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Experimental Study on Waste Valve Load's Effect on the Performance of Hydram to Water the Paddy Field in Pakandangan Village

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***Abstract*—In the Research of DIPA Grant in 2019, the size of the hydraulic ram (hydram) pump used in Pakandangan in Padang Pariaman Regency was designed. In this area, a water source had not been utilized to irrigate the paddy field of 10 hectares since it was located higher than the water source. The designed hydram pump was not maximal because the pump's optimal performance was not known yet. Therefore, a hydram pump is desgned by varying the load of waste valve. When the pump is operated, the load of waste valve is varied in the 200 g, 300 g, 400 g, 500 g and 600 g weight. The height (Hd) of the inlet pipe is 1 m, and the lift height (Hs) of the outlet pipe is 5 m. From the testing, it is obtained that the lowest waste discharge is in 200g waste valve load, that is 1.118 l/s, and the highest pump discharge is in 400 g waste valve load, namely 0.063 l/s. The best number of waste valve beats is found in 400 g waste valve load, that is 3/7 beats/s. The highest Rankine efficiency is 6.5% in 600 g valve load, and the highest D'Aubuisson efficiency is 21.24% in 200 g valve load.**

Keywords—efficiency, hydram pump, paddy field, pakandangan

I. INTRODUCTION

Hydraulic ram (hydram) pump is a pump working automatically without electricity, utilizing the energy from flowing water to pump water from the source to the destination [1]. The energy of the flowing water means potential energy from certain elevation which is converted to kinetic energy in the form of water speed and then strengthened by water hammer effect.

Hydram pump works without fuel or additional external energy. This pump uses the energy of the flowing water from a water source and the water is pumped to a higher place. In various situations, the use of hydram pump has more advantages than the use of other kinds of water pump. Some of the advantages are that it does not need fuel or additional energy from other sources, it does not need lubrication, the shape is simple, the manufacturing and maintenance cost is really cheap, and its manufacturing does not need advanced skills. In addition, this pump can work 24 hours a day. This hydram pump is perfect for the regions whose citizens have limited technical skills because its maintenance is simple. It is one of the energy efficient and environmentally friendly pumps. Hydram pump is an appropriate technology in pumping using water hammer effect to lift the pumped water, so it becomes one of the water pumps that do not use fossil fuel and electricity [2,3].

A. *The Components of Hydram Pump*

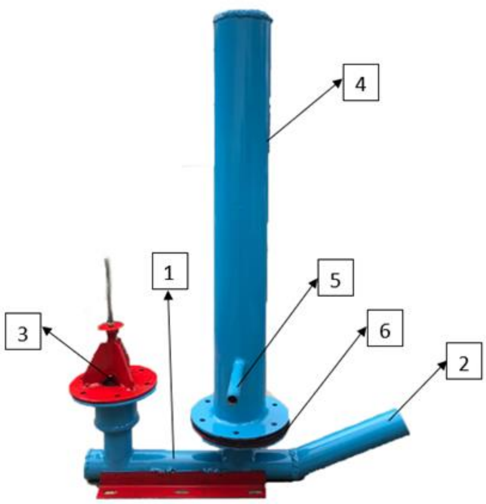

Fig. 1. The Components of Hydram Pump.

The function of hydram pump components is as follows: 1. Hydram body is the place where the pumping takes place. 2. Drive pipe is inlet pipe to the pump. 3. Waste valve is one of the most important components of the hydram pump; therefore, it should be made well in order that its weight and movement can be adjusted. The waste valve itself functions to convert the kinetic energy of the working fluid flowing through the inlet pipe into the pressure energy of dynamic fluid that will lift the working fluid to air chamber. 4. Air chamber is used to compress the air inside and restrain the pressure from the ram cycle. Besides that, the air chamber enables the air to pass through the delivery pipe continuously. If the air chamber is full of water, it will vibrate violently, causing it to burst. In this case, the ram must be stopped immediately. According to some experts, to avoid this problem, the volume of the air chamber must be equal to the volume of the delivery pipe. 5. Delivery valve should have a large hole to allow the pumped water to enter the air chamber. This valve can be made in a simple shape called non-return valve. 6. Snifter valve. Snifter valve is a valve that sucks water from the hydram body to the air chamber and prevent the incoming water from draining back to the hydram body.

