



CALIBRATION AND SIMILARITY OF CENTRIFUGAL PUMP

Lab3



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Contents

Calibration and similarity of centrifugal pump.....	2
Objective.....	2
Procedure	2
Calculations	3
Pump Monomeric head:.....	3
Flow Rate:.....	3
Efficiency.....	4
Practical calculations at case 1 (N=2000 RPM).....	4
Practical calculations at case 2 (N=2500 RPM).....	5
Theoretical calculations at case 2.....	5
Comment	7

Calibration and similarity of centrifugal pump

Objective

To study the performance of the centrifugal pump for different flow rates at different speed, draw the pump characteristic curves and Verify using of similarity rules on this pump. Using the experiment model shown in figure 1

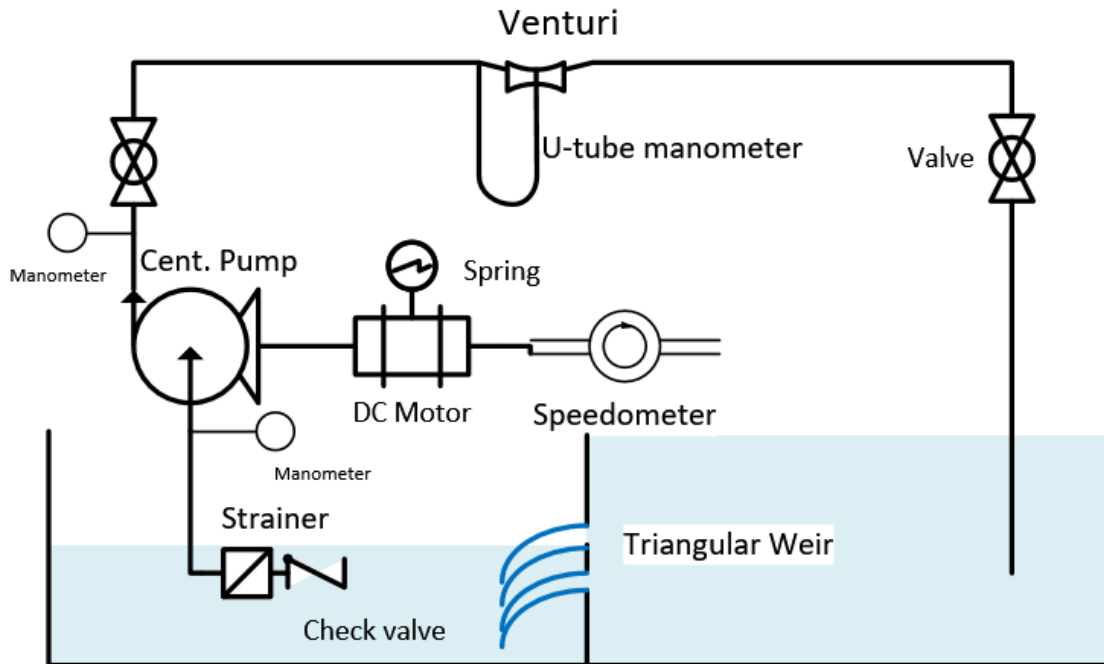


Figure 1

Procedure

1. Operate the pump at certain speed (2000 RPM)
2. Start open the valve at delivery side till its maximum opening
3. Change the current supplied to the motor till we have the pump running at (2000 RPM)
4. Take the needed readings for that case and start fill the table
 - Monomeric suction head (H_{ms}) by using pressure gauge on suction side (ft.) fig.3
 - Monomeric delivery head (H_{ms}) by using pressure gauge on delivery side (ft.)
 - U-tube manometer Reading (y) in (cm) as shown in fig.2
 - Force (F) that balance the stator by using spring mass balance (kg.f) fig.4
5. Start to change the valve opening and repeat step 3,4
6. Change the speed on the pump to be (2500 RPM)
7. Repeat from step 2 till step 5 for this speed

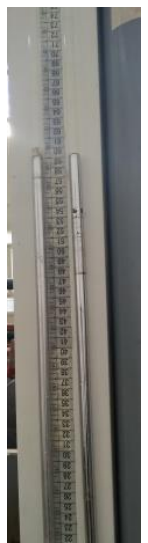


Figure 2
Manometer
reading

Reading at case 1 ($N = 2000 \text{ RPM}$)

$Y \text{ (cm)}$	$H_{ms} \text{ (ft)}$	$H_{md} \text{ (ft)}$	$F \text{ (kg.f)}$
17	9	20	5
13	6	32	4.2
6	3	45	3.2
0	0	60	0.5



Figure 3 pressure gauges

Reading at case 2 ($N = 2500 \text{ RPM}$)

