<table>
<tr><td>UNIVERSITI TEKNIKAL MALAYSIA MELAKA</td><td>No Dokumen:
MMB/BMCG 3011/4</td><td>No Isu./Tarikh:
1/1-03-2021</td></tr>
<tr><td>MECHANICAL ENGINEERING LABORATORY III
System and Pump Characteristics</td><td>No Semakan/Tarikh:</td><td>Jum. Mukasurat:
6</td></tr>
</table>

OBJECTIVE

To determine the system and pump characteristic curves for a pump by establishing the operating point of the pump.

LEARNING OUTCOME

At the end of the laboratory session, the students should be able to:-

1. Calculate the volumetric flow rate for in order to establish the pump and system characteristics.
2. Calculate the mechanical and hydraulic power to establish the efficiency of the pump.
3. Apply Bernoulli equation to establish the delivery head for each pump and system characteristics.
4. Plot graph of pump, system characteristics and pump efficiency to determine and evaluate the operating point of the pump.
5. Write a well described technical report based on the experimental data according to the well established report writing format as well as deriving clear and meaningful conclusions.

THEORY

In a centrifugal pump that was driven at a constant speed, the delivery head depends on the delivery volume flow rate. The correlation between these performance data is represented in a characteristic curve. To obtain the operating point for the pump, there are two characteristics curves involved. These characteristics curves are:

1. Pump charactheristic curve and
2. System charactheristic curve.

The pump characteristic curve will indicate the pump performance in terms of its delivery head against the discharge. As shown in Figure 1, as the dischrge increased, there will be some lost in its delivery head. For the system characteristics, this is shown in Figure 2. At different rotational speed, the pump behaves in such a way that it would uniquely delivered the discharge at certain delivery head.

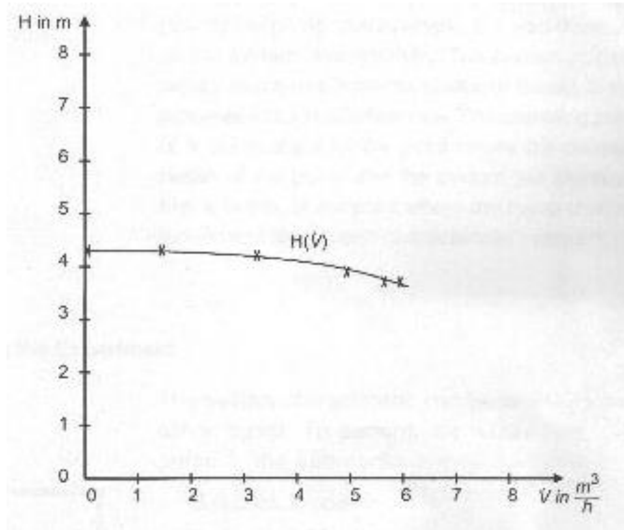

Figure 1 Pump Characteristics Curve

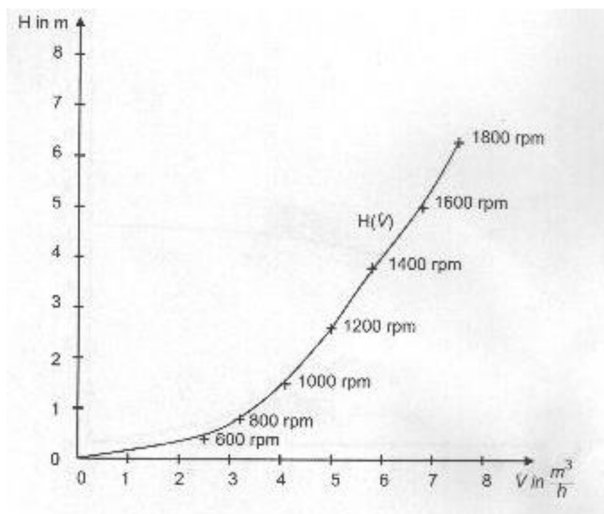

Figure 2 System Characteristic Curve

The operating point of a pump depends on the pump characteristic and system characteristic. The operating point of a pump starts at the point where the delivery head of the pump and the system are identical. This point is given by the intersection of the pump characteristic curve and the system characteristic curve. The example of this point is shown by Figure 3.