B. Efficiency

The power required to lift the water is directly proportional to the volumetric flow rate of the pumped water multiplied by the height of the pump. Likewise, the power available in the supplied water to operate the hydram pump is directly proportional to the magnitude of the volumetric rate of the supplied water multiplied by n-height supply. Hydram pump works by using the available power to lift the flow to the higher place. Thus, the efficiency of hydram pump is stated as D-Aubuission equation, that is:

$$\eta_A = \frac{q\ .\ hd}{(Q+q).Hs}\ x\ 100\% \tag{1}$$

η_A= Efficiency D'Aubuison (%)
q = Debit output (lt/s)
Q = Debit Waste (lt/s)
h = Head Discahrge (meter)
H = Head Suction (meter)

$$\eta_R = \frac{q\ .\ (hd - Hs)}{(Q+q).Hs}\ x\ 100\% \tag{2}$$

η_R= Efficiency Rankine (%)
q = Debit output (lt/s)
Q = Debit Waste (lt/s)
hd = Head Discahrge (meter)
Hs = Head Suction (meter)

The pump used in this study was the self-made pump using the existing research design as the reference. The inlet pipe entered the pump with 2 m high storage tank and 0.0508 m diameter (2 inches) and 6m length pipe. The valve variation of the load model used spring loaded sequentially from 0.4kg-1kg at intervals of 0.1kg. The variations of the ratio of the valve's cross-sectional area to the inlet pipe's cross-sectional area were 1:2, 2:3, and 3:4. From the research, it was obtained that the highest efficiency of hydram pump in 4 m height of the delivery pipe was in the waste valve of 1:2 at the load of 0.4 kg, namely 39.53076%. In the 6 m high delivery pipe, namely in the waste valve of 1:2 at 0.4 kg load, the efficiency of the pump was 23.45%. At the 8 m high delivery pipe, in the waste valve of 3:4 at 0.4 kg load, the efficiency of the pump was 17.82345% [4].

Energy is needed in the mobilization mechanism of either electricity energy or fossil energy. Hydram pump is the tool used to lift water from lower to higher place by using water hammer effect without using renewable energy. In Pakandangan, Padang Pariaman regency, there was a water source that could not be used to irrigate 10 hectares of paddy field since the field was higher than the water source. The methodology used in this research was surveying the location and designing the dimension of the hydram pump. The result was that the head height of the water entering the pipe was 2.5 m, and that the pumping height was 7 m. The pump dimension was the result of the design from the hydram size 1 in a diameter of 2 inches [5].

In this research, the design of the hydramp pump used the variation of air chamber height of 40 cm and 60 cm with a diameter of 6.35 cm and the variation of the inlet pipe length of 8 m, 10 m, and 12 m. The height of the delivery pipe was 2.3 m, and the height of the pressure pipe was 8 m. From the calculation, it was obtained that the maximum pump capacity was 0.0000346666 m^3 /s. The maximum efficiency of hydram pump was 29.55% at 60 cm height of tube and 10 m length of inlet pipe [6].

This research aimed to investigate the effect of the height difference between the waste valve, the delivery valve, and the diameter of the inlet pipe on the performance of the hydram pump. The method used in this research was the experimental method. The data measured were the pump discharge, waste discharge in each independent variable, namely the difference in the valve height (10 cm, 15 cm, 20 cm, and 25 cm) and the diameter of the inlet pipe (2 inches, 2.5 and 3 inches). Measurement data and installation data were used to analyze the effective head. The data of the pump discharge, waste discharge, and intake flow, and the data from head analysis were used to calculate the pump efficiency [7]. The pump efficiency used here was D'aubuisson's and Rankine's efficiency. The results showed that the minimum efficiency was 59.15% which occurred at the difference of valve height of 15 cm and 3 inch diameter of inlet pipe, whereas the maximum efficiency was 95.29% at the difference of valve height of 10 cm dan 2 inch diameter of inlet pipe in the hydram pump [8].

The research was conducted using a hydram pump with 3 m surface height of the reservoir, 4 m length of inlet pipe, 2.5-inch diameter of pressure pipe, 1.5 inch diameter of hydram body, and 0.5 inch diameter of delivery pipe, 6 m height. The variations of air chamber volume were 4866.35 cm3, 5677.41 cm3 and 6488.47 cm3. The results showed that 4866.35 cm^3 volume of air chamber produced a discharge of 0.0355 l/s, and the pump efficiency of 24.64% and 6488,47 cm3 produced a discharge of 0.072 l/s and efficiency of 28.32% [9].

In this research, the prototype of the hydraulic ram pump was made based on the following specifications: 1.5 m input head, 2-inch diameter input, 40 mm diameter pump, 4 inch and

650 mm long inlet air chamber, 1 inch diameter output with 3 mm and 4 mm output head. Likewise, Januddi et al [10] in their research fabricated and modelled the hydram used as well by adjusting the waste valve designed. Here, in this current research, the weight was given to the pump valve in the variation of 0.6, 0.7, 0.9, 1.05 kg and at the distance of 5,8,10, and 12 mm from the valve. Observation and analysis were carried out on the flow rate and efficiency result. The data were taken from 2 head points, 3 m and 4 m. As the results of variation and distance experiments, it can be concluded that the greater the distance is, the lower the flow rate and the efficiency are. The maximum flow rate at 3 m head was 21.6 l/min and at 4 m head 14.64 l/min. The best efficiency generated at 3 m head was 16.26% and at 4 m head 14.7%. [11].

