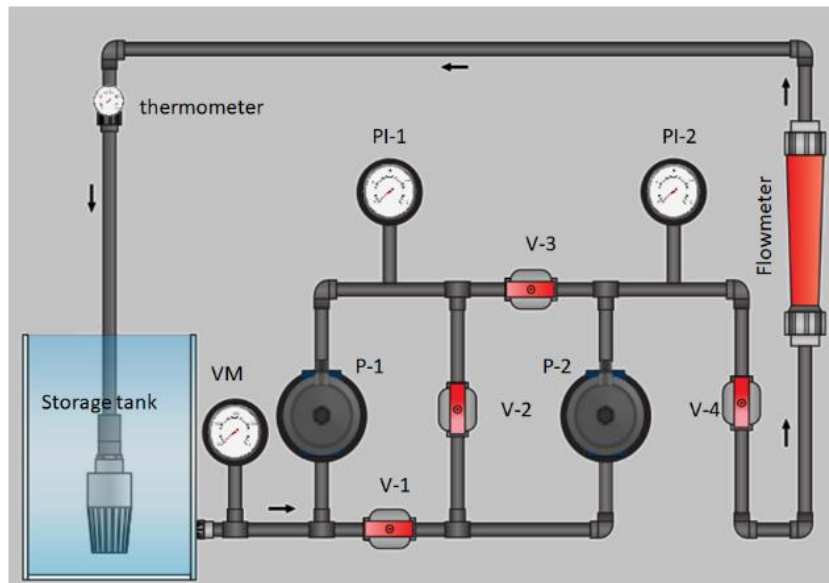**EXPERIMENT NUMBER:** 1

A) EXPERIMENT NAME: Serial/Parallel Centrifugal Pump

B) *EXPERIMENTAL SETUP:* T-415 Serial/Parallel Centrifugal Pump Test Set

Fig 1. T-415 Serial/Parallel Centrifugal Pump Test Set

PI: Pressure inductor   P: Pump   V: Valve   VM: Vacuum manometer

Fig 2. Schematic Diagram of Pump Set

C) AIM OF THE EXPERIMENT:

1) **Finding pump head-flow rate relation**

   Investigation of Pump discharge head supplied by the pump. Velocity differences at the input and output of the pump can be ignored. Then the total head will be reduced to pressure head.

2) **Finding pump efficiency**

   Pump efficiency is the ratio of pump hydrolic power requirement to electrical motor power input. Pumps operates with different efficiencies in different operational conditions.

3) **To investigate the result on discharge and total head of operating pumps in series**

   The experiment aims to obtain the characteristic curve of two pumps connected in series and compare the result with a single pump case.

4) **To investigate the result on discharge and total head of operating pumps in parallel**

   The aim of the experiment is to obtain the characteristic curve of two pumps which are connected in parallel, and compare the result with a single pump case

D) THEORY

Centrifugal pumps are often used together to enhance either the flow rate or the delivery pressure beyond that available from the single pump. For some piping system designs, it may be desirable to consider a multiple pump system to meet the design requirements. Two typical options include parallel and series configurations of pumps which require a specific performance criteria. In serial operation the heads of the pumps are added and in parallel operation the flow rates (capacities) of the pumps are added.

A single pump may be insufficient to produce the performance required. Combining two pumps increases the pumping capacity of the system. Two pumps may be connected in series, so that water passes first through one pump and then through the second. When two pumps operate in series, the flow rate is the same as for a single pump but the total head is increased. The combined pump head capacity curve is found by adding the heads of the single pump curves at the same capacity.
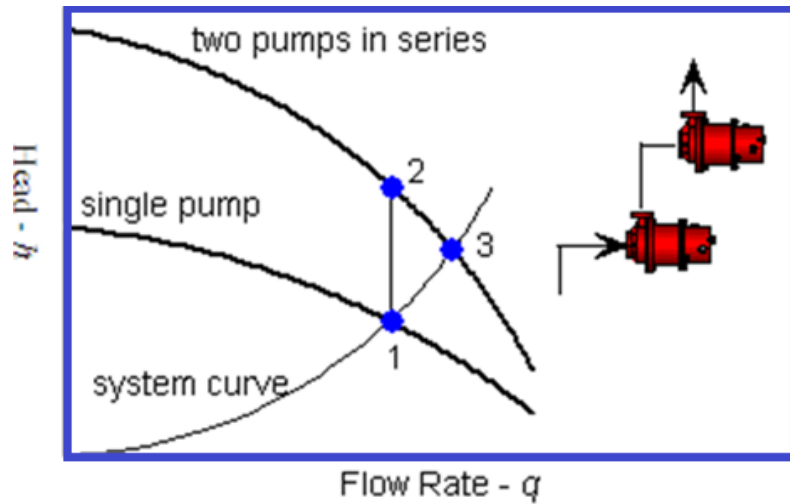
Figure 3: Pump curve for two pumps in series

