International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 8 ǁ August 2022 ǁ PP. 320-324

Effect of Waterfall Height to the Efficiency of Hydram Pump

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Abstract
Hydraulic Ram Pump is a pump that does not require external energy as the main driving force, to raise water from low places to high places. The working mechanism of the hydraulic ram 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. The dynamic pressure will be transmitted 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 sewage valve. This research will try to further develop the hydraulic ram pump by making an output at the bottom of the compressor tube by varying the plunge height. The hydraulic ram pump used has the following specifications with an input diameter of 1.5 inches, an output diameter of 0.5 inches and a compressor tube diameter of 3 inches with a height of 60 cm. The variations in the height of the waterfall used are 1, 1.25, 1.5, 1.75, 2, 2.25 and 2.5 meters. The results showed that the highest installation efficiency was obtained at a 1 meter high waterfall, which was 48%. The higher the waterfall, the lower the installation efficiency obtained. The highest D'Aubuission efficiency is obtained at a 1 meter high waterfall, which is 32.86%. Likewise, Rankine efficiency will decrease along with the increase in the height of the inlet waterfall. The highest rankine efficiency is obtained at a 1 meter high waterfall, which is 28.13%.

Keywords: *hydram, waterfall height, efficiency.*

Date of Submission: 06-08-2022 Date of acceptance: 21-08-2022

I. INTRODUCTION

Hydraulic Ram Pump is a pump that does not require external energy as the main driving force, to raise water from low places to high places. The working mechanism of the hydraulic ram pump is to multiply the force of the air blow in the air tube, where there is a change in the kinetic energy of the air into dynamic pressure which causes a water hammer. Dynamic pressure will enter the air tube which works as a booster. However, the work of this pump cannot ensure all the water that enters, so that some of the water is pumped and some is discharged through the sewage valve. This research will try to further develop the hydram pump by making the output at the bottom of the compressor tube by varying the plunge height in order to obtain better efficiency.

A hydraulic ram pump is a pump whose energy or driving force comes from the pressure or blow 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, produces dynamic pressure that allows water to flow from a low place to a higher place. The use of hydram is not only limited to providing water for household needs, but can also be used for agriculture, animal husbandry, and inland fisheries.

Hydram pump design and testing the effect of variations in the height of the air tube and the length of the intake pipe on the performance of the hydraulic ram pump. The research was carried out using variations in the height of the air tube 40 cm and 60 cm with a diameter of 6.35 cm and variations in the length of the intake pipe 8 m, 10 m and 12 m. The supply line height is 2.3 m and the pressure line height is 8 m. The results showed the maximum pump capacity of 0.035 lt/s. The maximum efficiency of the hydraulic ram pump is 29.55% at a tube height of 60 cm and an inlet pipe length of 10 m [1].

Research on the effect of the diameter of the air tube and the distance of the pressure pipe hole with the delivery valve on the efficiency of a 2-inch hydram pump. The results showed that the use of variations in the diameter of the air tube and the distance of the pressure pipe hole greatly affects the efficiency of the hydraulic ram pump. It can be seen that the use of air tubes and the distance of the pressure pipe holes have the highest and lowest efficiency values in each condition, but overall the highest efficiency occurs in the 2 inch diameter air tube with the pressure pipe hole distance of 22.5 cm by 35.30%. while the lowest efficiency is 19.57% on the use of a 2.5-inch air tube at a pipe hole distance of 25 cm. [2].

The results of the research showed the largest output discharge at the length of the input pipe 6 meters and 8 meters with the diameter of the 1-inch waste valve hole, while the output discharge was mined to the length of the 2 meter input pipe with the diameter of the ½ inch waste valve. The best efficiency is 57.3% on the length of the 8 meter input pipe with the diameter of the 1-inch waste valve hole, while for the worst efficiency of 17.27% on the length of the 2 meter input pipe with the di- ameter of the ½ inch waste valve [3].

Research on hydraulic ram pumps that have an ILK (input-waste-compressor) arrangement has the best efficiency at a drop height of 2.5 meters with an input discharge of 2.458 lt/s while the output discharge that can be lifted by the pump is 0.087 lt/s while the lift height or vertical height of the pump which is 30 meters and the efficiency of the hydraulic ram pump is 13.6%. Meanwhile, the IKL arrangement has the best efficiency at a 2-meter plunge height with an input discharge of 2,302 lt/s while the output discharge that can be lifted by the pump is 0.068 lt/s while the lift height or vertical height of the pump is 25 meters and the hydraulic ram pump efficiency is equal to 14.2% [4].

