Contents

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

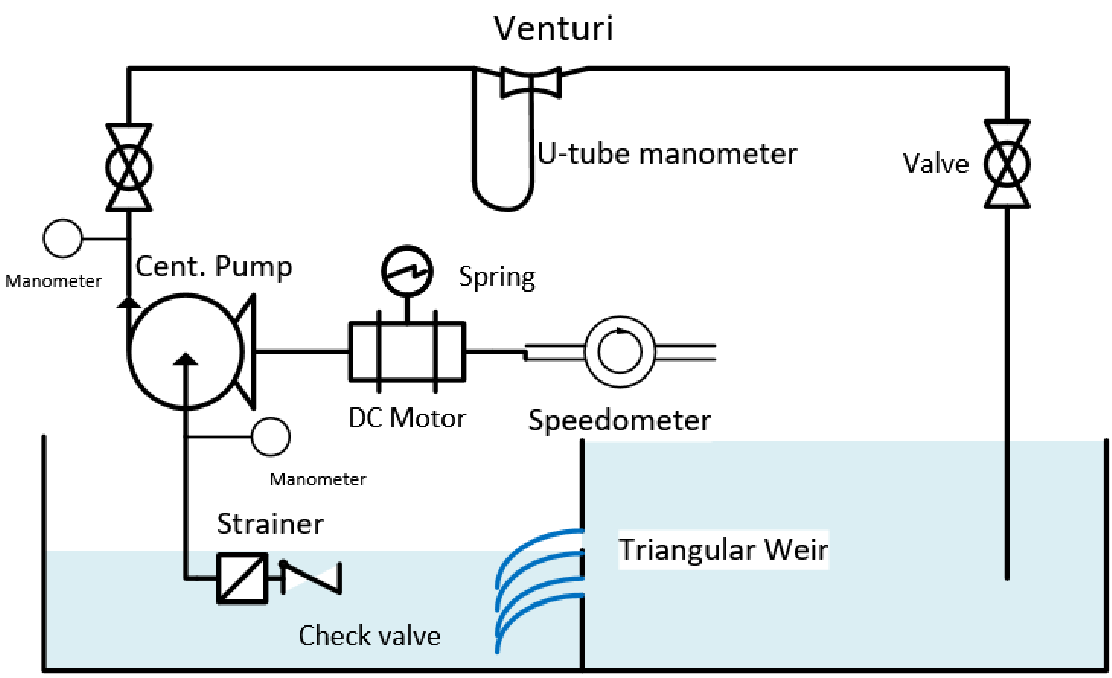


Figure 1

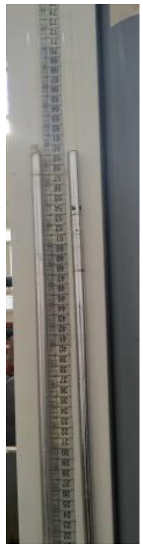


Figure 2 Manometer reading

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

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

$Y\ (cm)$	$H_{ms}\ (ft)$	$H_{md}\ (ft)$	$F\ (kg.f)$
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 ($N = 2500\ RPM$)

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

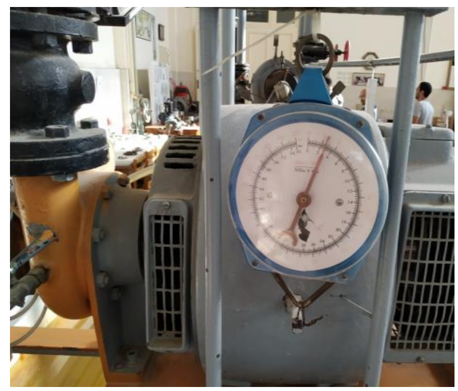


Figure 4 spring reading

Calculations

Pump Monomeric head

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

$$1\ ft = 0.3048\ meter$$

Flow Rate

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

$$h = y\ [SG_u \backslash SG_f - 1$$

Where:

