FLUID FLOW SIMULATION WITH CENTRIFUGAL PUMP VARIATIONS : AN EXPERIMENTAL STUDY

Amrullah[1)], Jalaluddin Jumhur[2)], M. Oemar Assad[2)], Muhaemin[2)]

[1)] Lecturer of the Department of Mechanical Engineering at the State Polytechnic of Ujung Pandang, Makassar

[2)] Student of the Department of Mechanical Engineering at the State Polytechnic of Ujung Pandang, Makassar

ABSTRACT

The purpose of this study was to determine the best characteristics of single and double pump installations with different pump specifications. The research was conducted experimentally using centrifugal pumps with different specifications, especially on discharge. The size of the pipe used is 1 inch with galvanized material and PVC with thread, flange and glue connection methods. The flow meter is used as a measuring instrument to vary the flow rate. Tests have been carried out by flowing the fluid in two pumps with different specifications with varied installations, namely single 1, single 2, double series and double parallel. Tests have been carried out by flowing the fluid in two pumps with different specifications with varied installation, namely single 1, single 2, double series and double parallel. The best results obtained from this test are in a series of parallel double pumps with a discharge value is 4.6 m^3/h, total head is 6.754 m and efficiency is 33.765%. The use of parallel double pumps with different pump specifications can increase the discharge and total head so that it is expected to be a solution for high water requirements at high positions.

Key words *: pump, discharge, series, parallel*

1. INTRODUCTION

Pumps have a very important role for industries such as drinking water, oil, petrochemical, power plants and several other applications. In the process, centrifugal pumps have the advantages of simple working principle, strong construction, requiring less space, uninterrupted flow of liquid, high pump rotation speed, allowing for direct drive by an electric motor and easy maintenance.

Several things that need to be considered in planning the installation and selection of pumps include high pressure, suction height, discharge and fluid properties. The head is the main factor in determining the pump for clean water needs with a relatively small capacity. The suction lift must also not exceed the maximum recommended limit. Discharge is a determining factor for pump size and will affect the class of pump unit selected. Fluid properties also affect the pump construction to be used[1].

In a study conducted by Akbar to determine the effect of the arrangement of two centrifugal pumps on the head and discharge, the parallel pump arrangement has a higher flow value than the series pump arrangement while the series pump arrangement has a higher head value than the parallel pump arrangement[2]. Related research was also carried out by Hafizar where the highest head value obtained from experimental and computational was found in the series pump installation while the parallel pump installation had the largest capacity because there were two suction channels[3].

In a study conducted by Helmizar with the same pump specifications and variations in valve opening, it was found that the smaller the valve opening setting, the greater the head produced but there was a decrease in the amount of water discharge[4]. From research related to the pump installation, it can be seen that testing on double pumps with the same specifications can increase the hydraulic power of the pump and decrease the average fluid velocity at each increase in the pressure head[5]. Research related to the double pump installation was also carried out by Wahyudi with the result that the series installation pump is an option to overcome the shortage of head on a single pump [6].

From several previous studies, double pump testing has been carried out with the same specifications. Tests on double pumps in series show the achievement of high head values and parallel double installations show the achievement of high discharge values. In this study, tests were carried out on single and double pumps with different specifications. The purpose of this study was to determine the best characteristics of single and double pump installations with different pump specifications.

The average fluid velocity (V) is determined from the magnitude of the discharge (Q) against the cross-sectional area of the pipe (A)

$$V = \frac{Q}{A} \quad (1)$$

[1] Corresponding Author: Amrullah,S.T.,M.T., Telp 0811424425,amrullah@poliupg.ac.id

The Reynolds number determines the type of flow that depends on a non-dimensional parameter where V is the average velocity of the fluid in a pipe, D is diameter of pipe and ν is the kinematic viscosity of the fluid[3]. Type of flow, laminar or turbulent is shown in Figure 1.