Research on hydraulic ram pumps shows that for every 1 m increase in plunge height, the output discharge will increase by an average of 36.6% and the maximum head will increase by 5-6 m. Variations in the d/h ratio of the compressor tube affect the output discharge but do not affect the maximum head of the hydraulic ram pump. While the highest efficiency is obtained at a height of 2 m and a compressor tube d/h ratio of 0.198, which is 33.98% [5].

The greater the plunge angle, the smaller the suction and thrust of the hydraulic ram pump. From the research results of the hydraulic ram pump at a plunge height of 2 m, the largest suction force value is 194.1 N at a plunge angle of 35° and the smallest is 164.6 N at an angle of 55°. While the largest thrust is 19.9 N at a 35° plunge angle and the smallest thrust is 17.2 N at a 55° angle [6].

The pump with a size of 1.5 inches had the best efficiency at a plunge height of 2 meters which was 18.4% with an input discharge of 1.44 liters/second while the output discharge produced was 0.11 liters/second while the lift height of pump which is 26.1 meters [7].

To determine the efficiency of the hydraulic ram pump, in this study three efficiency equations were used, namely installation efficiency, D'Aubuisson efficiency and Rankine efficiency.

a. Installation efficiency

The power or power required to raise the water is directly proportional to the rate of water being pumped multiplied by the height of the pump. Likewise, the power available to the supplied water flow to operate the hydraulic ram pump is directly proportional to the volumetric water rate of the supplied water multiplied by the supply level. The hydraulic ram works by utilizing the available power to bring the flow to higher ground. [8] :

$$\eta_I = \frac{P_p}{P_d} \ x \ 100\%$$

Where , η_I hydram pump installation efficiency (%), P_p pumping power (watts), P_d driving water power (watts),

b. 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 by the total capacity of the pumping water and the capacity of the discharge water multiplied by the height of the water fall, where in Rankine efficiency the head loss is neglected. Then the rankine efficiency value can be calculated as follows [8]:

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

Where , η_D is D'Aubuission Efficiency (%), Q_p pumped water discharge (m3/s), Q_w discharge water discharged through the waste valve (m3/s), h_s water fall height (m) and h_d pumping lift height (meters) .

c. Rankine Efficiency

Efficiency according to Rankine is the ratio between the height difference between the suction pressure and the exhaust side times the suction capacity, with the suction pressure height multiplied by the capacity of the water displaced where in Rankine efficiency the head loss loss is negligible [8]:

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

Where η_R is Rankine efficiency (%).

II. RESEARCH METHODS

The hydraulic ram pump used in this study has the following specifications: 1.5 inch input diameter, 0.5 inch output diameter and 5 mm piston stroke on the waste valve, and the compressor tube size is 3 inches in diameter and 24 cm high. The heights of the waterfalls are 1.25, 1.5, 1.75, 2, 2.25 and 2.5 meters.

The variables to be studied in this study are divided into independent variables and dependent variables.

a. Independent Variable
   The independent variables in this study were the height of the water falling from the source to the hydram pump (hs) in meters (m), input water discharge (Qs) in lpm and pump dimensions in mm.
b. Dependent variable
   The dependent variable in this study is efficiency.

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

- The height of the input pressure (hs; height of the plunge) is measured by the vertical distance from the water elevation in the reservoir to the hydraulic ram pump. In this study used variations in the height of the waterfall 1, 1.25, 1.5, 1.75, 2, 2.25 and 2.5 meters.
- High output pressure (hd) is measured using a pressure gauge, which is the vertical distance from the pump to the reservoir.
- Waste discharge (Qw) and output discharge (Qp) are measured using a flowmeter.