$$Cd = 0.94$$

$$dpipe = 10\ cm\ \left(A_{pipe} = \frac{Pi}{400}\ m^2\right)$$

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

$$y \; = \; U - tube\; manometer\; reading$$

$$SG_u \; = \; 13.6$$

$$SG_f \; = \; 1$$

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

Efficiency

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

Where:

$$\frac{O}{P} = \; Denistywater * \; Hm * \; Q$$

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

$$T \; = \; F * \; R$$

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

$$R \; (brake\; radius) \; = \; 0.3048\; m.$$

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

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

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

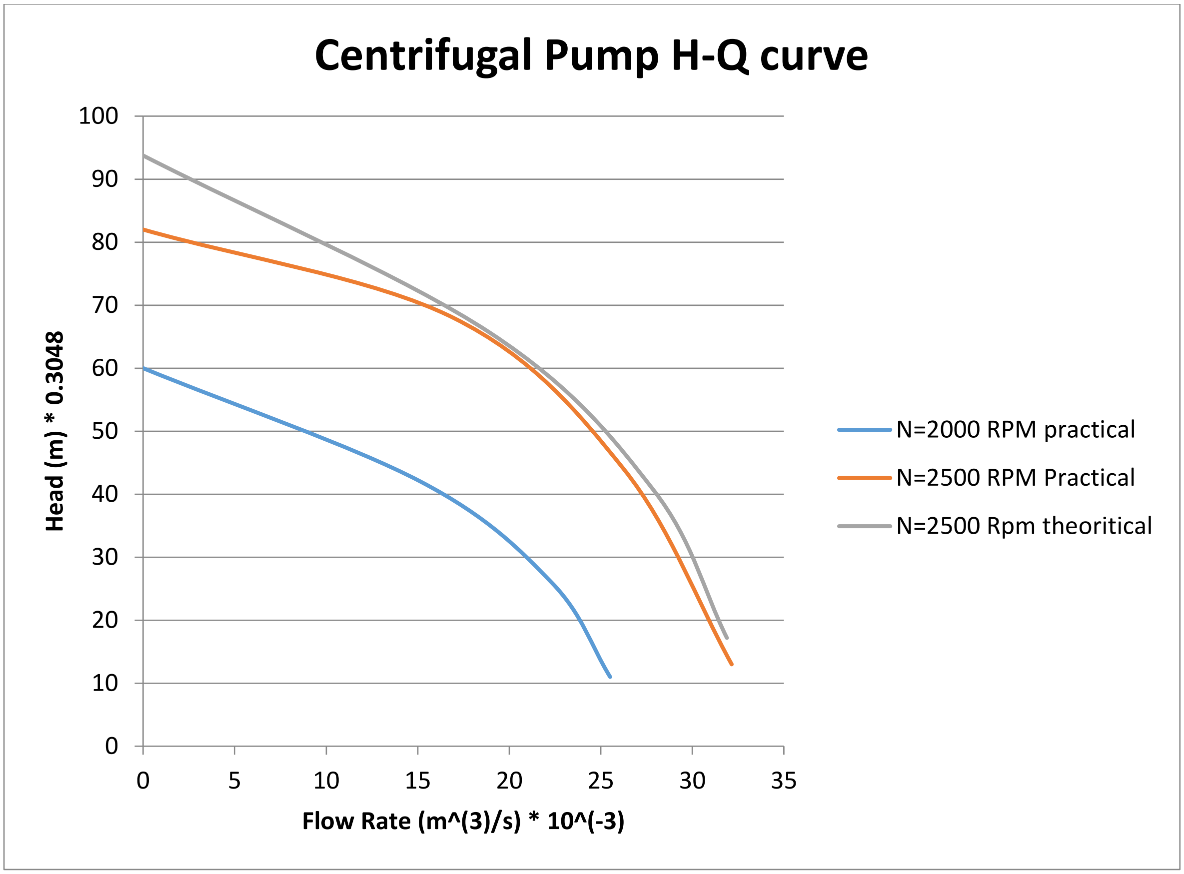
$(N = 2500)$ using similarity rules at case 1 readings.

