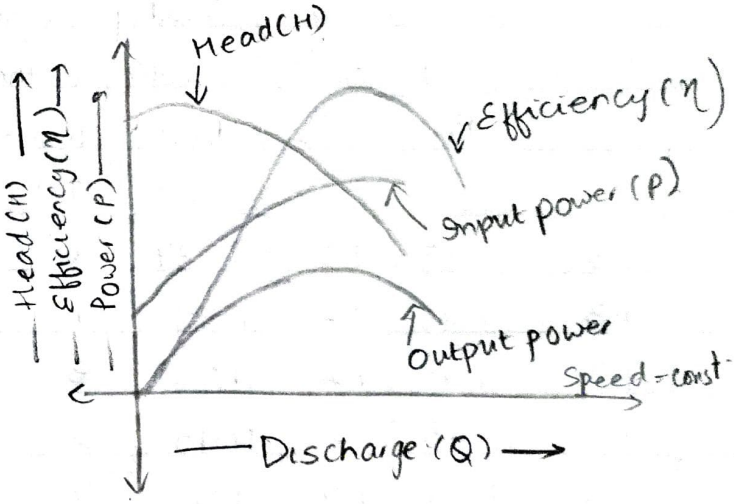




Main characteristics curves



Operating characteristics curves

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Observations

Rated RPM of the pump = 2900 RPM

S.No	Speed (50% of rated rpm)	Power Input (kW)	Discharge	Delivery Pressure gauge reading (Kg/cm²)
	1450	0.2	11.24	0
1	1450	0.2	7.96	0.5
	1450	0.2	5.4	1
	1450	0.2	0	1.5

S.No	Speed (60% of rated rpm)	Power Input (kW)	Discharge	Delivery Pressure gauge reading (Kg/cm²)
	1740	0.4	12.22	0
2	1740	0.4	11.25	0.5
	1740	0.4	9.56	1
	1740	0.3	6.02	1.5

S.No	Speed (70% of rated rpm)	Power Input (kW)	Discharge	Delivery Pressure gauge reading (Kg/cm²)
	2030	0.8	11.96	0
3	2030	0.8	10.75	0.5
	2030	0.8	10.37	1
	2030	0.8	9.09	1.5

S.No	Speed (80% of rated rpm)	Power Input (kW)	Discharge	Delivery Pressure gauge reading (Kg/cm²)
	2320	1.0	10.7	0
4	2320	0.9	10.85	0.5
	2320	1.11	10.7	1
	2320	1.2	10.7	1.5