Dry land is one of the agroecosystems of land resources that have great potentials for agricultural development. Technical obstacle in dry land agriculture is the availability of water. In order to increase the cropping index in dry lands, it is necessary to utilize the surface water resources as optimal as possible. To fulfill the need of irrigation water in dry lands, an alternative that can be developed is the use of environmentally friendly pump irrigation system, namely hydram pump. The aim of this research was to investigate the effect of the d/h ratio of the air chamber on the performance of the hydram pump. The hydram pump used in this research had 1.5-inch size and the variation of 2 m, 3 m, 4 m, and 5 m head suction. The hydram pump used in this research had the arrangement of input, waste, air chamber by calculating the effect of d/h variation ratio of the air chamber with the constant volume of 2650 cm3 on the performance of the hydram pump including: output discharge, waste discharge, maximum head, the efficiency produced by the hydram pump. The results showed that every 1 m of the head rise increased the output discharge averagely 36.6% and the maximum head 5-6 m. D/h variation ratio of the air chamber affected the output discharge but did not influence the maximum head of the hydram pump. Meanwhile, the highest efficiency obtained at 2 m head suction) and d/h ratio of the air chamber of 0.198 was 33.98%. [1].

II. METHOD OF THE RESEARCH

A. Time and Place

This research was conducted from January to April 2020. It was carried out in three stages, namely the making of the hydram design, the making of the waste valve load in the Production Workshop of the Mechanical Engineering Department, Politeknik Negeri Padang, and the testing of the effect of the waste valve load in Pakandangan.

B. Flowchart of the Research

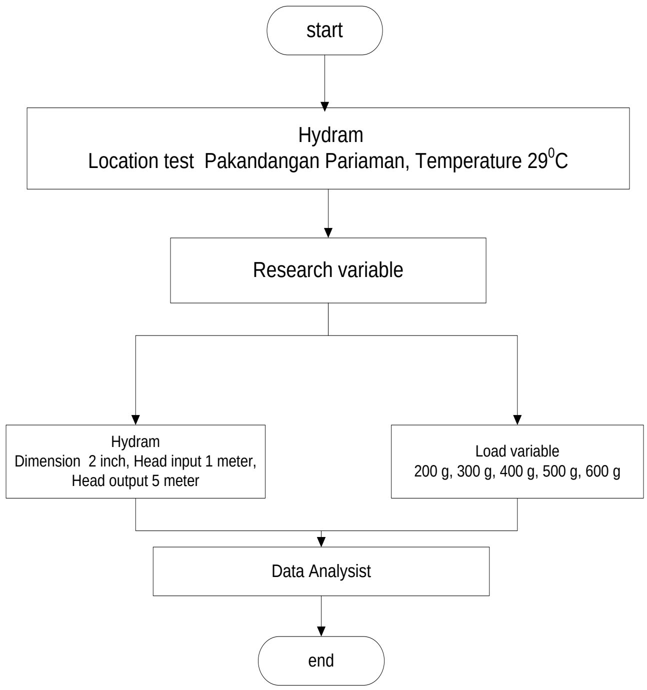

Fig. 2. Flowchart of the research.

C. Tools and Materials

Hydram pump, measuring cup, stopwatch, pipes, and 200 g, 300 g, 400 g, 500 g, and 600 g valve load.

D. Procedure of the Research

The test procedure was carried out with a load of waste valve sizes of 0 grams, 300 g, 400 g, 500 g, and 600 g during the operation of the hydram pump. The height of the inlet pipe (hd) is 1 m and the height of the delivery pipe was 5 m. Then the water capacity coming out of the outlet pipe Qd and the capacity of the wasted water Qw in the waste valve were calculated, so that the efficiency of the hydram pump could be calculated.

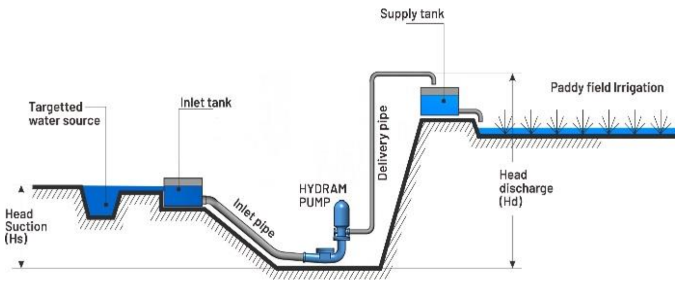

Fig. 3. The testing procedure.