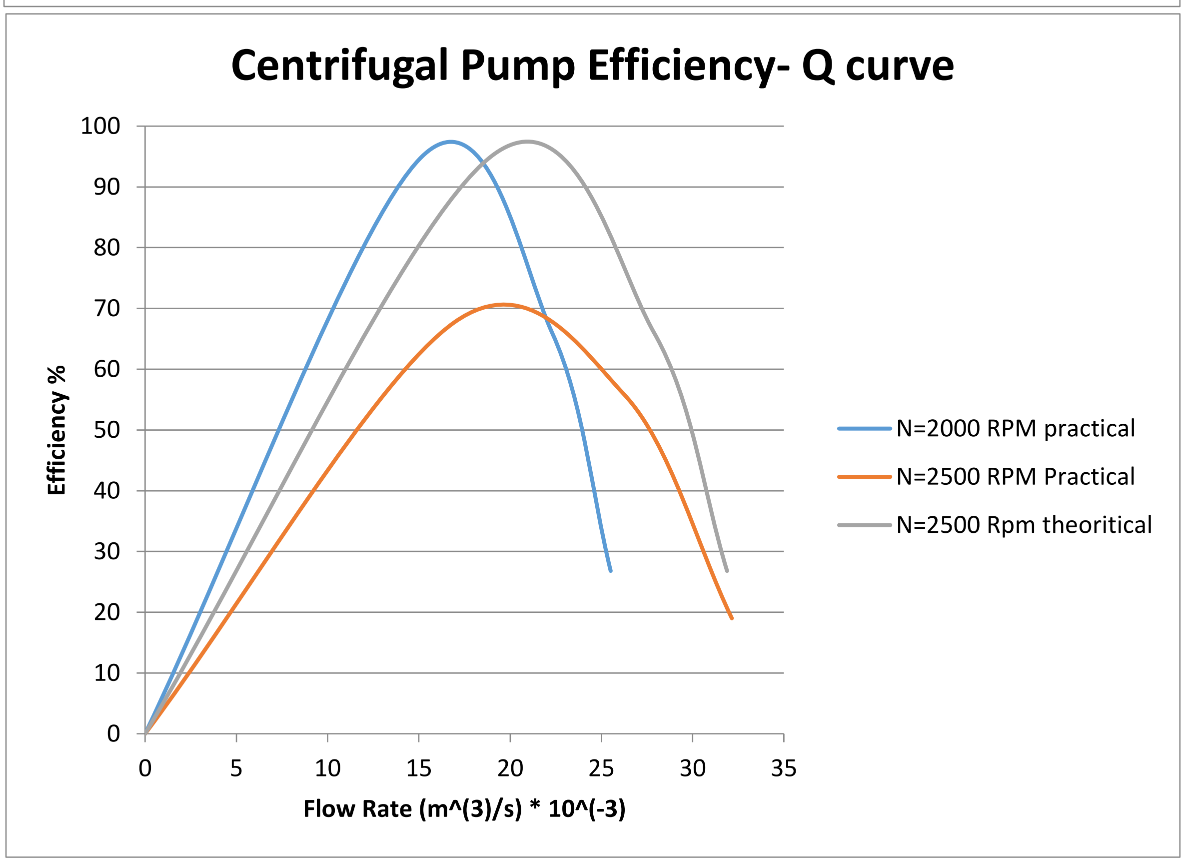
$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

