EXPERIMENT 2
CENTRIFUGAL PUMP

I. INTRODUCTION

Centrifugal pump usually works at constant speed and its flowrate and pressure vary with working condition. The (graph of) relationship between flowrate and pressure – main characteristic curve – is the most important information required for choosing pump. Two other characteristic curves are also useful for designing pumping system: the relationship between power and flowrate and the relationship between efficiency and flowrate.

The three characteristic curves – $H = f_1(Q)$, $N = f_2(Q)$, $\eta = f_3(Q)$ – are depicted in Figure 2.1

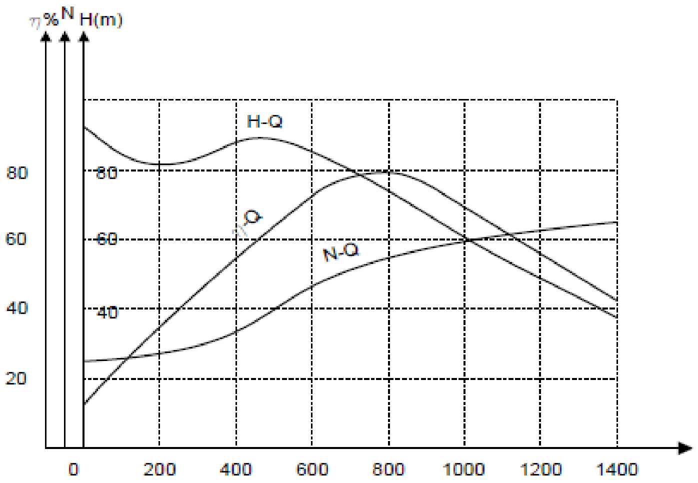

Figure 2.1. *Centrifugal pump characteristic curves*

When centrifugal pump rotate at different speed, these curves also change:

$$\frac{Q_1}{Q_2} = \frac{n_1}{n_2}; \frac{H_1}{H_2} = \left(\frac{n_1}{n_2}\right)^2; \frac{N_1}{N_2} = \left(\frac{n_1}{n_2}\right)^3 \quad (2\text{-}1)$$

It can be seen in the Figure 1 that power N increases with flowrate Q, power is smallest at Q = 0. To prevent motor overload, it is necessary to close suction valve before starting centrifugal pump.

Fluid flows through a piping system need driving force (head) to overcome frictional resistance. The required head depends on fluid flowrate. This relationship is called operating line of the system or system curve:

$$H_{mg} = \left(1 + \frac{\lambda.L}{d} + \sum \xi\right)\frac{\omega^2}{2.g} + H_h + H_c \quad (2\text{-}2)$$

λ - friction factor;

L – pipe length, m;

d – pipe diameter, m;

$\sum\xi$ - sum of loss coefficients;

g – gravitational acceleration, m/s^2;

f – pipe cross sectional area, m^2;

H_h – height difference between suction and discharge ends, m;

H_c – pressure difference between suction and discharge ends, m;

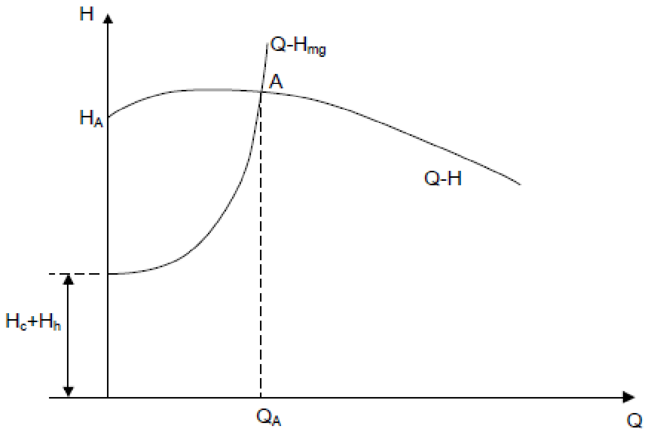

Figure 2.2. *Pump curve and system curve*

For a given piping system:

$$\frac{\left(1+\frac{\lambda.L}{d}+\sum\xi\right)}{2.g.f^{2}}=a \quad \text{is a constant (2-3)}$$

$$H_n + H_c = b \text{ is also a constant}$$

Equation (2-2) can be rewritten as: $H_{mg} = aQ^2 + b$ (2-4)

The graph of equation (2-4) is parabolic. When pump curve and system curve are drawn on the same coordinates, their intersection is called operating point.

