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Effect Of Pressure Divider Valve On Hydram Pump Efficiency

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Abstract— Hydram pump is a pump that does not require external energy as the main source of propulsion, to raise water from a low place to a high place. The working mechanism of the hydram pump is to multiply the force of the water blow in the air tube, where there is a change in the kinetic energy of the water into dynamic pressure which causes a water hammer. Dynamic pressure will be forwarded into the air tube which functions as an amplifier. However, the work of this pump cannot pump all the incoming water, so some of the water is pumped and some is discharged through the waste valve. This study aims to determine the effect of using a pressure divider valve on the input power, output power and efficiency of the hydram pump. The hydram pump used in this study was an air tube with a height of 60 cm and a diameter of 3 inches. The height of the waterfall is 2 m from the pump body and the output height is 4 m. The pressure divider valve is installed at a height of 2 m from the pump body. Pressure divider valve tube lengths: 20, 25, 30, 35, 40, 45 and 50 cm. The method used in this research is the experimental method. The results showed that the highest input power was obtained at 5.53 watts when using a tube length of 20 cm and the lowest input power was obtained at 5.32 watts when using a tube length of 50 cm. the highest output power that can be pumped at 1.75 watts occurs when using a tube length of 20 cm. While the lowest output power pumped at 1.56 watts occurred when using a tube length of 50 cm. The highest D'Aubuisson efficiency was obtained at 31.6% when using a tube length of 20 cm. The lowest efficiency was obtained at 29.3% when using a tube length of 50 cm.

Keywords—component; Hydram pump, Pressure divider valve, power, efficiency.

I. Introduction

A hydram pump is a pump whose energy or driving force comes from the pressure or impact of water entering the pump through a pipe. The entry of water from various water sources into the pump must run continuously or continuously. The working principle of this tool is to produce dynamic pressure which allows water to flow from a lower place to a higher place. The use of hydrams is not limited to providing water for household needs, but can also be used for agriculture, animal husbandry and inland fisheries.

The hydram pump is an environmentally friendly water pump in the field of pumping using a water hammer to raise water. A hydram pump is a water pump that does not use fuel oil and electricity and can work twenty four hours. The efficiency and effectiveness of the performance of the hydram pump is influenced by many factors including the height of the plunge, the diameter and length of the air tube, the diameter of the pipe, the length of the pipe, and the length of the piston at the waste valve. The existing hydraulic ram pumps have low efficiency, on average, below 20%.

The effect of changes in diameter (1/2, 3/4 and 1 inches) on the inlet pipe and the three levels of inlet height (1.9, 1.8 and 1.65 m) showed an inverse relationship between the height and outflow rate and the pressure in the vessel had no effect on the height and outflow rate. In addition, the maximum efficiency is 29% at a tank height of 1.9 m and a diameter of 0.5 inches [1]. Changes in waste valve mass (1.5, 2, 2.5 and 3 kg) and changes in lift height (3, 5 and 7 m) on hydram pump efficiency show that waste valve mass and lift height affect the hydram pump efficiency. The highest hydram pump efficiency of 60.6% was obtained at a lifting height of 5 m and a waste valve mass of 1.5 kg. While the lowest hydram pump efficiency is 27.1% at a lifting height of 7 m and a waste valve mass of 3.0 kg [2].

Changes in the diameter of the waste valve and the diameter of the delivery valve greatly affect the efficiency of the hydram pump. The highest D'Aubuisson efficiency was 67.66% with a waste valve diameter of 2.75 inches and a delivery valve diameter of 2 inches. The lowest efficiency is 36.14% for a waste valve diameter of 2.25 inches and a delivery valve diameter of 0.6 inches [3]. Hydram pumps using a spherical delivery valve model have the best efficiency [4].

Variations in the arrangement of hydram pump installation on the performance of both ILK and IKL arrangements show that the higher the waterfall, the greater the output discharge produced by the hydram pump. The highest output discharge is at a height of 4.1 m with the position of the ILK (Input-Waste Valve-Compressor) arrangement of 0.121 lt/s while the position of the IKL (Input-compressor-waste valve) arrangement is 0.112 lt/s. The highest maximum head is obtained at a height of 4.1 m with an ILK arrangement of 16 meters. Meanwhile, for the position of the IKL arrangement, the maximum head produced is 12 m. The greatest efficiency at a drop height of 3.1 m with an ILK arrangement position of 2.618%, while with an IKL arrangement position an efficiency of 2.357% is obtained [5]. The effect of the inlet pipe angle on the performance of the hydram pump is that the highest suction force is 194.1 N at a drop angle of 35° and the smallest is 164.6 N at an angle of 55°. While the biggest thrust is 19.9 N at an angle of 35° and the smallest thrust is 17.2 N at an angle of 55° [6]. Variation of the angle of installation of the compressor tube on the performance of the hydram pump with the results showing that the best output discharge is 0.035 lt/s in the installation of a 90° compressor tube with a water lift height of 4 meters. While the lowest output discharge is 0.011 lt/s when installing a 0° compressor tube at water lifts height of 5 m [7].