$Y \text{ (cm)}$	$H_{ms} \text{ (ft)}$	$H_{md} \text{ (ft)}$	$F \text{ (kg.f)}$
27	13	26	8.4
18	8	52	7.9
7.5	4	72	6.5
0	0	82	2.2

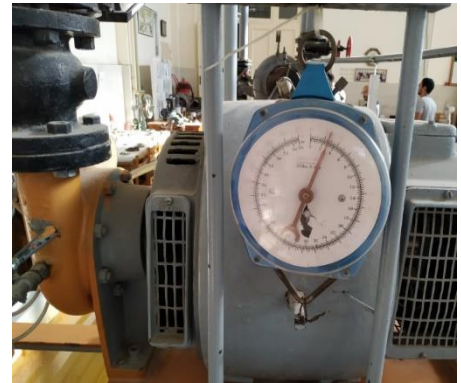


Figure 4 spring reading

Calculations

Pump Monomeric head

$$H_m = H_{md} - H_{ms}$$

$$1 \text{ ft} = 0.3048 \text{ meter}$$

Flow Rate

$$Q = \frac{C_d A_{pipe} * A_{throat}}{\sqrt{A_{pipe}^2 - A_{throat}^2}} * \sqrt{2 * g * h}$$

$$h = y [SG_u \setminus SG_f - 1]$$

Where:

$$Cd = 0.94$$

$$d_{pipe} = 10 \text{ cm} \quad (A_{pipe} = \frac{\pi d^2}{4} \text{ m}^2)$$

$$d_{throat} = 6.86 \text{ cm } (A_{throat} = \frac{3.696}{1000} \text{ m}^2)$$

$$y = U - \text{tube manometer reading}$$

$$SG_u = 13.6$$

$$SG_f = 1$$

$$\text{Final Form; } Q = \left(\frac{61.877}{1000}\right) * (y)^{0.5}$$

Efficiency

$$\eta = (O/P) / (I/P)$$

Where:

$$\frac{O}{P} = \text{Density}_{\text{water}} * Hm * Q$$

$$\frac{I}{P} = T * \omega$$

$$T = F * R$$

$$\omega = \frac{2\pi N}{60}$$

$$R (\text{brake radius}) = 0.3048 \text{ m.}$$

$$\text{Final Form; } I/P = \left(10.16 * \frac{\pi}{1000}\right) * N * F$$

$$\text{Final form; } \frac{O}{P} = 1000 * Hm * Q$$

Practical calculations at case 1 (N=2000 RPM)

$Hm (ft) * 0.3 [ft/m]$	$Q * 10^{-3}$	$O/P (W)$	$I/P \{Shaft Power\} (W)$	$Efficiency$
11	25.51	85.53	319.2	26.8%
26	22.31	176.8	268.1	65.94%
42	15.156	194	204.3	94.95%
60	0	0	32	0%

Practical calculations at case 2 (N=2500 RPM)

$Hm (ft) * 0.3[ft/m]$	$Q * 10^{-3}$	$O/P (W)$	$I/P \{Shaft Power\} (W)$	$Efficiency$
13	32.15	127.4	670.3	19%
44	26.25	352	630.4	55.83%
68	16.94	351.1	518.676	67.7%
82	0	0	175.5	0%

Theoretical calculations at case 2

($N = 2500$) using similarity rules at case 1 readings.