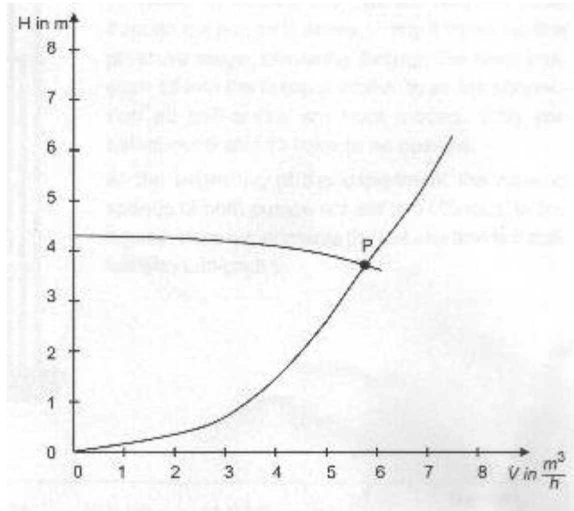

Figure 3 Operating Point, P

In addition to the head or power added to the fluid, the overall efficiency is of interest. The overall pump efficiency is affected by the hydraulic losses in the pump. Performance characteristics for a given pump geometry and operating speed are usually given in the form of plots of system characteristic, pump characteristic, and efficiency versus volume flow rate as illustrated in Figure 4.

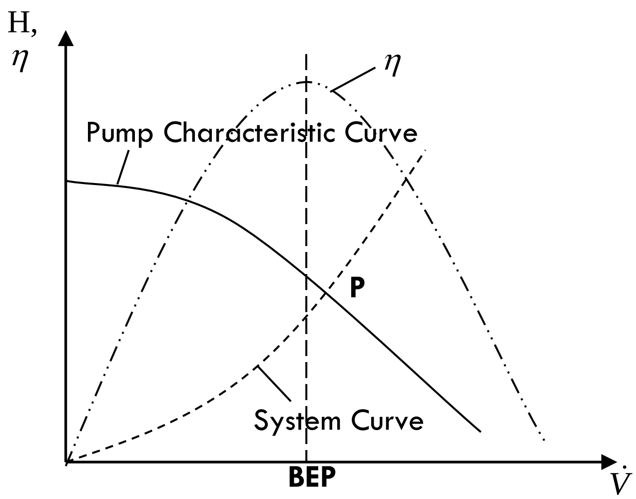

Figure 4 Typical performance characteristics for a centrifugal pump of a given size operating at a constant speed

Efficiency is a function of flow rate and reaches a maximum value at some particular value of the flowrate, commonly referred to as the normal or design flowrate or capacity for the pump. The points on the various curves corresponding to the maximum efficiency are denoted as the best efficiency points (BEP). It is apparent that when selecting a pump for a particular application, it is usually desirable to have the pump operate near its maximum efficiency. Thus, performance curve of the type shown in Figure 4 are very important to the engineer responsible for the selection of pumps for a particular flow system.

