Analysis of the Effect of Double Waste Valves in Series Arrangement and Compressor Tube Layout on the Performance Efficiency of 2 Inch Hydraulic Ram Pump

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Keywords: Hydraulic Ram Pump, Layout, Double Waste Valve, Efficiency, Performance, Series Arrangement.

Abstract: Water is an absolute necessity for the survival of life because without water there will be no life in this world. For areas that are close to water sources or are located close to springs, the need for water is not a problem. The laws of physics say that water flows from a higher place to a lower place, but the fact is that the land surface is not always flat; there are hilly and bumpy areas. For areas that are higher than the water source, it will be difficult to get a continuous supply of water. One of the efforts to get water supply for areas that are higher than the spring is to use a water pump. The types of pumps commonly used today are electric-powered water pumps and fuel-powered water pumps. In urban areas, the need for fuel and electricity is not a problem, but in rural areas, the availability of fuel and electricity is very scarce and expensive. The hydraulic ram is the answer to this problem. One of the efforts to increase the efficiency of hydraulic ram pump performance is by increasing the number of waste valves arranged in series. The problem is, is there any effect of the arrangement of the double waste valve series on the performance efficiency of the 2-inch hydraulic ram pump at the Input-Compressor-Waste-Waste (ICWW) position, the Input-Waste-Waste-Compressor (IWWC) position, and the Input-Waste-Compressor-Waste position. (IWCW)? The purpose of this research is to design, manufacture, and test the arrangement of the double valve series of hydraulic ram pumps at three different positions (ICWW, IWWC, and IWCW) using a 3000 ml compressor tube. So, it could be seen the optimal performance efficiency of the hydraulic ram pump. The method used is a site survey, literature study, and action method with the design of the hydraulic ram pump installation, as well as observing the effect of using a double exhaust valve in series at the ICWW, IWWC, and IWCW positions on the efficiency of the 2-inch hydraulic ram pump performance. The results of this study indicate that the largest pumping discharge occurs in the IWCW pump arrangement (Input-Waste-Compressor-Waste) with a waste valve weight of 367 grams; at input 180 liters/minute produces output 0.131 liters/second and at input 170 liters/minute produces output 0.107 liters/second. The greatest efficiency also occurs in the IWCW pump arrangement (Input-Waste-Compressor-Waste) with a waste valve weight of 367 grams; at the input of 180 lt/min by 132% and at the input of 170 lt/min by 110% (according to D'Aubuison Efficiency).

1 INTRODUCTION

Water is an absolute necessity for the survival of life, because without water there will be no life in this world. Especially for areas that are close to water sources or are located under springs, water demand is not too much of a problem. Areas where the land surface is higher than the water source will have difficulty getting a continuous water supply.

One of the efforts to meet water needs, especially in locations higher than the springs, is to use a water pump. The type of pump that is commonly used today is a water pump powered by an electric motor or a fuel oil engine which is difficult to obtain in remote rural areas. The solution is to use a hydraulic ram pump, because a hydraulic ram pump works without the use of fuel or electricity.

The problem is whether to increase the number of waste valves (double waste valves) arranged in series at the Input-Waste-Waste-Compressor (IWWC), Input-Compressor-Waste-Waste (ICWW) and Input-Waste-Compressor-Waste (IWCW) positions. , can increase the efficiency of the 2 inch hydram pump performance.

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Various studies have been carried out in an effort to improve the efficiency of the hydraulic ram pump performance, such as (Asep Supriyanto et al., 2017) conducted a study entitled "Pengaruh Variasi Jarak Sumbuh Katub Limbah dengan Sumbuh Tabung Udara Terhadap Efisiensi Pompa Hidram", in which the results showed that the variation of the shortest distance (0.25 m) get an output discharge of 0.0041 m^3/second with an efficiency of 14%.

(Aris Eko Sulistiawan, et al., 2006), also conducted a study entitled "Pengaruh Berat Katub Limbah dan Ketinggian Discharge Terhadap Kerja Pompa Hidram". The results showed that, the best capacity at the west of the waste valve is 200 grams with a value of 7.75 liters/minute at 3 meters discharge, volumetric efficiency is 52.961% and pump efficiency is 60.623%.

