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ANALYSIS OF HYDRAM PUMP PERFORMANCE ON VARIATION OF WATERFALL ANGLES

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KeyWords
Hydram pump, waterfall angle, discharge force, suction force, efficienscy.

ABSTRACT
Water is one of the most important and necessary factors in the life of living things. Therefore, water must be available anytime and anywhere in sufficient quantity, time, and quality. A hydraulic ram pump is a pump that does not require external energy as its power source. The purpose of this study was to determine the effect of the inlet angle on the force and efficiency of the hydraulic ram pump. This study uses a hydraulic ram pump with a compressor tube diameter of 3 inches and a height of 20 cm. The height of the water drop is 2 meters with five variations of the waterfall angle of the pump, namely 45^o, 40^o, 31^o, 26^o and 22^o as well as two variations of the installation arrangement, namely input-compressor-waste (IKL) and input-waste-compressor (ILK). The method of analysis is done by analyzing the data obtained during the study, where the results are quantitative data presented in the form of tables and figures. The results showed that the best efficiency of the hydraulic ram pump with the ILK arrangement was 22.3%, which was obtained at a waterfall angle of 26^o, while in the IKL arrangement it was 14.2%, which was obtained at a waterfall angle of 45^o. The suction force obtained on average is almost the same, namely 156.5 N in both the ILK arrangement and the IKL arrangement for all variations of the inlet waterfall angle. While the best discharge force was obtained at an angle of 31^o which is 11.18 N for the IKL arrangement while for the ILK arrangement the best discharge force was obtained at an angle of 22^o which was 12.42 N.

INTRODUCTION
Water is one of the most important and necessary factors in the life of living things. In addition to the physiological development of living things, water is also an input for various efforts or activities of living things in order to produce something for their survival. The emergence of problems related to water caused by the increase in various needs and interests of living things, in turn has an impact on the disruption of conditions of water supply and demand.

Some areas that are located far from water sources or are above water sources will certainly have difficulty getting water. Therefore we need a technology that is able to lift water from a low place to a higher place. One of the efforts to meet water needs, especially in locations that are higher than the springs, is to use a water pump. The types of pumps commonly used today are water pumps powered by electric motors and pumps that use fuel oil. For urban areas, the need for fuel oil is not too much of a problem. Meanwhile, from the data that has been collected that in rural areas or remote areas the existence of fuel oil is very rare, if any, the price is very expensive. To overcome this problem, the idea arose to use a water pump without an electric motor and a pump that does not require fuel oil.

The hydraulic ram pump utilizes the power of the flow of water that falls from a water source and some of the water is pumped to a higher place. In various situations, the use of hydraulic ram pumps has advantages compared to other types of pumps, namely it does not use fuel or additional power from other sources, does not require lubrication, simple form, low manufacturing and maintenance costs and does not require high skills to make it. This pump can run twenty four hours.

Hydraulic Ram pump is a pump that does not require external energy as the main propulsion source. In addition to not requiring external energy as a source of prime propulsion, hydraulic ram pumps also have other advantages, namely: simple construction, no need for lubrication, can work continuously for 24 hours without stopping, easy operation, low manufacturing and maintenance costs [1].

Research on hydraulic ram pumps with a size of 3.75 cm and the ILK arrangement had 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 the pump could lift was 0.087 lt/s while the lift height was 0.087 lt/s. or the vertical height of the pump is 30 meters and the efficiency of the hydraulic ram pump is 13.6%. As for the IKL arrangement, it has the best efficiency at a waterfall height of 2 meters 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%. [2].

In the research of Cahyanta and Taufik (2008), the study of the performance of the hydraulic ram pump with variations in the load of the waste valve aims to determine the performance of the hydraulic ram pump with variations in the weight of the exhaust valve and the input head. The hydraulic ram pump used has an inlet pipe diameter of 1.5 inches and an outlet pipe diameter of 0.5 inches. Variations in the weight of the waste valve used are 410 g, 450 g, 490 g, 540 g, 580 g and 630 g. The results showed that the maximum flow capacity, maximum head discard and maximum efficiency were achieved at a waste valve weight of 410 g. The maximum flow capacity is 11.146 × 10-5 m^3/s, the maximum head discard is 7.378 m and the maximum efficiency is 16.3%. [3].