The effect of variations in the d/h ratio of the compressor tube with a constant volume of 2650 cm^3 on the performance of the hydram pump at various variations in waterfall heights of 2,3,4 and 5 m. The results showed that for every 1 meter increase in the height of the waterfall, the output discharge will increase by an average of 36.6% and the maximum head will increase by 5 ÷ 6 meters. Variations in the d/h ratio of the compressor tube affect the output discharge but do not affect the maximum head of the hydram pump [8]. Every 0.25 meter increase in the height of the waterfall, the output discharge will increase by an average of 12.7%, the waste flow rate will decrease by an average of 1.3%, the drive power will increase by an average of 15.2% and the pumping power will experience an average increase -an average of 13.6%. The greatest output discharge is generated at a 2.5 meter drop height of 1.78 lt/s. The greatest pumping power is obtained at a 2.5 meter drop height of 1.5 watts and a drive power of 3.5 watts [9].

To determine the efficiency of the hydram pump, this study used the efficiency equation, namely D'Aubuissondan efficiency and Rankine efficiency.

a. D'Aubuission Efficiency

Efficiency according to D'Aubuission is the ratio between the height of the pumping side multiplied by the capacity of the pumping water with the sum of the capacity of the pumping water and the capacity of the discharged water multiplied by the height of the water fall, where at rankine efficiency the head loss is ignored. Then the rankine efficiency value can be calculated as follows [10] :

$$\eta_D = \frac{(Q_p \ x \ h_d)}{(Q_p + Q_w) \, h_s} \ x \ 100\% \qquad (1)$$

Where, η_D D'Aubuission efficiency (%), Q_p pumped water discharge (m^3/s), Q_w wasted water discharge through sewage valves (m^3/s), h_s falling water height (m) and h_d pumping lift height (meter).

b. Rankine efficiency

Efficiency according to Rankine is the ratio between the difference between the suction head and the exhaust side multiplied by the suction capacity, with the suction head multiplied by the capacity of the displaced water where in Rankine efficiency the head loss is ignored [10] :

$$\eta_R = \frac{Q_p(h_d - h_s)}{(Q_w)\, h_s} \; x \; 100\% \qquad (2)$$

Where, η_R adalah Rankine efficiency (%).

II. Research Methods

The research method used is direct experiment in the field. The hydram pump used in this study has the following specifications: input diameter is 1.5 inches, output diameter is 0.5 inches and the piston stroke at the waste valve is 5 mm, and the size of the compressor tube is 3 inches in diameter and 24 cm in height. The height of the waterfall is 2 meters. The installation height of the pressure divider valve is 2 meters from the pump body. The height of the water lift is 4 meters.

The variables examined in this study are divided into independent variables and dependent variables.

a. Independent Variables

The independent variables in this study are the height of the water falling from the source to the hydram pump in meters (m), the input water discharge in lt/s units and the pump dimensions in mm.

b. Dependent variable

The dependent variable in this study is the discharge of wastewater and pumped water in units of lt/s.

To determine the input and output parameters, measurements are made with the following criteria:

- The input pressure height (fall height) is measured the vertical distance from the water level in the reservoir to the hydram pump.
- Variations in the length of the tube on the pressure divider valve of 20, 25, 30, 35, 40, 45 and 50 cm.
- High output pressure is measured using a pressure gauge, namely the vertical distance from the pump to the reservoir.
- Input discharge and output discharge are measured using a flowmeter.

Test equipment arrangement

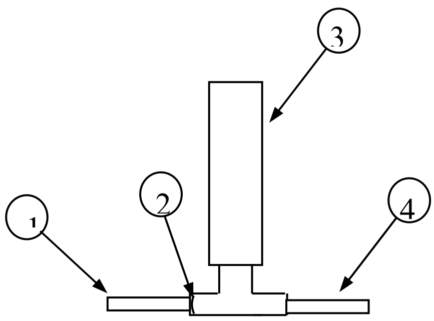

Fig 1. Pressure divider valve; 1. Input, 2. Check valve, 3. Divider tube, 4. Output.