Two pumps may be connected in parallel, so that half the flow passes through one of the pumps and the other half through the second pump. When two pumps operate in parallel, the total head increase remains unchanged but the flow rate is increased. The head-capacity curve is found by adding the capacities of the single pump curves at the same head.
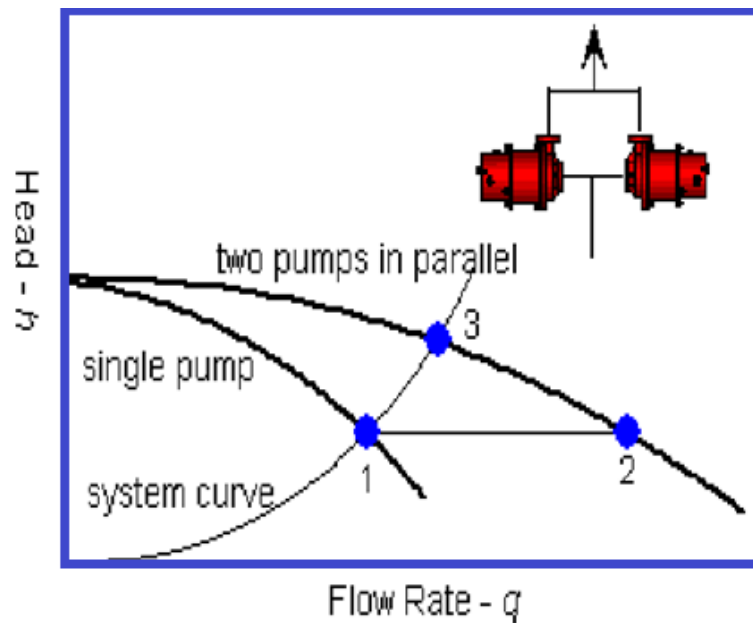

Figure 4: Pump curve for two pumps in parallel

E) EXPERIMENTAL PROCEDURE:

Find pump head-flow rate relation

1) Turn valves number 3 and 4 on all the way.
2) Turn the main switch on and operate the pump by turning switch 1 on.
3) Decrease flow rate gradually by adjusting the valve. Read flow rate and head for each case and record to the table below.
4) When the flow rate becomes zero, pump will give the maximum head available.
5) Plot table values.

Properties/Number of measurement	1	2	3	4	5	6	7	8	9	10
Pump head [mH$_2$O]										
Volumetric flow rate [m^3/h]										
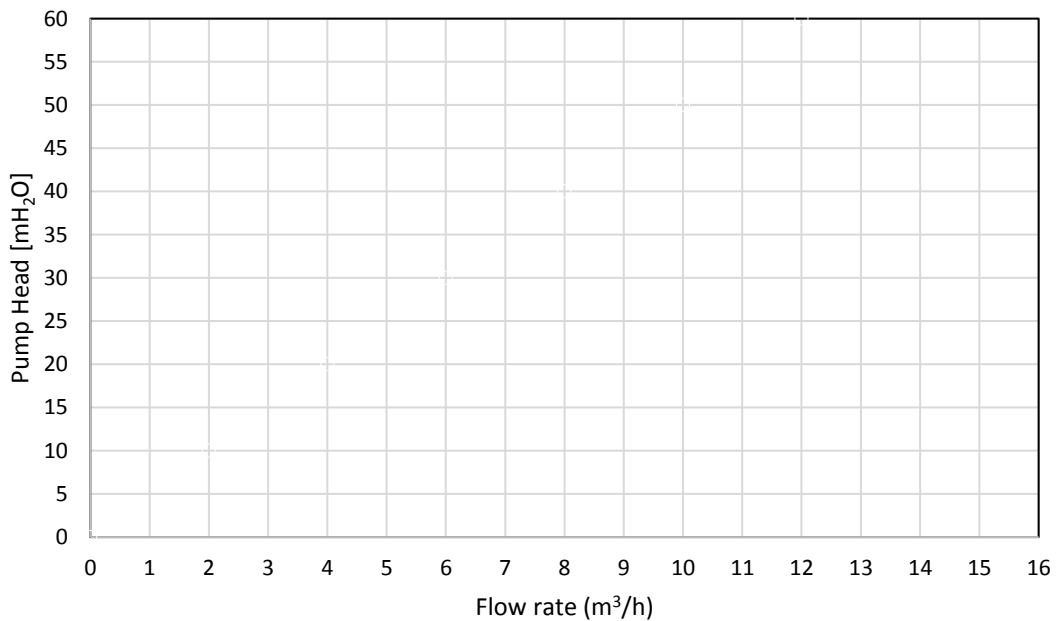
Finding pump efficiency