$$\mathrm{Re} = \frac{VD}{\nu} \tag{2}$$

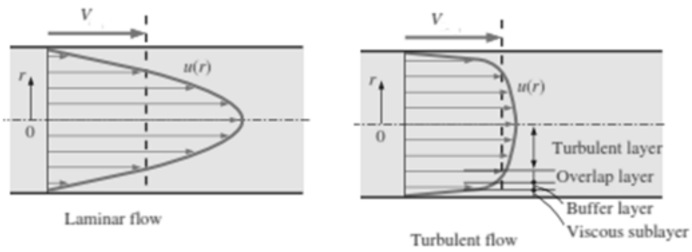

Figure 1. Type of flow in pipe : laminar and turbulent

The head loss (H_L) is determined from the major loss (h_f) due to friction in the pipe and minor loss (h_k) at the pipe and valve connection. Major losses can be determined from the friction factor (f), pipe length (L), pipe diameter (D), average fluid velocity (V) and acceleration of gravity (g). For minor losses, the compressive height loss is usually expressed in the form of a dimensionless loss coefficient (k) [7].

$$\mathrm{h_f} = \mathrm{f}\frac{\mathrm{L}}{\mathrm{D}}\frac{\mathrm{V}^2}{2\mathrm{g}} \tag{3}$$

$$\mathrm{h_k} = \mathrm{k}\frac{\mathrm{V}^2}{2\mathrm{g}} \tag{4}$$

$$\Sigma\,\mathrm{H_L} = \mathrm{h_f} + \mathrm{h_k} \tag{5}$$

Mechanically, the total head (H) is the sum of the suction head (H_s), the pressure head (H_d) and the head due to friction, connections and valves (ΣH_L) [8].

$$\mathrm{H} = \mathrm{H_s} + \mathrm{H}_d + \sum \mathrm{H_L} \tag{6}$$

Pump hydraulic power (P_h) can be determined from the density of water (ρ), acceleration of gravity (g), total head (H) and discharge (Q).

$$\mathrm{P_h} = \rho.\mathrm{g}.\mathrm{H}.\mathrm{Q} \tag{7}$$

Pump efficiency can be determined from the ratio of the pump hydraulic power (P_h) to the shaft power(P_s).

$$\eta = \frac{P_h}{P_s} \times 100\% \tag{8}$$

2. EXPERIMENTAL METHODE

Experimental study using centrifugal pumps with different specifications and installations as shown in Figure 2. Pump 1: Model SE-125A, maximum capacity 30 L/min, maximum suction : 9 m, thrust height 24 m. Pump 2: Model CPM-130, Q_{max}:80 L/min, H_{max}=16 m, maximum suction : 9 m.

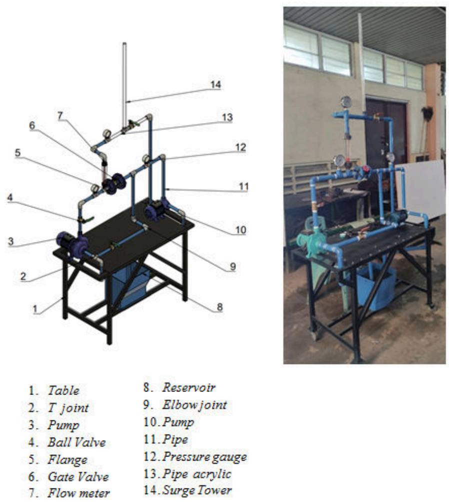

Figure 2. Installation of centrifugal pump testing equipment

Tests are carried out with single pump 1, single pump 2, double series and double parallel as shown in Figure 3. The size of the pipe used is 1 inch with galvanized material and PVC with thread, flange and glue connection methods. The flow meter is used as a measuring instrument to vary the flow rate.