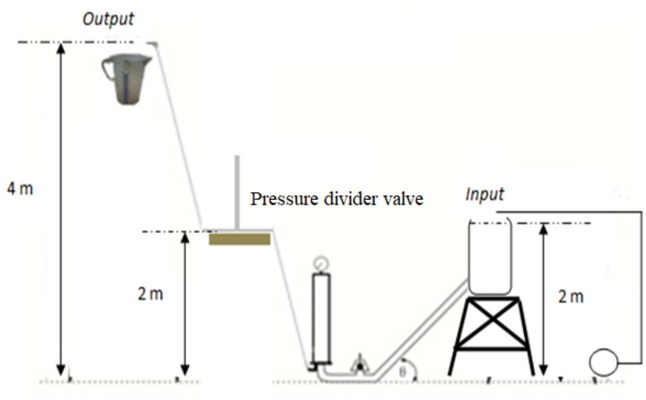

Fig 2. Research scheme for a hydram pump using a pressure divider valve

III. Results And Discussion

Fig 3 shows that the length of the tube on the pressure divider valve is inversely proportional to the input power achieved. The highest input power is obtained from a hydram pump that does not use a pressure divider valve. Meanwhile, for hydram pumps that use pressure divider valves, the highest input power of 5.53 watts is obtained when using a tube length of 20 cm and the lowest input power of 5.32 watts is obtained when using a tube length of 50 cm. This happens because in the same treatment where the air discharge entering the divider pressure is the same, the water pressure is the same and the diameter of the pressure divider tube is the same, the volume of air trapped in the pressure divider air tube is different because the height of the air tube is different as a result the air tube is 20 cm at This study has a higher compression ratio than other air cylinders.

TABLE 1. Input power data for various tube lengths of pressure divider valves

Pressure divider valve tube length (cm)	No Valve	20	25	30	35	40	45	50
Input Power (watt)	5.69	5.53	5.48	5.44	5.41	5.37	5.32	5.32

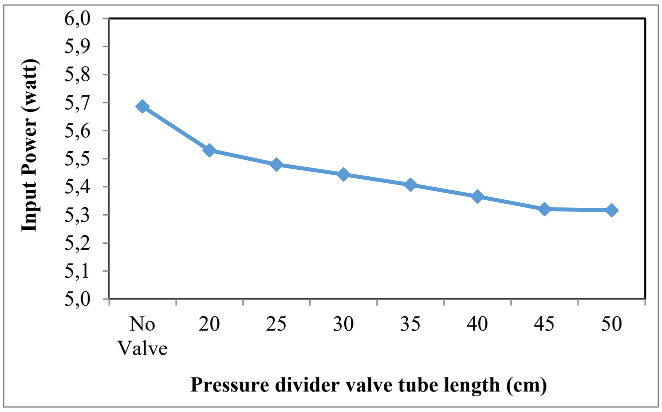

Fig 3. Graph of the relationship between the length of the pressure divider valve tube and the input power.

Fig 4 shows that the length of the tube on the pressure divider valve is inversely proportional to the output power achieved. The highest output power was obtained from a hydram pump using a pressure divider valve, the highest output power of 1.75 watts was obtained by using a tube length of 20 cm and the lowest output power of 1.56 watts was obtained by using a tube length of 50 cm. This happened because in the same treatment where the water discharge entering the pressure divider was the same, the water compressive force was the same and the diameter of the pressure divider tube was the same, the volume of air trapped in the pressure divider air tube was different because the height of the air tube was different as a result the air tube was 20 cm at This study has a higher compression ratio than other air cylinders.

TABLE 2. Output power data at various lengths of pressure divider valve tube

Pressure divider valve tube length (cm)	No Valve	20	25	30	35	40	45	50
Output Power (watt)	1.51	1.75	1.73	1.69	1.66	1.62	1.56	1.56

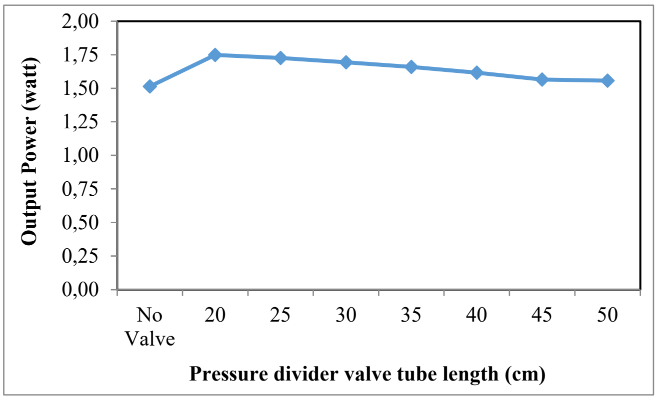

Fig 4. Graph of the relationship between the length of the pressure divider valve tube and the output power.