Another study conducted by (Muhamad Jafri et al., 2017), entitled "Analisa Beda Tinggi Katub Limbah dan Variasi Diameter Pipa *Inlet* Terhadap Unjuk Kerja Pompa Hidram Ukuran Dua Inchi". The results showed that the minimum efficiency of 59.15% was obtained at a valve height difference of 15 cm and an inlet pipe diameter of 3 inches, while the highest efficiency was obtained at 95.29% at a different valve height of 10 cm and an inlet pipe diameter of 2 inches.

(Muhamad Fajri et al., 2015), also conducted a study entitled "Pengaruh Diameter Katub Limbah dan Jarak Antara Katub Limbah dengan Katub Penghantar Terhadap Efisiensi Pompa Hidram. The results showed that the highest efficiency obtained was 79.7535% at a waste valve diameter of 0.041 meters and a distance between valves of 0.130 meters.

From previous studies, no researcher has raised the issue of the number of waste valves used in increasing the efficiency of hydraulic ram pump performance.

The purpose of this study was to design and manufacture a hydraulic ram pump and to test the use of a double valve in series arrangement in three positions: Input-Waste-Waste-Compressor (IWWC), Input-Compressor-Waste-Waste (ICWW) and Input-Waste-Compressor-Waste (IWCW).

The main issue that will be raised in this research is the use of new and renewable energy in meeting the needs of clean water for rural communities, especially those that have not been reached by the State Electricity Company.

The results of this study are expected to solve the problems mentioned above, so that people can take advantage of the natural resources that are around them (river water), for their daily needs such as drinking water, watering plants and giving water to their livestock. Thus the standard of living of the people will be better.

2 RESEARCH METHOD

2.1 Design and Manufacture of 2 Inch Ram Hydraulic Pump with Double Drain Valve Series Arrangement

The hydraulic ram pump is designed with an input pipe diameter of 2" or 5.075 cm, an output pipe diameter of 1.27 cm, a compressor tube volume of 3000 ml, with variations in the arrangement of ICWW, IWWC and IWCW. The inclination angle of the inlet pipe is 5^0, water drop height is 1.5 meters, and water lift height is 5 meters. The hydraulic ram pump is made using iron pipe (T shock) ø 2 inch, double nipple 2 inch, elbow 2 inch, elbow inch, steel pipe ø 2½ inch, elbow iron 70x70x6000 mm, solid stainless ø 10 mm, steel axle ø 40 mm , paralon pipe ø 2 inch and ½ inch, 5 mm thick rubber, bolts and nuts. The results of the design of the hydraulic ram pump as shown in Figures 1, 2 and 3 below:

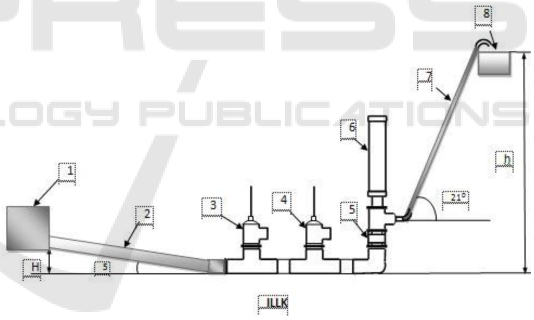

Figure 1: Installation of Hydraulic Ram Pump in IWWC Arrangement.

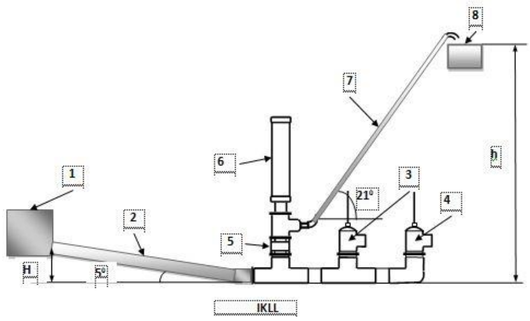

Figure 2: Installation of Hydraulic Ram Pump in ICWW Arrangement.

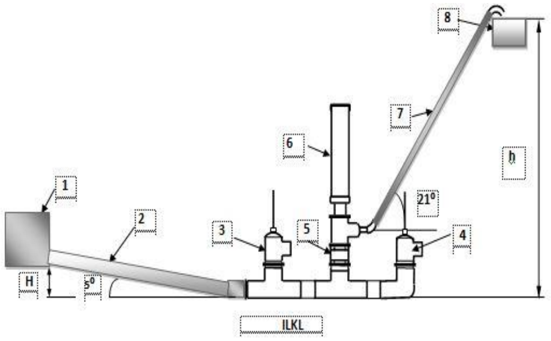

Figure 3: Installation of Hydraulic Ram Pump in IWCW Arrangement.