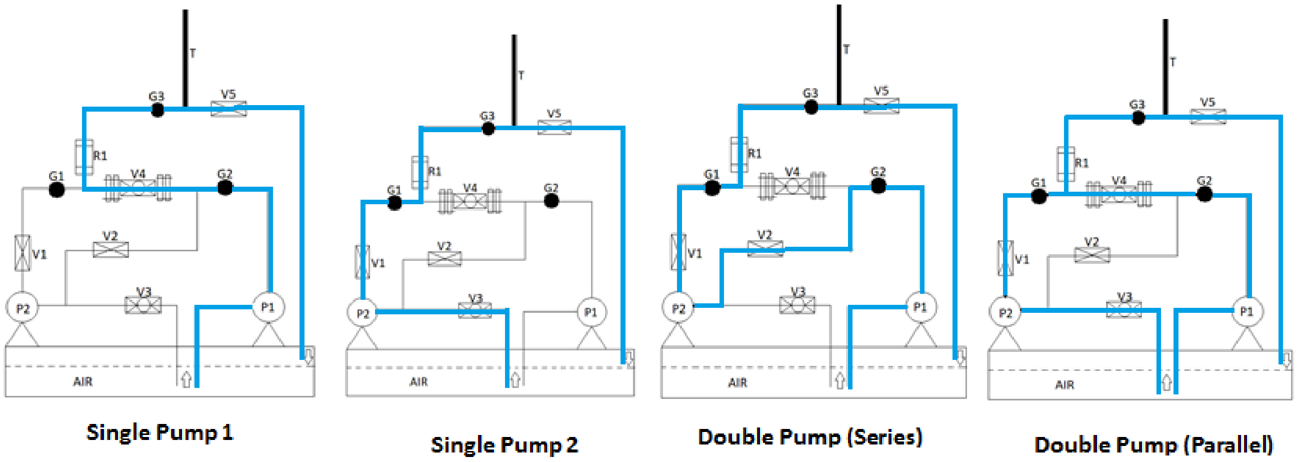

Figure 3. Fluid flow schematic diagram

3. RESULT AND DISCUSSION

Experimentally, research has been carried out on test equipment with different pump specifications and varied installations. Test results can be shown in Table 1 and graphs below.

Table 1. Calculation results with maximum discharge (Q_{max})

Pump Installation	$Q_{max.}$ (m^3/h)	h_f(m)	h_k (m)	ΣH (m)	H_s (m)	H_d (m)	H (m)	P_h(W)	P_s (W)	η (%)	Re	Flow
Single 1	1.6	0.264	0.279	0.543	0.49	0.35	1.383	6.012	125	4.810	25045.18	Turbulent
Single 2	3.4	1.091	1.060	2.151	0.49	0.35	2.991	27.634	125	22.107	53221	Turbulent
Series	1.8	0.451	0.613	1.064	0.49	0.35	1.904	9.310	250	3.724	28175.82	Turbulent
Parallel	4.6	2.942	2.972	5.914	0.49	0.35	6.754	84.411	250	33.765	72004.88	Turbulent

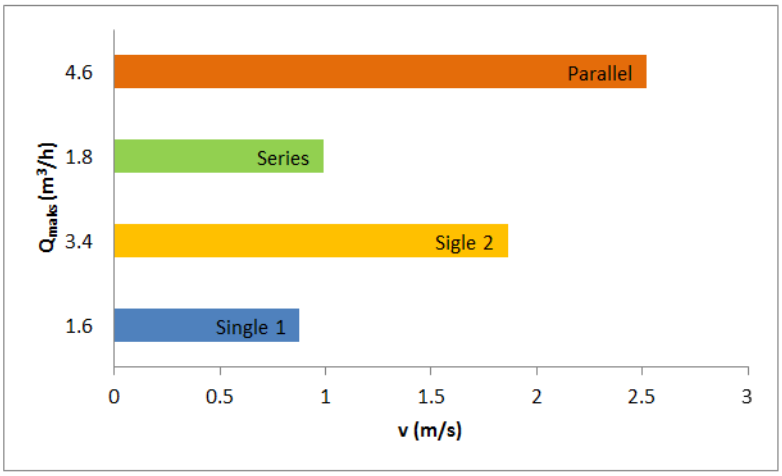

Figure 3. Graph of maximum discharge (Q_{max}) and velocity (V)

In the graph as shown in Figure 3, it can be seen that there is an increase in fluid flow velocity due to an increase in the discharge in each pump installation, namely single pump 1, single 2, double series and double parallel. The test is carried out by opening the valve in the maximum position so that the maximum flow rate is obtained. The maximum flow rate measured for single pump 1 is 1.6 m^3/h, for single pump 2 is 3.4 m^3/h, for series double pumps is 1.8 m^3/h and for parallel double pumps is 4.6 m^3/h. The test results show that the highest flow velocity occurs in a parallel double pump installation, which is 2,523 m/s. This shows that to increase the flow rate and flow rate in piping installations, it can be done by assembling double pumps in parallel.