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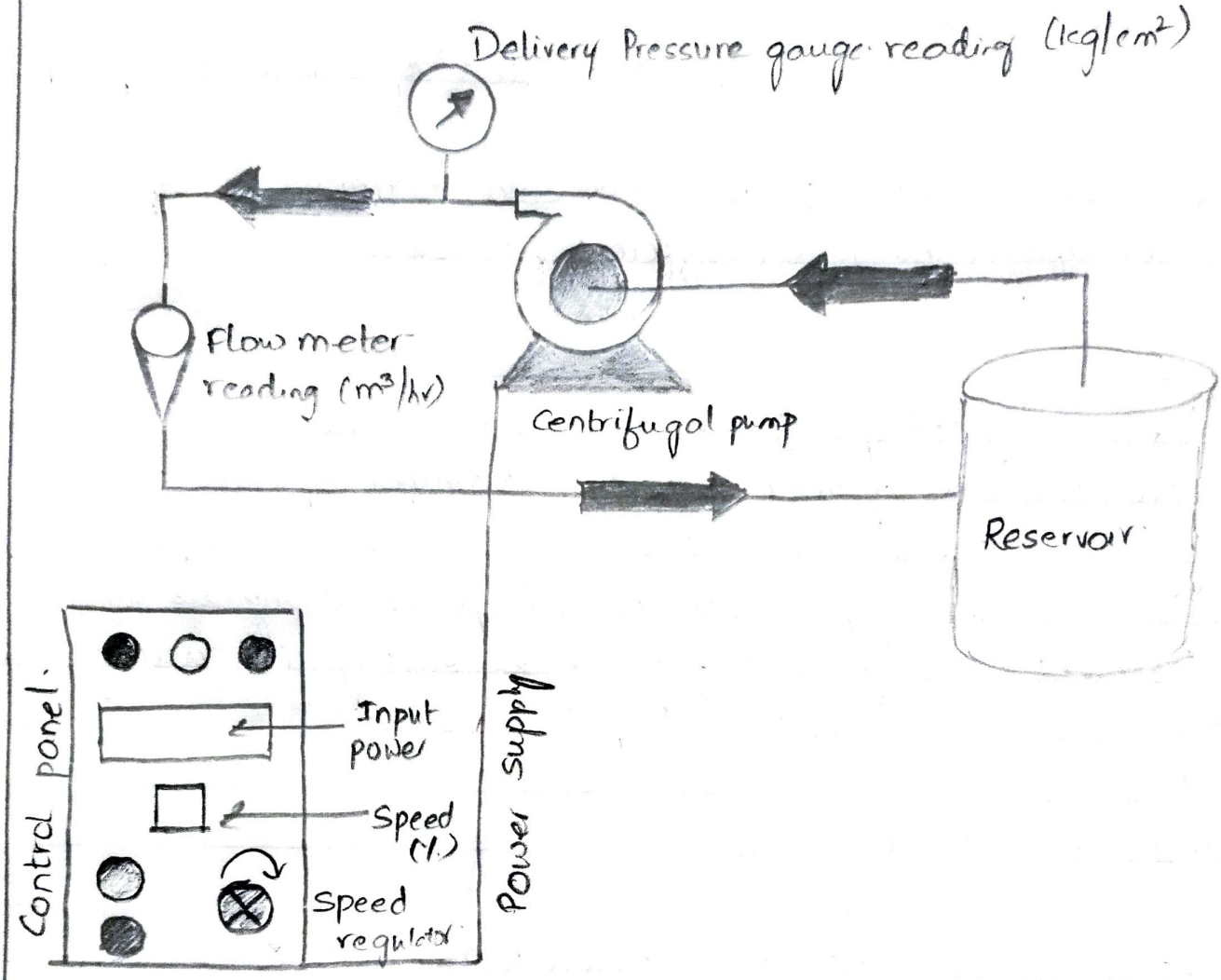

Single stage centrifugal pump test rig

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Calculations

For run 1, N = 1450 rpm

CASE-1:

- Weight of water = density of water x discharge x g
  = 1000 x 11.24 x 9.81 N/hr = 110.264 x 10^3 N/hr
- Manometric head = 10 x delivery pressure gauge = 10 x 0 = 0m
- Power output = weight of water lifted x manometric head
  = 110.264 x 10^3 x 0/3600 W = 0W = 0kW
- Efficiency = η = 0/0.2% = 0%

CASE-2:

- Weight of water = density of water x discharge x g
  = 1000 x 7.96 x 9.81 N/hr = 78.088 x 10^3 N/hr
- Manometric head = 10 x delivery pressure gauge = 10 x 0.5 = 5m
- Power output = weight of water lifted x manometric head
  = 78.088 x 10^3 x 5/3600 W = 0.108 kW
- Efficiency = η = 0.108/0.2% = 54%

CASE-3:

- Weight of water = density of water x discharge x g
  = 1000 x 5.4 x 9.81 N/hr = 52.97 x 10^3 N/hr
- Manometric head = 10 x delivery pressure gauge = 10 x 1 = 10m
- Power output = weight of water lifted x manometric head
  = 52.97 x 10^3 x 10/3600 W = 0.147 kW
- Efficiency = η = 0.147/0.2 % = 73.5 %

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CASE #4:

- Weight of water = density of water x discharge x g
  = 1000 x 0 x 9.81 N/hr = 0 N/hr.
- Manometric head = 10 x delivery pressure gauge = 10 x 1.5 = 15m.
- Power output = weight of water lifted x manometric head.
  = 0 x 5W = 0kW
- Efficiency = η = 0/0.2 % = 0 %

For run 2, N = 1740 rpm.

CASE-1:

- Weight of water = density of water x discharge x g
  = 1000 x 12.22 x 9.81 N/hr = 119.88×10^3 N/hr.
- Manometric head = 10 x delivery pressure gauge = 10 x 0 = 0m
- Power output = weight of water lifted x manometric head.
  = 110.264×10^3 x 0/3600 W = 0W = 0kW.
- Efficiency = η = 0/0.4 = 0%.

CASE-2:

- weight of water = density of water x discharge x g.
  = 1000 x 12.25 x 9.81 N/hr = 120.172×10^3 N/hr.
- Manometric head = 10 x delivery pressure gauge = 10 x 0.5 = 5m.
- Power output = weight of water lifted x manometric head.
  = 120.172×10^3 x 5/3600 = 166.9 kJ = 0.166 kW
- Efficiency = η = 0.166/0.4 = 0.4172 x 100 % = 41.72 %.