Image Captions:

1. Water source
2. Inlet pipe
3. Waste valve (1)
4. Waste valve (2)
5. Delivery valve
6. Compressor tube
7. Exhaust pipe
8. Reservoir

H = Height of fall
h = Lift height

2.2 Research Flowchart

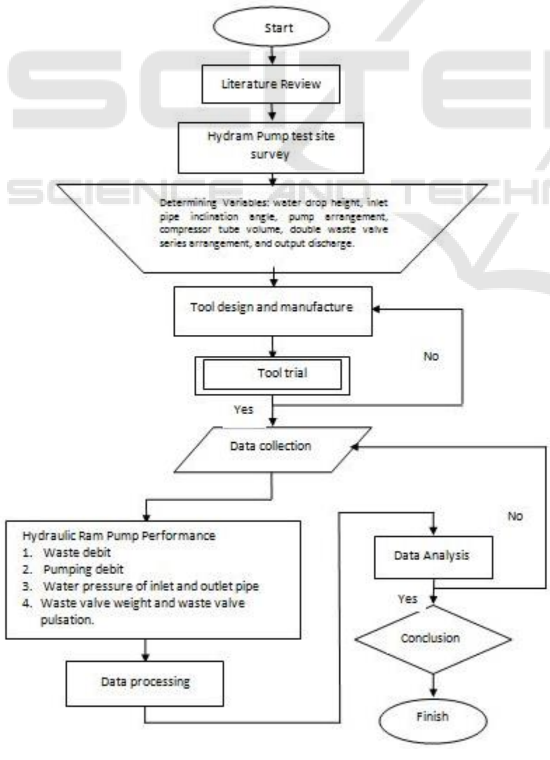

Figure 4: Flowchart of this system.

2.3 Data Collection Method

The method used is experimental method with 10 independent variables. They are the water fall height (H) 1.5 m, lift height (h) 5 m with a slope of $21{,}72^0$ following the contour of the ground and the length of the outlet pipe is 13.60 m, the slope angle of the slide pipe (5^0) with a slide pipe length of 17.24 m, water flow entering the pump (180 and 170 liters/min), IWWC position, ICWW position, IWCW position, compressor tube volume 3000 ml. While the 7 dependent variables are: sewage discharge (Q), inlet water pressure, outlet pressure, pumping discharge (q), waste valve weight, waste valve pulse and hydraulic ram pump efficiency (calculated using equation 1).

Prior to testing and data collection, the water drop height (H) was conditioned at least 1.5 m with the discharge water being 180 liters/minute and 170 liters/minute. The test will be carried out 18 times in accordance with 3 variations of the compressor tube position (IWWC, ICWW, IWCW) and 3 variations of the weight of the waste valve (367 grams, 567 grams, 695 grams) both at intake discharge of 180 liters/minute and 170 liters/minute. Each test will be recorded carefully in the data table that has been prepared.

(a) IWWC (b) ICWW (c) IWCW

Figure 5: Schematic of the hydraulic ram pump test installation.

In testing the researcher used supporting equipment such as a measuring cup, a bucket, seal tapes, PVC glue, machete, shovel, roller meter, pressure gauge, water fitting, nylon ropes, bamboo, pipe wrench, and a stopwatch. Data retrieval is done by reading the pressure on the pump inlet pipe, pressure on the outlet pipe, measuring the pulse of the waste valve, measuring the discharge of the waste and the discharge of the pumping.

2.4 Data Processing Method

The data that has been collected in tabular form will be made in graphical form to obtain the relationship between variations in the position of the compressor tube, variations in the weight of the waste valve, and the pulse of the waste valve to the pumping discharge.

The hydraulic ram pump efficiency can be calculated in two ways:

According to D'Aubuisson (Murni, 2016)

$$\eta = \frac{q(H+h)}{(Q+q)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

According to Rankine :

$$\eta = \frac{q.h}{Q.H} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where: η = hydraulic ram pump efficiency (%)

q = result (m^3/det.)

Q = waste (m^3/det.)

h = head out (m)

H = head in (m)

3 RESULT AND DISCUSSION

The test result data can be seen in Tables 1, 2 and 3 below:

Table 1: Position of IWWC.