The longer the inlet pipe size, the larger the hydram pump discharge (Q) will be. This is also directly proportional to the efficiency of the hydraulic ram pump, the longer the inlet pipe used, the greater the discharge value (Q) produced. The maximum hydraulic ram pump discharge (Q) is 2.5 m long, with a weight of 0.46 kg, with a value of Q = 142.126 cm3/sec. The maximum pump efficiency value is the efficiency using a weight of 0.46 kg at an inlet pipe length of 2.5 m and a delivery pipe head (H+h) 200 cm, with a discharge efficiency of 24.4% and a D'Aubuisson efficiency of 35.9 %. [4].

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, with the waste valve position located before (input – waste – compressor, ILK) and after (input – compressor – waste, IKL) the compressor tube and the size of the compressor tube with a diameter of 3 inches and a height of 20 cm. The height of the water drop is 2 meters with five waterfall angle variations of the pump, namely 45°, 40°, 31°, 26° and 22°.

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 waterfall from the source to the hydraulic ram (H_1) in meters, the input water flowrate (Q_1) in lt/minute or m^3/s and the pump dimensions in mm.
b. Dependent variable, The dependent variable in this study is the suction force and the discharge force

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

- The input pressure height (H_1; waterfall height) is measured by the vertical distance from the water elevation in the reservoir to the hydraulic ram pump. In this study, the height of the waterfall was 2 meters and the waterfall angle was also varied, namely 45°; 40° ; 31° ; 26° ; 22° .
- High output pressure (H_2) is measured using a pressure gauge, which is the vertical distance from the pump to the reservoir.
- The input flowrate (Q_1) and output flowrate (Q_2) are measured directly.

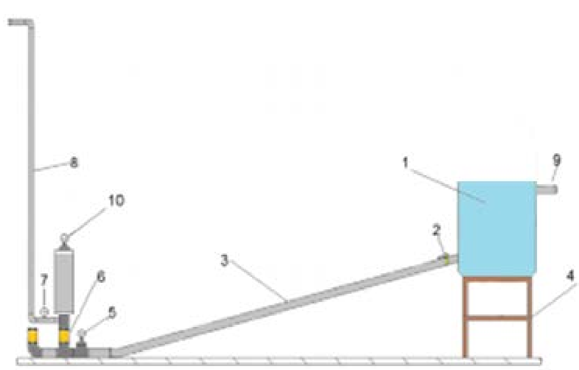

Figure 1. Series of test equipment. 1. Reservoir tub, 2. Ball valve, 3. Inlet pipe, 4. Reservoir tub holder, 5. Pressure gauge inlet pipe, 6. Hydram pump, 7. Pressure gauge conduit pipe, 8. Conduit pipe, 9. overflow hole, 10. pressure gauge air tube.

RESULTS AND DISCUSSION

The prime mover of the hydraulic ram pump uses energy as a result of the difference in the height of the source water level with the pump position. Besides that, the waterfall angle also affects the pump's ability to raise water to a higher place, the greater the waterfall angle, the greater the suction force or water pressure force exerted. entering the pump this is because the greater the waterfall angle, the dynamic head contained by the water will be greater indirectly the dynamic energy contained will be higher as well, as shown in Figure 2, but at an angle of 40^{o} there is a decrease in the suction force this is more because the dynamic energy contained by the water will decrease along with the closer the horizontal distance between the pump and the source besides the suction force that occurs is only formed by the influence of gravity, but for the waterfall angle below 40^{o} the suction force that occurs in addition to the influence of gravity also comes from the influence of energy and from the water, this occurs in both arrangements of the hydraulic ram pump as shown in Figure 2.