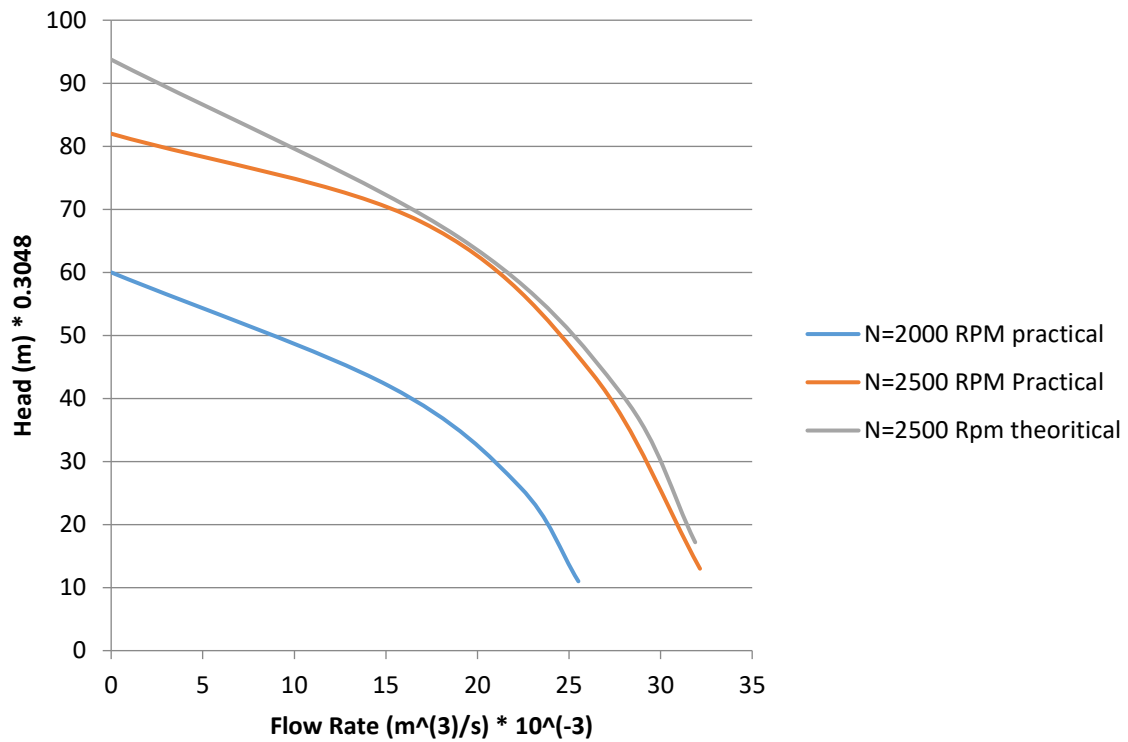
$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

$$\frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2$$

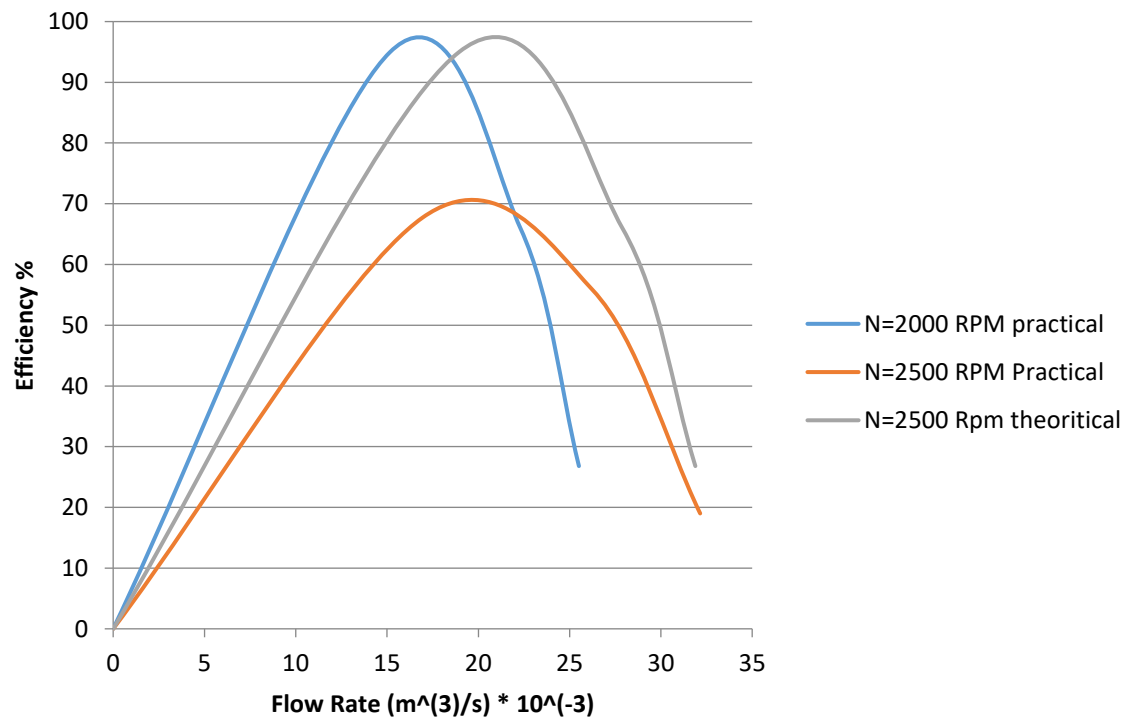
$$Psh_2/Psh_1 = \left(\frac{N_2}{N_1}\right)^3$$