Incoming debit (L/minute)	Waste valve weight (gram)	Waste valve pulsation (x/minute)	Waste debit Q (L/second)	Yield debit Q (L/second)	D'Aubuison Efficiency η (%)	Pump inlet pressure (bar)	Pump outlet pressure (bar)
180	367	36	0,495	0,114	122	0,6	0,6
	567	28	0,679	0,126	102	0,6	0,6
	695	26	0,800	0,120	85	0,6	0,6
170	367	34	0,537	0,095	98	0,6	0,6
	567	26	0,752	0,077	60	0,6	0,6
	695	18	0,869	0,056	39	0,6	0,6
135							

Tabel 2: Position of ICWW.

Incoming debit (L/minute)	Waste valve weight (gram)	Waste valve pulsation (x /minute)	Waste debit Q (L/second)	Yield Debit Q (L/second)	D'Aubuison Efficiency η (%)	Pump inlet pressure (bar)	Pump outlet pressure (bar)
180	367	34	0,494	0,115	123	0,6	0,6
	567	28	0,645	0,123	104	0,6	0,6
	695	26	0,754	0,115	86	0,6	0,6
170	367	33	0,493	0,095	115	0,6	0,6
	567	26	0,768	0,077	72	0,6	0,6
	695	21	0,921	0,056	53	0,6	0,6
135							

Tabel 3: Position of IWCW.

Incoming debit (L/minute)	Waste valve weight (gram)	Waste valve pulsation (x /minute)	Waste debit Q (L/second)	Yield Debit Q (L/second)	D'Aubuison Efficiency η (%)	Pump inlet pressure (bar)	Pump outlet pressure (bar)
180	367	34	0,514	0,131	132	0,6	0,6
	567	28	0,639	0,131	103	0,6	0,6
	695	25	0,764	0,124	91	0,6	0,6
170	367	33	0,523	0,107	110	0,6	0,6
	567	25	0,749	0,089	69	0,6	0,6
	695	17	0,088	0,066	37	0,6	0,6
135							

The results of the hydraulic ram pump test on the layout of the compressor tube, Input-Waste-Waste-Compressor (IWWC), Input-Compressor-Waste-Waste (ICWW) and Input-Waste-Compressor-Waste (IWCW) with 2 variations of intake discharge (180 liters) /minute 170 liters/minute) and 3 variations of the weight of the waste valve, as shown in tables 4.1, 4.2 and 4.3 above. The relationship between the weight of the waste valve and the output discharge to the position of the compressor tube is presented in Figure 5 (incoming flow rate of 180 liters/minute) and Figure 6 (incoming flow rate of 170 liters/minute). The position of the IWCW compressor tube shows a higher pumping discharge compared to the position of the IWWC and ICWW compressor tubes.

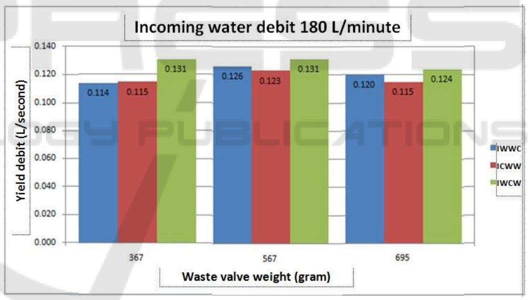

Figure 6: Comparison of the output discharge value with the weight of the waste valve on the compressor tube position.

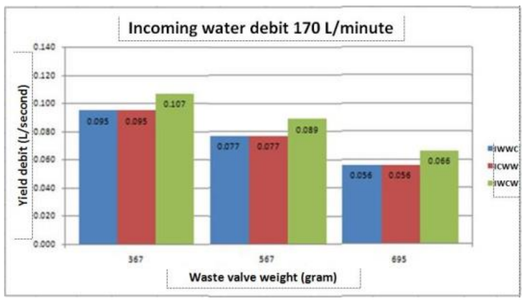

Figure 7: Comparison of the output discharge value with the weight of the waste valve on the compressor tube position.

The most ideal waste valve weight is 567 grams at the intake discharge of 180 liters/minute for the three compressor tube positions (IWWC, ICWW and IWCW), while at the intake discharge 170 liters/minute, the appropriate waste valve weight for the three compressor tube positions is 367 grams (see Figure 8), in which the weight of the waste valve must be adjusted to the intake discharge.

The effect of the weight of the waste valve on the pulse of the waste valve and the position of the compressor tube is presented in Figures 7 and 8, where the heavier the waste valve, the slower the pulse produced, both at the intake discharge of 180 liters/minute and 170 liters/minute.