The purpose of this experiment is determining characteristic curves of centrifugal pump at constant speed.

II. PURPOSE

1. Have knowledge of centrifugal pumping system and how to operate it.
2. Determine characteristic curves of centrifugal pump at constant speed: $H = f_1(Q)$; $N = f_2(Q)$; $\eta = f_3(Q)$ and find the suitable operating point.

III. EXPERIMENT SETUP

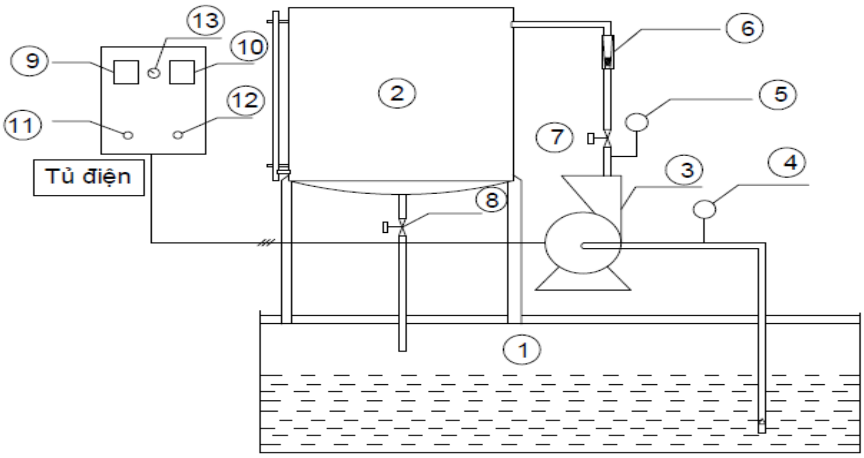

Figure 2.3. *Experiment setup*

1. Water tank
2. Removed
3. Centrifugal pump
4. Vacuum gauge
5. Pressure gauge
6. Flowmeter
7. Discharge valve
8. Removed
9. Power meter
10. Voltmeter
11. Start button
12. Stop button
13. Varistor

IV. OPERATING PROCEDURE

1. Open discharge valve
2. Turn on experiment 2 setup (button Bai 2 on main electrical cabinet)
3. Turn varistor to set frequency at 50Hz (shown on inverter)
4. Push start button
5. Use discharge valve to change flowrate, record value indicated by vacuum gauge, pressure gauge, power meter at different flowrate
6. Push stop button and drain the pump.

V. QUESTION

1. The construction of centrifugal pump?
2. What are pump curves and system curve? The meaning of operating point?
3. How do pump curves change when pump run at different speeds?

VI. CALCULATION

1. Total head of the pump:

$$H = P_{ak} + P_{ck} + h + \frac{W_đ^2 - W_h^2}{2g}, \quad m \qquad (2-6)$$

P_{ak} – discharge pressure, mH_2O;

P_{ck} – suction vacuum, mH_2O;

h - height different between pressure gauge and vacuum gauge, m;

$W_đ$ – discharge velocity, m/s ;

W_h – suction velocity, m/s ;

2. Power outut of the pump

$$N_b = \frac{Q.\rho.g.H}{1000}, \quad kw \qquad (2-8)$$

g – gravitational acceleration, g = 9,81, m/s^2

ρ - water density, depend on temperature, kg/m^3

3. Pump efficiency

$$\eta = \frac{N_b}{N} \qquad (2-10)$$

4. Record

No.	Q	P_{ak}		P_{ck}		H	N_b	N	η
	(m^3/s)	psi	mH_2O	" Hg	mH_2O	mH_2O	Kw	Kw	%
1									
2									
3									
4									
5									
6									
7									

5. Draw pump curves and choose the most suitable operating point

6. Comments on experiment