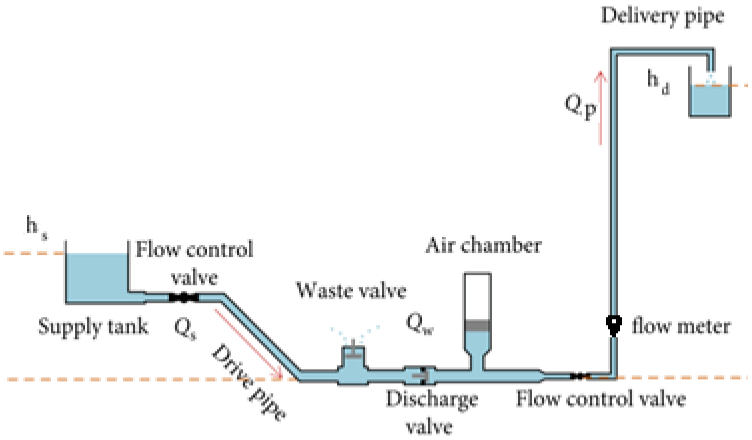

Figure 1. Series of test equipment

Table 1. Tools and materials

Name	Specification
Hydram pump	Body pump 1.5", air chamber 3"
Presure gauge	Max 2.5 kg/cm^2
Diameter of drive pipe	1.5 "
Diameter of delivery pipe	0.5 "
Flowmeter	1-15 liter/menit

III. RESULT AND DISCUSSION

The results of laboratory research show that the highest installation efficiency is obtained at a 1 meter high plunge, which is 48%. Figure 2 shows that the higher the waterfall, the lower the installation efficiency obtained even though the pumping power obtained is greater. On the hydram pump with a size of 1.5 inches on the pump input pipe and 0.5 inches for the pump output pipe, the data obtained as shown in Figure 2 shows that the higher the waterfall, the greater the drive power contained in the input water or flowing water. into the pump. This will also be followed by a greater pumping power which will have an impact on the delivery flow rate which will be even greater. The increase in pumping power is not as large as the increase in drive power for every 0.25 meter increase in inlet water inlet height. This causes the installation efficiency to decrease along with the increase in the fall of water into the hydram pump.

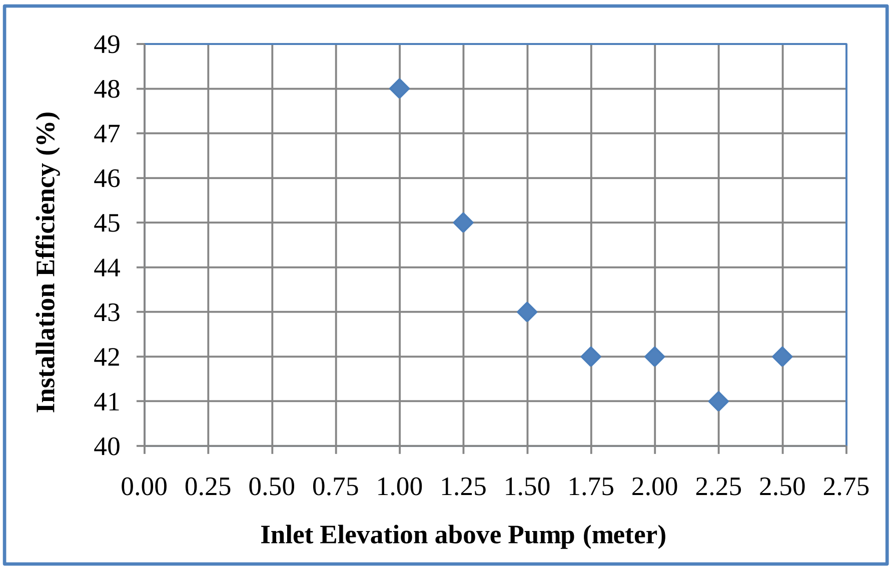

Figure 2. Graph of the relationship between the variation of the inlet elevation above Pump and the installation efficiency.

The highest D'Aubuission efficiency is obtained at a 1 meter high waterfall, which is 32.86%. The higher the waterfall, the lower the D'Aubuission efficiency obtained even though the pumping discharge is getting bigger, as shown in Figure 3. This is more because for every increase in the height of the water fall into the hydraulic ram pump, the driving flow will be even greater which is followed by with an increase in pumping discharge, but the increase in driving discharge is much greater than the increase in pumping discharge. This causes the D'Aubuission efficiency to decrease along with the increase in the height of the water entering the hydram pump.