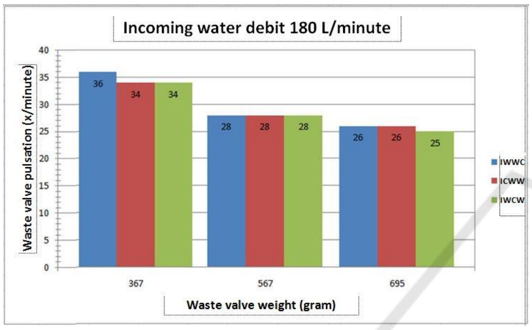

Figure 8: Comparison of the value of the weight of the waste valve with the pulse of the waste valve to the position of the compressor tube (inlet discharge 180 liters / minute).

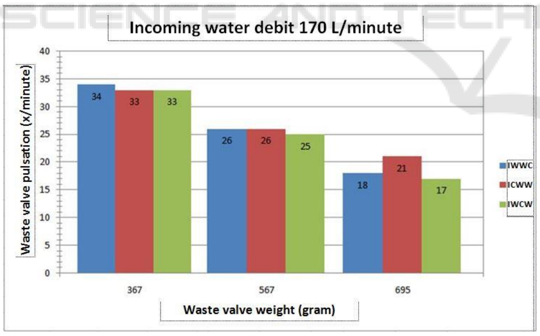

Figure 9: Comparison of the value of the weight of the waste valve with the pulse of the waste valve to the position of the compressor tube (at the inlet 170 liters/minute).

The relationship of the waste valve pulse to the pumping discharge at the hydraulic ram pump with the arrangement of IWWC, ICWW and IWCW is shown in Tables 1, 2 and 3, where the higher the number of pulses, the higher the pumping discharge.

The efficiency of the hydraulic ram pump as a comparison of the pumping discharge with the inlet and effluent discharges as well as the ratio of the weight of the waste valve and the output discharge in each pump arrangement is presented in Figure 9 below.

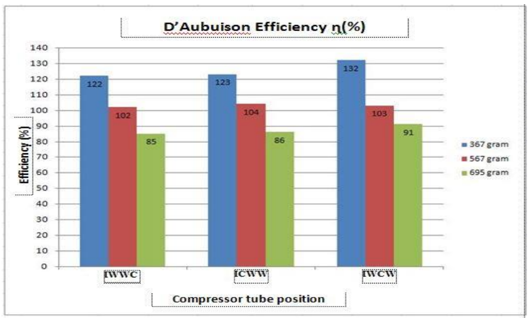

Figure 10: Graph of the relationship between compressor tube position and waste valve weight on D'Aubuisson efficiency.

In general, the highest efficiency value is obtained at the position of the IWCW compressor tube (Input-Waste-Compressor-Waste), both at the intake discharge of 180 liters/minute and 170 liters/minute with a waste valve weight of 367 grams which is 132% and 110% (according to the D'Aubuison efficiency).

The results of previous research using a single waste valve, the highest efficiency obtained was only 127% on the IWC hydraulic ram pump arrangement. This means there is an increase in efficiency by 5%.

The efficiency value obtained according to D'Aubuison looks greater than 100%, occurs at every position of the compressor tube IWWC, ICWW and IWCW. This is due to the large amount of water entering the pump, which is 180 liters/minute (measurements before testing). In addition, the slope angle of the inlet pipe is getting smaller (50) so that the inlet pipe is getting longer which affects the suction and thrust forces so that the efficiency of the hydraulic ram pump is higher. Research conducted by R. Sutanto (2019), also shows that the smaller the plunge angle used, the greater the output discharge generated, the greater the plunge angle, the smaller the suction and thrust forces of the hydraulic ram pump.

4 CONCLUSIONS

Based on the results of testing and data processing, it can be concluded as follows:

a. The largest output/pumping discharge occurred at the position of the IWCW (Input-Waste-Compressor-Waste) compressor tube, both at the intake discharge of 180 liters/minute and 170 liters/minute with a waste valve weight of 367 grams which were 0.131 liters/second and 0.107 liters. /second.

b. The greatest efficiency also occurs at the position of the IWCW compressor tube (Input-Waste-Kompresor-Waste), both at the intake discharge of 180 liters/minute and 170 liters/minute with a waste valve weight of 367 grams, which are 132% and 110% (according to the efficiency of D 'Aubuison).

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