APPARATUS

HM360 Multi-Pump Test Rig, stop watch and hand-held tachometer

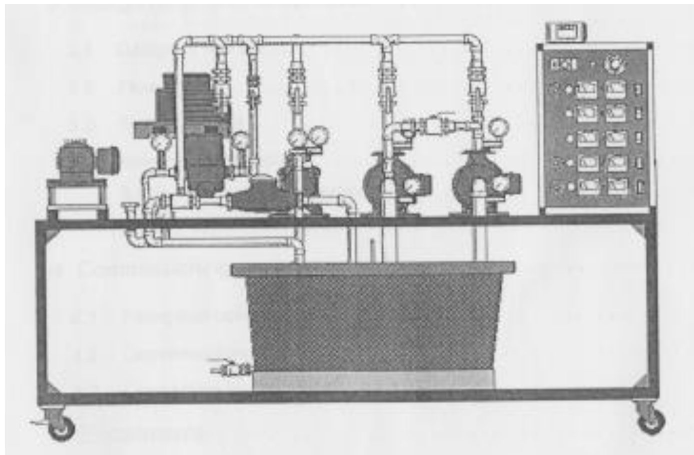

Figure 5 HM 360 Multi-Pump Test Rig

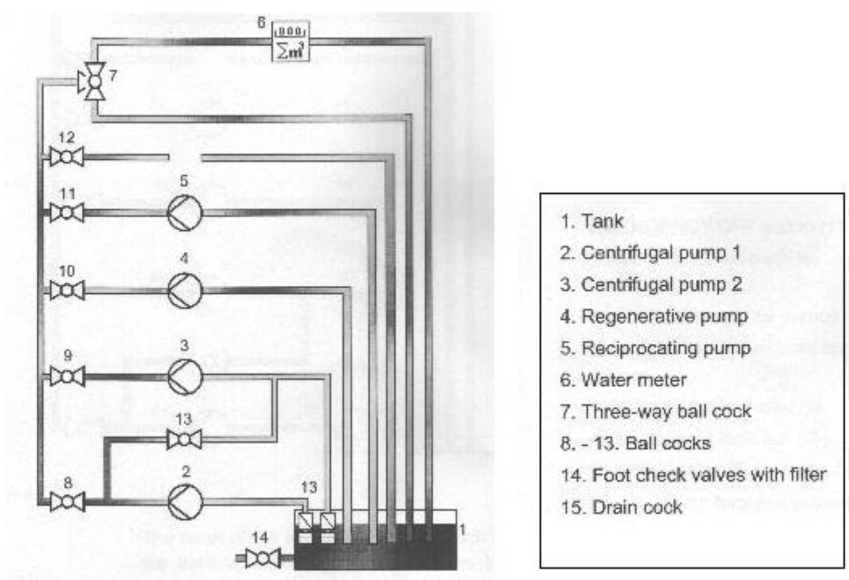

Figure 6 Multi- Stage Pump Diagram

PROCEDURES

A. System Characteristic (Refer Table 1)

1. Open ball cock 8 and close all other ball cock (9-13).
2. Switch water meter with three-way ball cock (7) to rest position.
3. Record a starting value of water meter V_1.
4. Set stopwatch to zero.
5. Switch on pump 1.
6. Hold the tachometer vertically over the hole in the coupling guard. Adjust the potentiometer on the switch cabinet until the rotational speed of the pump, n = 600 rpm. Check the rotational speed using hand-held tachometer.
7. Switch over three-way ball-cock and at the same time start the stop watch. Sixty seconds (60) is a reasonable measuring period.
8. Reset three-way ball-cock to rest, and stop the watch.
9. Record the stop watch time and end value of water meter V_2.
10. Record inlet pressure p_1 and outlet pressure p_2..
11. Repeat step 3 until 10 with increasing the rotation speed from measuring point to measuring point by 200 rpm up to 1800 rpm.
12. Record the readings into **Table 1**. Use equationn (1) to calculate $\dot{V}$ and equation (4) for H.

B. Pump Characteristic for one pump (Refer Table 2)

1. Follow instruction 1 to 11 in part **A**, but this time fix the rotational speed, *n*, of the pump to 1400 rpm and adjust ball-clock 8 position to 30°, 45°, 60°, 75° and 90° (shut).
2. Record the readings into the **Table 2**. Use equation (1) to calculate $\dot{V}$ and equation (4) for H.
3. Plot a graph of H versus $\dot{V}$ (system characteristic (**Table 3**)) and pump characteristic (**Table 4**) onto one graph.

FORMULA FOR CALCULATION

Volume flow rate, $\dot{V} = \dfrac{V_2 - V_1}{\Delta t}$ (1)

Pipe diameter at suction side (inlet), d_1 = 50 mm

Pipe diameter at delivery side (outlet), d_2 = 32mm

Velocity at suction side, $c_1 = \dfrac{\dot{V}}{A_1}$ (2)

Velocity at delivery side, $c_2 = \frac{\dot{V}}{A_2}$ (3)

Height difference between the pressure transducers, z = 0.2 m

Delivery head for one pump, H $= \frac{p_2 - p_1}{g\rho} + z + \frac{c_2^{\,2} - c_1^{\,2}}{2g}$ (4)