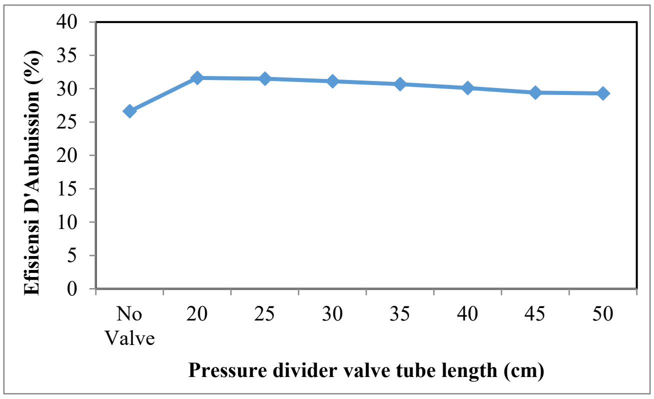

Fig 5. Graph of the relationship between the length of the pressure divider valve tube and the D'Aubuission efficiency

The effect of changing tube length on the pressure divider valve shows an inverse relationship between tube length and D'Aubuission Efficiency. The highest D'Aubuission efficiency of 31.6% was obtained at a tube length of 20 cm. While the lowest D'Aubuission efficiency of 29.3% was obtained at a tube length of 50 cm. The longer the tube at the pressure divider valve, the lower the D'Aubuission efficiency obtained, as shown in Fig 5. This is more because for each increase in tube length, the drive discharge will decrease, followed by a decrease in pumping discharge, but a decrease in discharge driving force is smaller than the decrease in pumping discharge. This resulted in the efficiency of D'Aubuission decreasing along with the increasing length of the tube on the pressure divider valve.

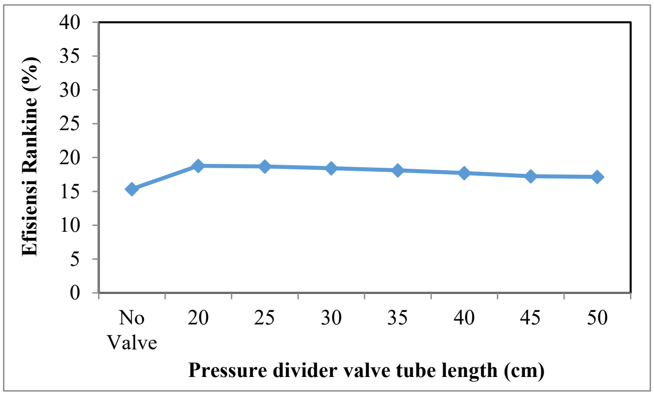

Fig 6. Graph of the relationship between the length of the pressure divider valve tube and Rankine efficiency

Fig 6 shows that the Rankine efficiency will decrease as the length of the tube on the pressure divider valve increases. The highest Rankine efficiency was obtained at 20 cm tube length of 18.8%. The lowest Rankine efficiency of 17.2% was obtained at a tube length of 50 cm. This is more because for every increase in tube length, the input pressure will decrease, followed by a decrease in output pressure, but the change in input pressure is much smaller than the change in output pressure. This causes the Rankine efficiency to decrease as the length of the tube on the pressure divider valve increases.

IV. CONCLUSION

From the results of the study it can be concluded that the use of a pressure divider valve has an effect on the water hammer effect. A hydram pump without a pressure divider valve will vibrate quite a bit. While the hydram pump with a pressure divider valve, the vibration of the hydram pump is reduced and the vibration of the vibration pressure divider valve disappears in the output pipe. The use of a pressure divider valve affects the pumping power or output power and the resulting efficiency. the highest input power was obtained at 5.53 watts when using a tube length of 20 cm and the lowest input power was obtained at 5.32 watts when using a tube length of 50 cm. the highest output power is 1.75 watts when using a tube length of 20 cm. While the lowest output power pumped at 1.56 watts occurred when using a tube length of 50 cm. The highest D'Aubuisson efficiency was obtained at 31.6% when using a tube length of 20 cm. The lowest efficiency was obtained at 29.3% when using a tube length of 50 cm.

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