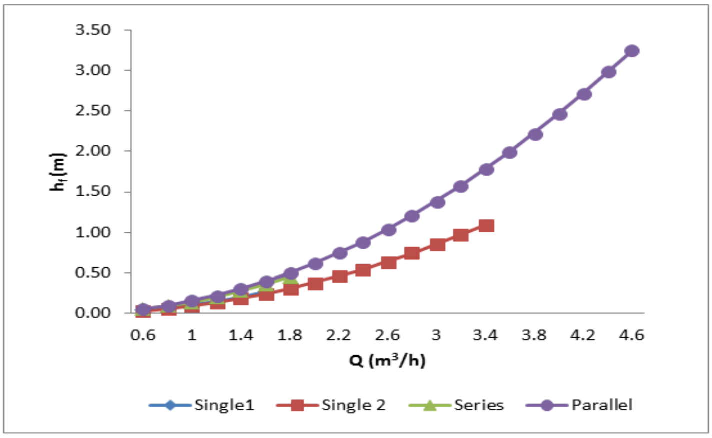

Figure 4. Graph of discharge (Q) and major losses (h_f)

In this test, discharge variations are carried out for each different pump installation. Head due to friction or major losses (h_f) occurs along the pipe flowing fluid. Besides being influenced by the length and diameter of the pipe, the increase in the value of h_f is also influenced by the value of the flow velocity (V). The greater the flow velocity which is affected by the increase in the discharge value, the higher the head due to friction (h_f) will also be. In a parallel, it shows the highest h_f value among all installations. This shows that the parallel installation suffers the highest friction loss among other installations as shown in Figure 4.

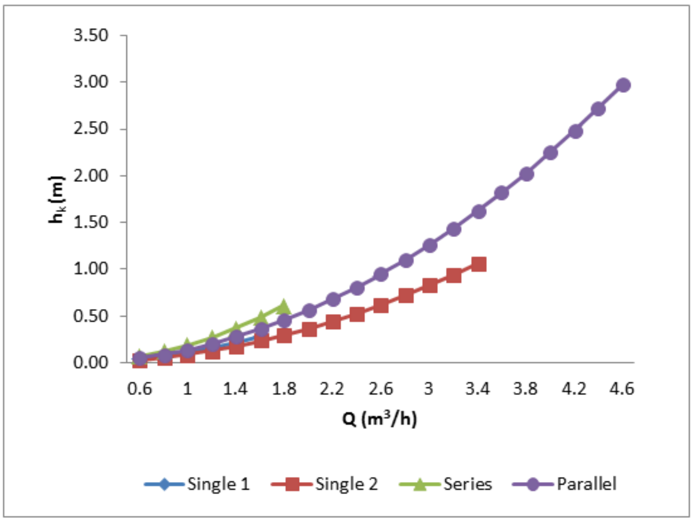

Figure 5. Graph of discharge (Q) and h_k

Experiments with variations in discharge are carried out for each different installation. Based on the graph in Figure 5, it can be seen that there is an increase in the value of minor losses (h_k) along with an increase in the discharge in each installation. In the installation of the test equipment, the series double installation has more connections and valves than the other installations so that the value of losses due to pipe connections and valves (h_k) is highest in the series double installation.