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CASE-3

- Weight of water = density of water x discharge x g
  = 1000 x 9.56 x 9.81 N/hr = 93.78 x 10^3 N/hr
- Manometric head = 10 x delivery pressure gauge = 10 x 1 = 10m
- Power output = weight of water lifted x manometric head
  = 93.78 x 10^3 x 10/3600 W = 0.26kW
- Efficiency = η = 0.26/0.4 = 65%.

CASE-4

- Weight of water = density of water x discharge x g
  = 1000 x 6.02 x 9.81 N/hr = 59.06 x 10^3 N/hr
- Manometric head = 10 x delivery pressure gauge = 10 x 1.5 = 1
- Power output = weight of water lifted x manometric head
  = 59.06 x 10^3 x 15/3600 W = 0.246 kW
- Efficiency = η = 0.246/0.3 = 82%.

For run 3, N = 2030 rpm.

CASE-1

- Weight of water = density of water x discharge x g
  = 1000 x 11.96 x 9.81 N/hr = 117.32 x 10^3 N/h
- Manometric head = 10 x delivery pressure gauge = 10 x 0 = 0m
- Power output = weight of water lifted x manometric head
  = 117.32 x 10^3 x 0/3600 W = 0W = 0kW
- Efficiency = η = 0/0.8 = 0%.

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CASE-2

- Weight of water = density of water x discharge x g.
  $= 1000 \times 10.75 \times 9.81 \text{ N/hr} = 105.46 \times 10^3 \text{ N/hr}$
- Manometric head = 10x delivery pressure gauge = $10 \times 0.5 = 5\text{m}$.
- Power output = Weight of water lifted x manometric head.
  $= 105.46 \times 10^3 \times 5/3600 = 0.146\text{kW}$
- Efficiency = $\eta = 0.146/0.8 = 18.25\%$.

CASE-3

- Weight of water = density of water x discharge x g.
  $= 1000 \times 10.37 \times 9.81 \text{ N/hr} = 101.73 \times 10^3 \text{ N/hr}$.
- Manometric head = 10x delivery pressure gauge = $10 \times 1 = 10\text{m}$.
- Power output = Weight of water lifted x manometric head.
  $= 101.73 \times 10^3 \times 10/3600 = 0.283\text{kW}$
- Efficiency = $\eta = 0.283/0.8 = 35.38\%$.

CASE-4

- Weight of water = density of water x discharge x g.
  $= 1000 \times 9.09 \times 9.81 \text{ N/hr} = 89.17 \times 10^3 \text{ N/hr}$
- Manometric head = 10x delivery pressure gauge = $10 \times 1.5 = 15\text{m}$.
- Power output = weight of water lifted x manometric head.
  $= 89.17 \times 10^3 \times 15/3600\text{W} = 0.372\text{kW}$
- Efficiency = $\eta = 0.372/0.8\% = 46.5\%$.

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For run 4, N = 2320 rpm.

CASE-1:

- Weight of water = density of water x discharge x g
  $= 1000 \times 10.7 \times 9.81$ N/hr $= 104.97 \times 10^3$ N/hr
- Manometric head = 10 x delivery pressure gauge = $10 \times 0 = 0$ m.
- Power output = weight of water lifted x manometric head.
  $= 104.97 \times 10^3 \times 0 / 3600$ W $= 0$ W $= 0$ kW
- Efficiency = $\eta = 0/1$ % = 0%.

CASE-2.

- Weight of water = density of water x discharge x g
  $= 1000 \times 10.85 \times 9.81$ N/hr $= 106.44 \times 10^3$ N/hr.
- Manometric head = 10 x delivery pressure gauge = $10 \times 0.5 = 5$ m.
- Power output = weight of water lifted x manometric head.
  $= 106.44 \times 10^3 \times 5 / 3600$ kW $= 0.148$ kW.
- Efficiency = $\eta = 0.298/1.11 = 26.44$ %.