1) Turn valves number 3 and 4 on all the way.
2) Turn the main switch on and operate the pump by turning switch 1 on.
3) Decrease flow rate gradually by adjusting the valve. Read flow rate, head, current, voltage and power factor for each case and record to the table below.
4) Calculate pump efficiency by using the given formulations, record to the table below and plot.

| Properties/Number of measurement	1	2	3	4
Pump head [mH$_2$O]				
Volumetric flow rate [m^3/h]				
Motor current input [A]				
Motor voltage [V]				
Power factor cos(ϕ)				
Pump efficiency (η)				

Calculations

Efficiency (η): The ratio of the hydrolic power to pump input

$$\eta = \frac{Hydrolic\ power}{Motor\ input\ power} = \frac{\dot{m}gH}{V_m I_m \cos\phi}$$

$\dot{m}$: mass flow rate [kg/s], g : gravitational acceleration [m/s^2], H : pump head [mH$_2$O]

V$_m$: Motor voltage [V], I_m : Motor current [A], $\cos\varphi$: power coefficient – phase angle
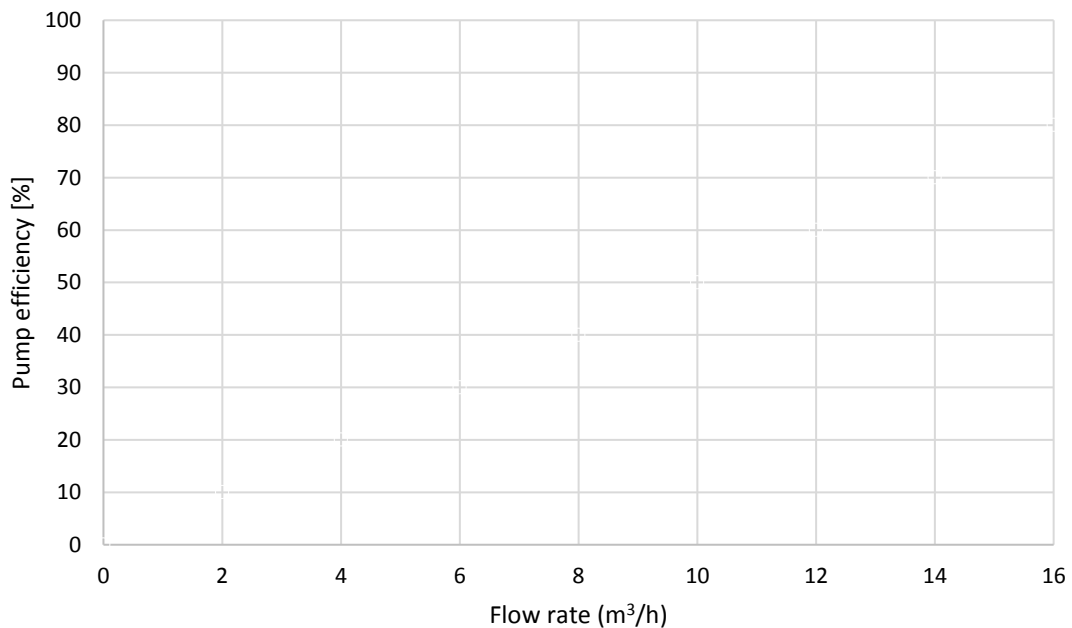
Pumps in series

1) Turn valves number 2 and 4 on all the way.

2) Turn the main switch on and operate both pumps by turning switches on.