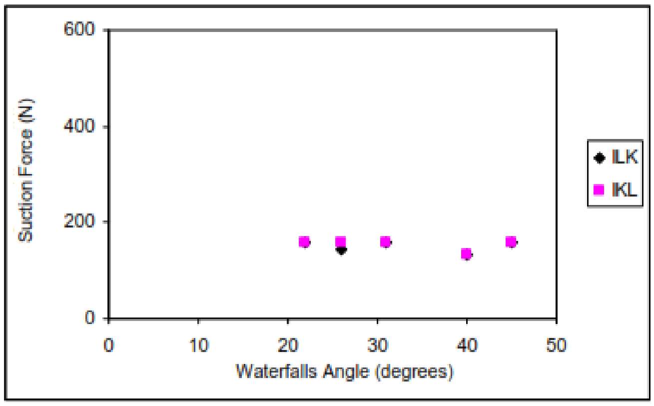

Figure 2. Relationship between waterfall Angle Variations and Suction Force

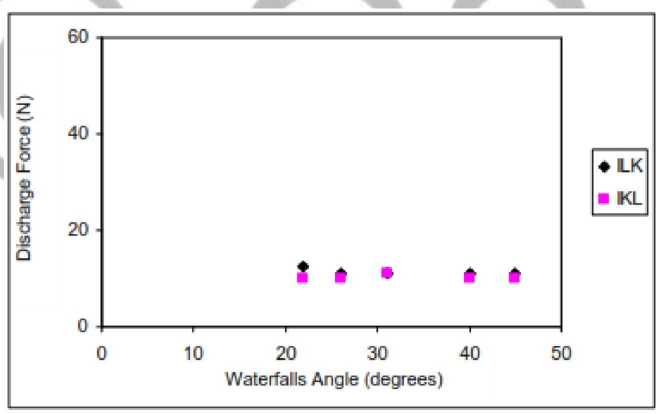

Figure 3. Relationship between waterfall angle variation and discharge force

The suction force of water entering the pump will push the valves in the hydraulic ram pump to close and stop the flow in the intake pipe. This condition causes a compressive force from the intake pipe and forces water to flow into the outlet pipe with high pressure so that it can flow to a higher location. The high pressure in the pump will also overcome the pressure in the air chamber on the delivery valve so that the valve will open and water will continue to flow again from the connecting pipe. The greater the angle of the waterfall angle, the greater the discharge force of the water, this occurs in both arrangements, namely IKL and ILK as shown in Figure 3.

While in Figure 4 it can be seen that the best efficiency of a 1.5 inch hydraulic ram pump with an ILK arrangement is 22.3% which is obtained at a waterfall angle of 26^{o}, from the graph it can be seen that the efficiency trend of a hydraulic ram pump with an ILK arrangement decreases with increasing waterfalls angle, this is more because the comparison between the suction force and the thrust force has a downward trend so that this has an impact on decreasing the efficiency of the hydraulic ram pump. While the IKL arrangement is 14.2% which is obtained at a 45^{o} waterfall angle, but the efficiency of the hydraulic ram pump with the IKL arrangement tends to increase along with the increase in the thrust of the water, this is more due to the comparison between the suction force and the thrust force there is a tendency to increase so that this has an impact on increasing the efficiency of the hydram pump.

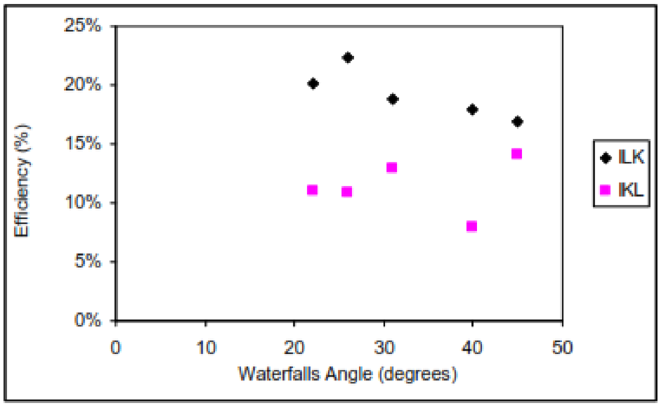

Figure 4. Relationship between waterfall Angle Variations with efficiency

CONCLUSION

The results showed that the best efficiency of the hydraulic ram pump with the ILK arrangement was 22.3%, which was obtained at a waterfall angle of 26^{o}, while in the IKL arrangement it was 14.2%, which was obtained at a waterfall angle of 45^{o}. While the best thrust was obtained at an angle of 31^{o} which is 11.18 N for the IKL arrangement while for the ILK arrangement the best thrust was obtained at an angle of 22^{o} which was 12.42 N.

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