CASE-3

- weight of water = density of water x discharge x g
  $= 1000 \times 10.7 \times 9.81$ N/hr $= 104.97 \times 10^3$ N/hr.
- Manometric head = 10 x delivery pressure gauge = $10 \times 1 = 10$
- Power output = weight of water lifted x manometric head.
  $= 104.97 \times 10^3 \times 10 / 3600$ W $= 0.292$ kW
- Efficiency $\eta = 0.292/1.11 = 26.31$ %

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CASE-4

- Weight of water = density of water x discharge x g
  = 1000 x 11.7 x 9.81 N/hr = 114.78 x 10^3 N/hr
- Manometric head = 10 x delivery pressure gauge = 10 x 1.5 = 15 m
- Power output = Weight of water lifted x manometric head
  = 114.78 x 10^3 x 15 / 3600 W = 0.478 kW
- Efficiency = η = 0.478 / 1.2 / . = 39.83 %.

SPEED (N) rpm	DISCHARGE (Q) m^3/hr	OUTPUT POWER (P) kW	HEAD (H) m	EFFICIENCY (η) %
1450	11.24	0	0	0
1450	7.96	0.108	5	54
1450	5.4	0.147	10	73 5
1450	0	0	15	0
1740	12.22	0	0	0
1740	12.25	0.166	5	91.72 %
1740	9.56	0.26	10	65
1740	6.02	0.246	15	82
2030	11.96	0	0	0
2030	10.75	0.146	5	18.25
2030	10.37	0.283	10	35.28
2030	9.09	0.372	15	46.5
2320	10.70	0	0	0
2320	10.85	0.148	5	16.44
2320	10.7	0.292	10	26.31
2320	11.7	0.478	15	39.83

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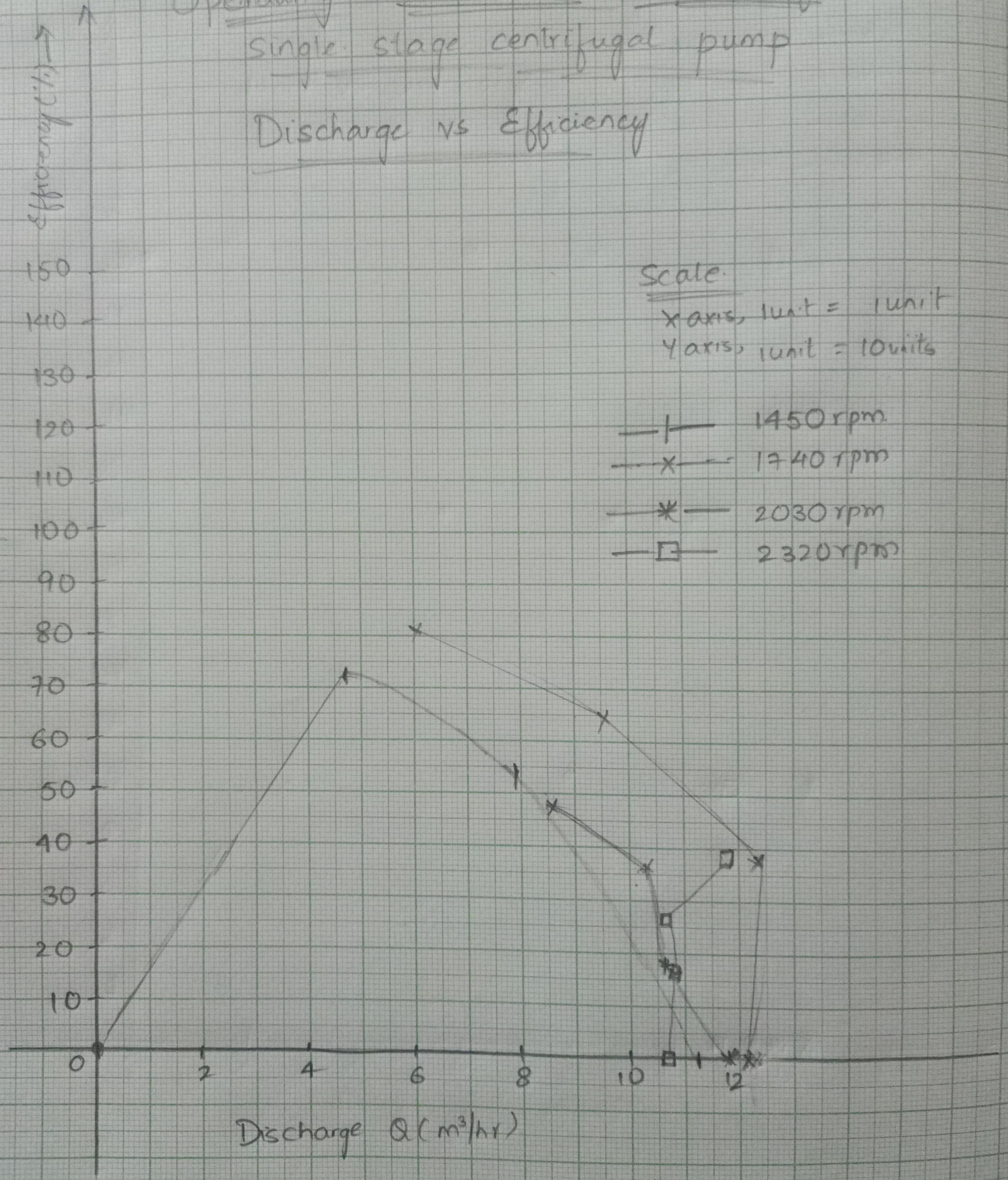
Operating characteristics curves of a single stage centrifugal pump