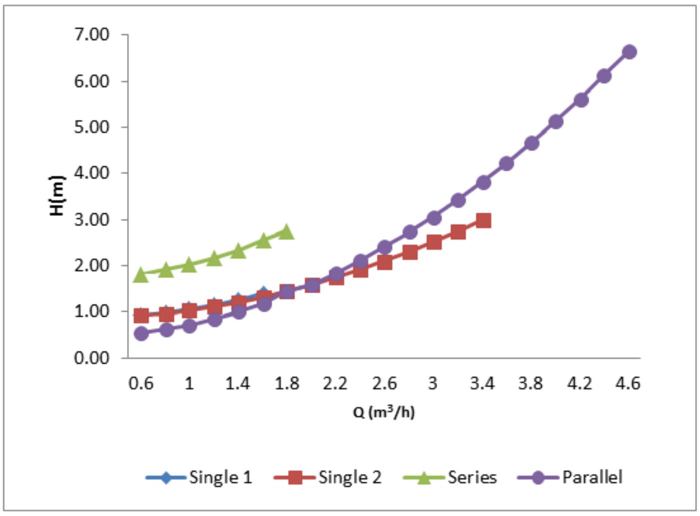

Figure 6. Graph of discharge (Q) and total head (H)

Figure 6 shows a graph of the relationship between the discharge in each pump installation and the total head. The flow rate increases from 0.6 m^3/h to 1.8 m^3/h, the highest H value is shown in the series double installation. This is because the series double pump series has the longest pipe installation and the number of connections and valves is more than other pump installations. As for the parallel double installation, the highest H value can be achieved at a discharge of 4.6 m^3/h. This shows that the increase in total head (H) in the piping installation is influenced by the number of connections, valves, pipe length and the increase in discharge.

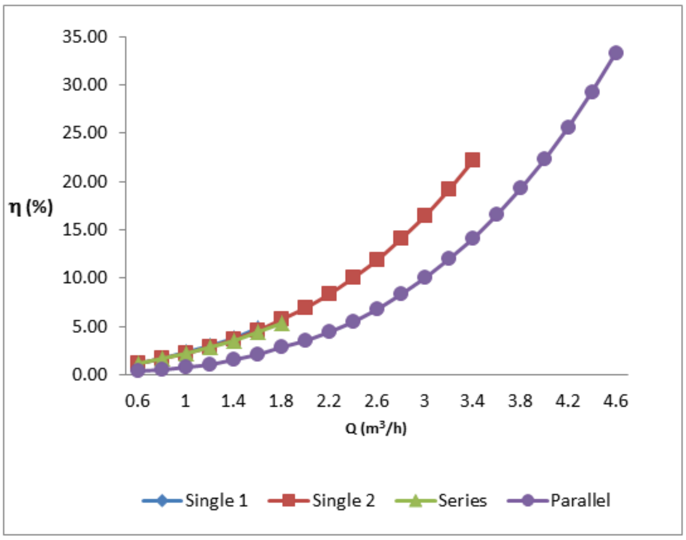

Figure 7. Graph of discharge (Q) and efficiency (η)

In fluid systems, we are usually interested in increasing the pressure, velocity and elevation of a fluid. This is done by supplying mechanical energy to the fluid by a pump. The degree of perfection of the conversion process between the mechanical work supplied or extracted and the mechanical energy of the fluid is expressed by the pump efficiency[9]. Figure 7 shows the pump efficiency of each test installation. Efficiency is influenced by the value of hydraulic power (P_h) to shaft power (P_s). When compared from the four pump installation that have been tested, it can be seen that the lowest efficiency in the series double installation is 3.724%. This is because in a series double pump installation, the discharge value only reaches 1.8 m^3/h with a shaft power 250 W. The efficiency achieved at 4.81% in a single pump 1 installation shows a higher value than the efficiency achieved in a series double pumps. . This is because the shaft power used for double pumps is greater than for single pumps. The highest efficiency can be achieved in a single pump 2 but only maximum at a flow rate of 3.4 m^3/h. In parallel double pumps, the efficiency is 14,139 % at a flow rate 3.4 m^3/h. Along with the increase in the discharge in the parallel double circuit which can be increased up to 4.6 m^3/h and efficiency is 33.765%.

4. CONCLUSION

Tests have been carried out by flowing the fluid in two pumps with different specifications with varied installation, namely single 1, single 2, double series and double parallel. The best results obtained from this test are in a series of parallel double pumps with a discharge value is 4.6 m^3/h, total head is 6.754 m and efficiency is 33.765%. The use of parallel double pumps with different pump specifications can increase the discharge and total head so that it is expected to be a solution for high water requirements at high positions.

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