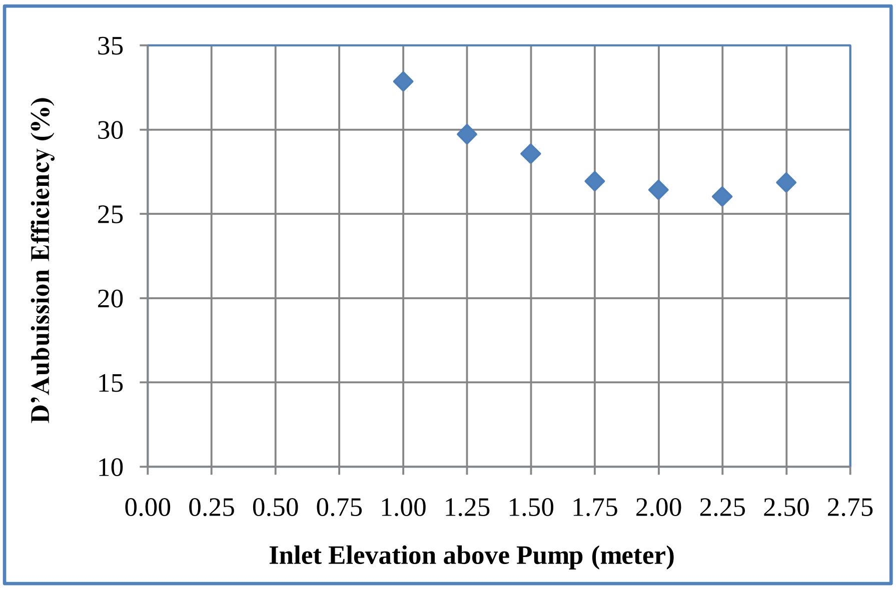

Figure 3. Graph of the relationship between the variation of the inlet elevation above Pump and the d'aubuission efficiency.

Figure 4 shows that Rankine efficiency will decrease with increasing inlet height. The highest rankine efficiency is obtained at a 1 meter high waterfall, which is 28.13%. This is more because for every increase in the height of the water plunge into the hydram pump, the input pressure will be greater followed by an increase in output pressure, but the increase in input pressure is much greater than the increase in output pressure. This causes the Rankine efficiency to decrease along with the increase in the height of the water entering the hydram pump.

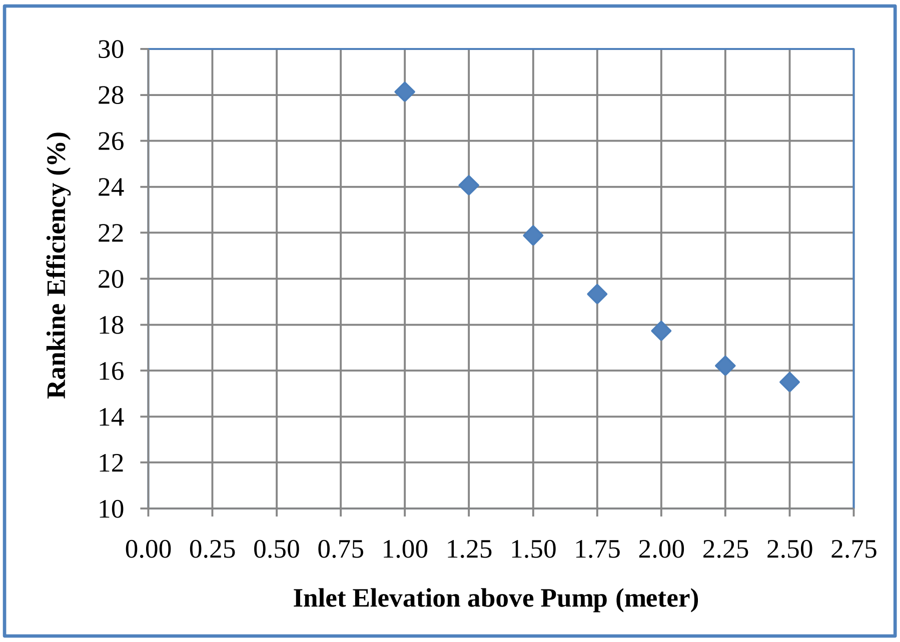

Figure 4. Graph of the relationship between the variation of the inlet elevation above Pump and the rankine efficiency.

IV. CONCLUSION

The highest installation efficiency is obtained at a height of 1 meter, which is 48%. The higher the waterfall, the lower the installation efficiency obtained. The highest D'Aubuission efficiency is obtained at a 1 meter high waterfall, which is 32.86%. Likewise, Rankine efficiency will decrease along with the increase in the height of the inlet waterfall. The highest rankine efficiency is obtained at a 1 meter high waterfall, which is 28.13%.

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