3) Decrease flow rate gradually by adjusting valve 4. Read flow rate and head for each case and record to the table below.

4) Plot the data. Plot the data from experiment T-415-01 on the same chart. Discuss the results.

Properties/Number of measurement	1	2	3	4	5	6	7	8	9	10
Pump head [mH$_2$O]										
Volumetric flow rate [m^3/h]										

Pumps in parallel

1) Turn all the valves on **except number 2** all the way.
2) Turn the main switch on and operate both pumps by turning switches on.
3) Decrease flow rate gradually by adjusting valve 4. Read flow rate and head for each case and record to the table below.
4) Plot the data. Plot the data from experiment T-415-01 on the same chart. Discuss the results.

Properties/Number of measurement	1	2	3	4	5	6	7	8	9	10
Pump head [mH$_2$O]										
Volumetric flow rate [m^3/h]										
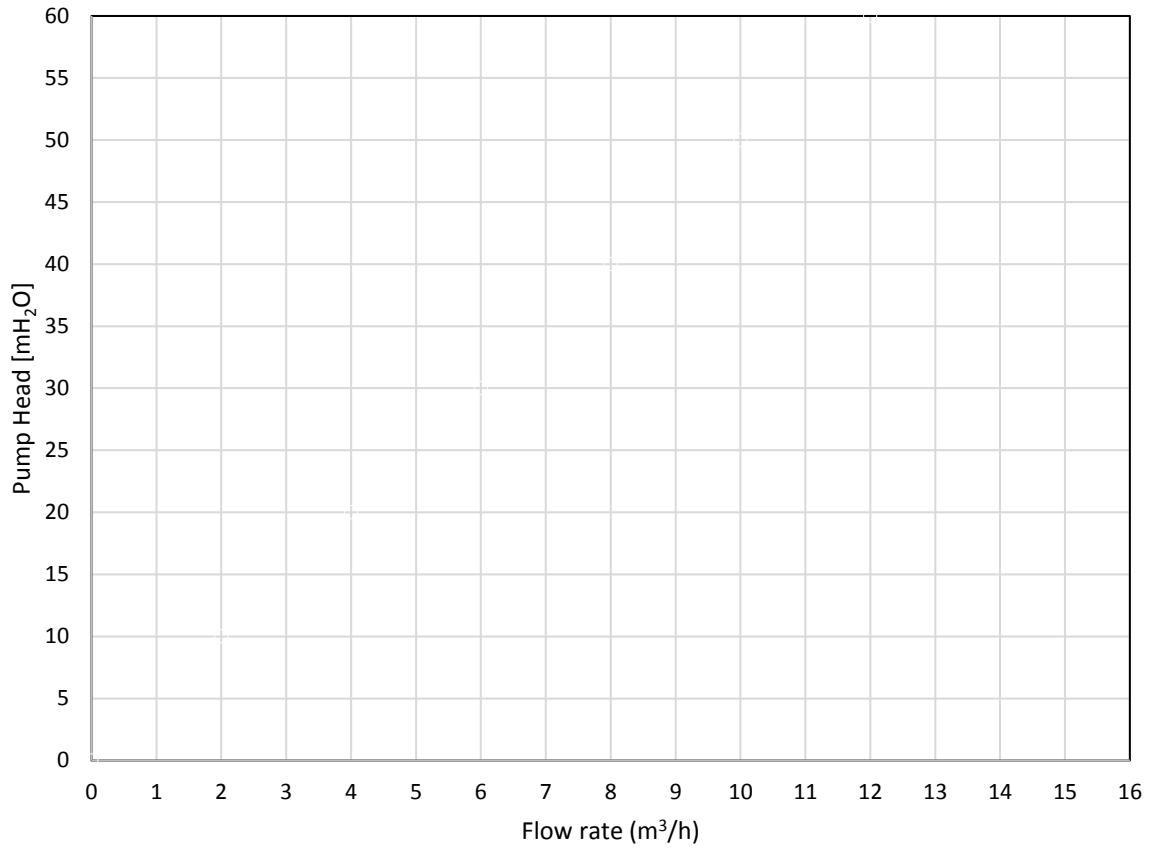
F) REQUIREMENTS IN REPORT: Experiment number, name and aim of the experiment. The table values, calculations and explanations. Plot a graph of pump head vs flow rate for serial and parallel pump. Plot a graph of pump efficiency vs flow rate. Calculate pump efficiency.