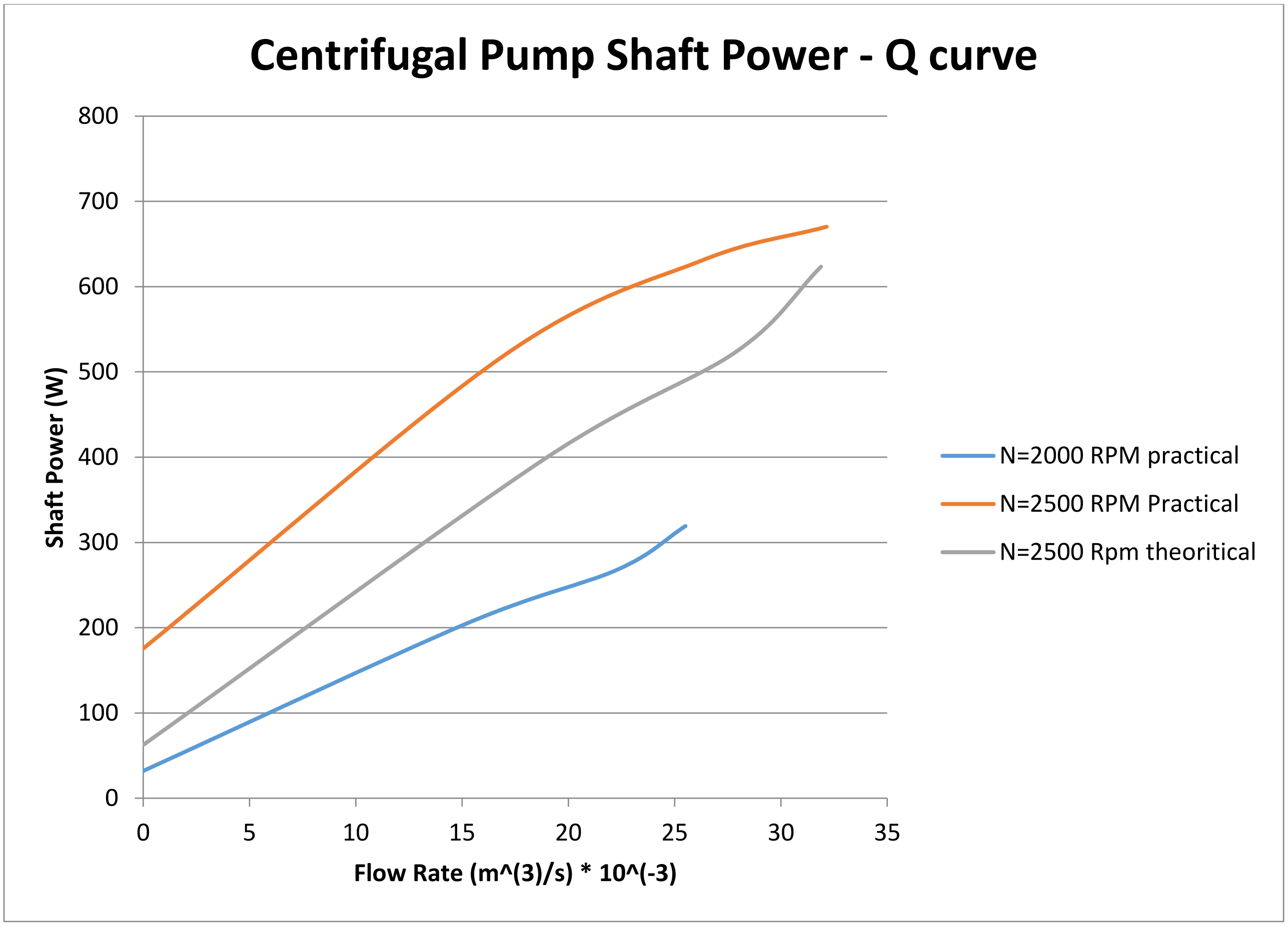
$$\frac{H_2}{H_1} = \left(\frac{N_2}{N_1}\right)^2$$

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

$Hm\ (ft) * 0.3[ft/m]$	$Q * 10^{-3}$	$O/P\ \ (W)$	$I/P\ \ \{Shaft\ Power\}\ (W)$	$Efficiency$
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
Head (m) * 0.3048
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
Flow Rate (m^(3)/s) * 10^(-3)
N=2000 RPM practical
N=2500 RPM Practical
N=2500 Rpm theoritical


Centrifugal Pump Efficiency- Q curve
Efficiency %
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
Flow Rate (m^(3)/s) * 10^(-3)
N=2000 RPM practical
N=2500 RPM Practical
N=2500 Rpm theoritical



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.