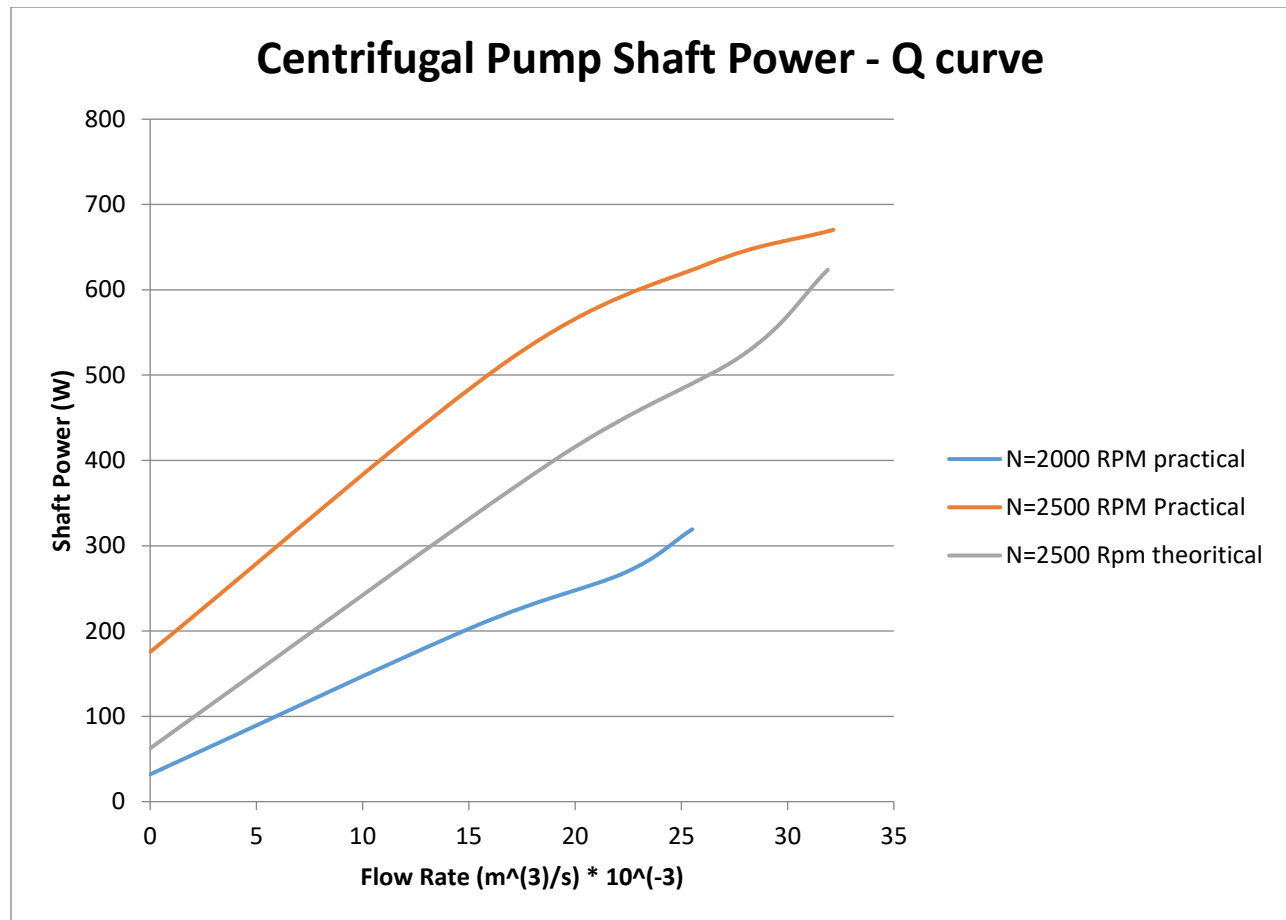
$Hm (ft) * 0.3[ft/m]$	$Q * 10^{-3}$	$O/P (W)$	$I/P \{Shaft Power\} (W)$	$Efficiency$
17.19	31.8875	167.1	623.4	26.8%
40.625	27.8875	345.3	523.6	66%
65.625	18.945	379	399	94.98%
93.75	0	0	62.5	0%

Centrifugal Pump H-Q curve



Centrifugal Pump Efficiency- Q curve





Comments

After studying the graphs we could deduce that:

- As the rotational speed of the pump increase
 1. The flow rate (Q) increases
 2. The Head (H_m) provided at this flow rate increases
 3. The shaft power also increases with the speed increases and
 4. Efficiency varies as in practical case it decreases.
- But for theoretical case which we get using the similarity rules we could say that as the rotational speed of pump increases we got increase in provided head, flow rate, Shaft power but here affinity rule take place and each flow rate has the same efficiency for its opposite flow rate at the other speed so we had that shifted efficiency at the theoretical case.
- Error exists in the second case between the theoretical and practical results due to having some reading errors in measuring instruments and variations in supplied current as load changes leading to further errors.