Discharge vs Efficiency



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Scale

X axis, 1 unit = 1 unit

Y axis, 1 unit = 1 unit

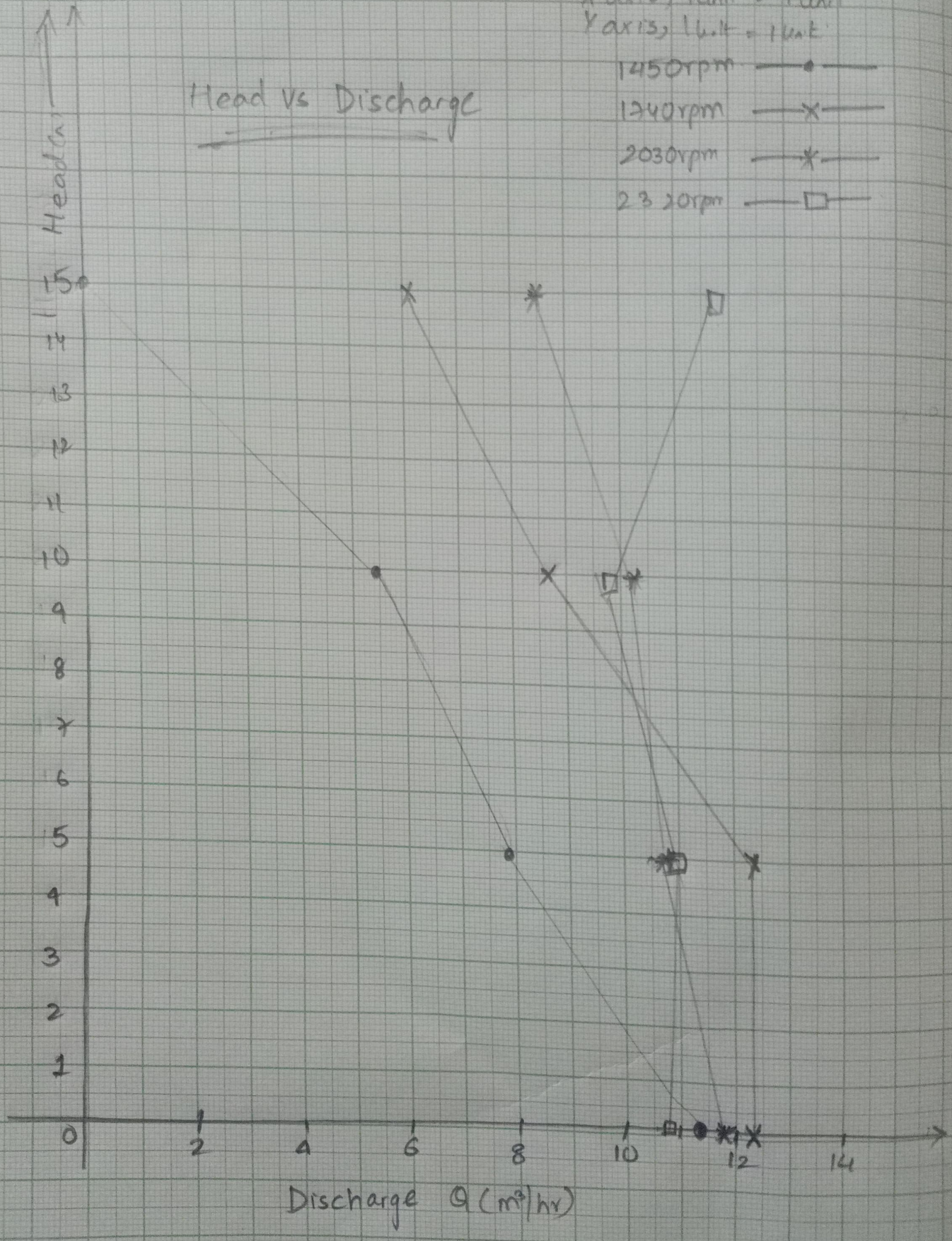
1450 rpm

1240 rpm

2030 rpm

2310 rpm

Head vs Discharge



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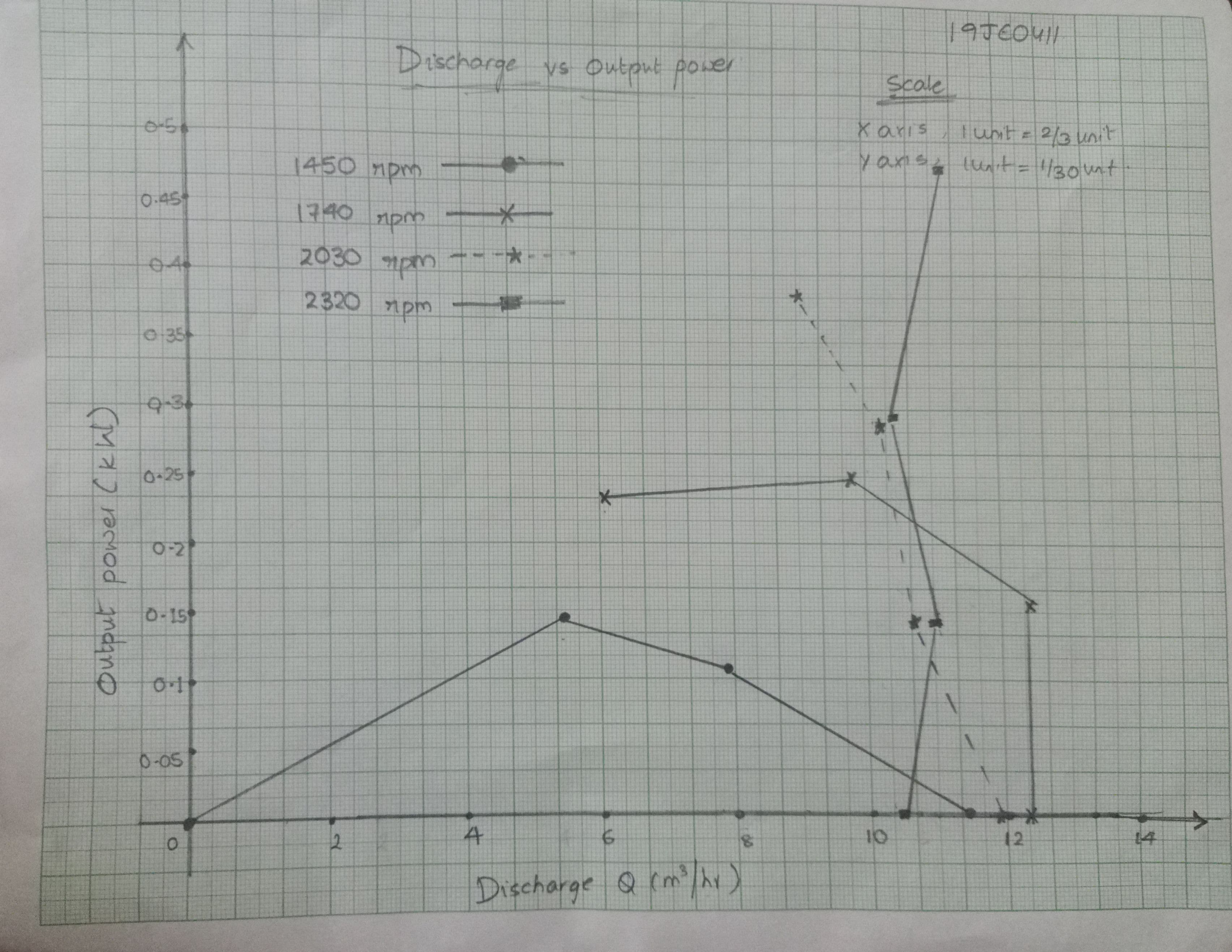
Discharge vs Output power



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Discussion:

From the experiment, we can conclude that more hydraulic power doesn't generate greater efficiency but we can improve performance could by reducing the fluid flow rat

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