III. Results and Discussion

From the research results, the obtained data and the graphs were presented as follows:

- The effect of the load variable on the output discharge and waste discharge with four-time data repetition. The fixed variable of Head suction (Hs) was 5 m, head discharge (Hd) was 1 m. From the graph of the testing, it can be seen that the output discharge decreases as the load in the waste valve rises. The maximum output discharge (Qs) in the experiment data is 0.01 l/s at the load of 200 g. After the average is calculated, it is obtained that the output discharge (Qs) is 0.063 l/s at the load of 400 g.

TABLE I. THE EFFECT OF THE LOAD ON THE PUMP DISCHARGE

Testing	200		300		400		500		600	
	Qs (lt/s)	*Qw (lt/s)*	*Qs (lt/s)*	*Qw (lt/s)*	*Qs (lt/s)*	*Qw (lt/s)*	*Qs (lt/s)*	*Qw (lt/s)*	*Qs (lt/s)*	*Qw (lt/s)*
1	0,100	1,183	0,074	1,754	0,086	2,023	0,078	2,266	0,049	2,230
2	0,062	1,100	0,074	1,365	0,081	1,847	0,076	1,914	0,043	1,973
3	0,050	1,020	0,063	1,666	0,075	1,507	0,077	2,193	0,050	2,364
4	0,036	1,169	0,052	2,222	0,075	1,711	0,073	2,000	0,050	2,735
Average	0,050	1,118	0,053	1,752	0,063	1,772	0,061	2,093	0,038	2,326

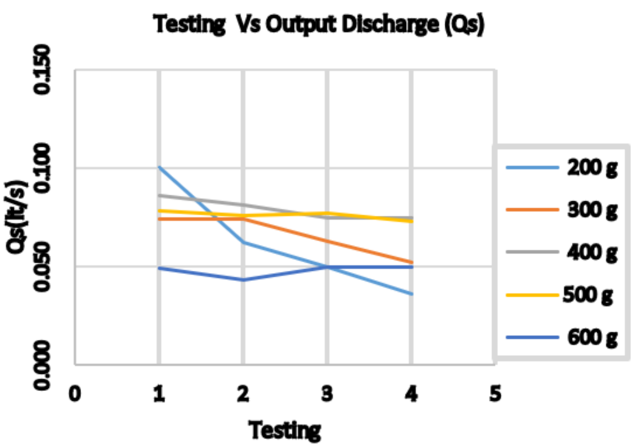

Fig. 4. Graph of testing on the output discharge.

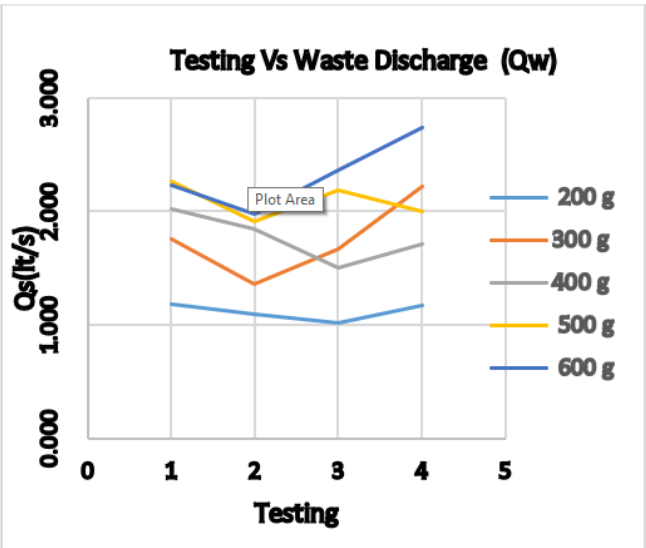

Fig. 5. Graph of the testing on the waste valve discharge.

From the graph, it can be seen that the waste discharge (Qw) will decrease as the load at the peak point rises, the waste discharge will increase. Maximum waste discharge (Qw) in the experiment data is 2.735 l/s at the 400 g load. After the average is calculated, it is obtained that the output discharge (Qw) is 2.326 l/s at 400 g load.

- Relationship between D'Aubuisson and Rankine efficiency and waste valve discharge. The testing data can be seen in Table 2. From the testing data, it is obtained that heavier the load of the waste valve load, the lower the efficiency. The largest D'Aubuisson efficiency, 21.24%, and Rankine efficiency, 16.99%, occured at 200 g load, and the smallest D'Aubuisson, 8.12% and Rankine efficiency, 6.5%, occured at 600 g load.

TABLE II. EFFICIENCY AGAINST THE WASTE VALVE LOAD

Load (g)	**Qs (lt/s)**	**Qw (lt/s)**	**Hd (meter)**	**Hs (meter)**	**Aubuison Efficiency (%)**	**Rankine Efficiency (%)**
200	0,050	1,118	5	1	21,24	16,99
300	0,053	1,752	5	1	14,73	11,78
400	0,063	1,772	5	1	15,29	12,23
500	0,061	2,093	5	1	10,92	8,73
600	0,038	2,326	5	1	8,12	6,50

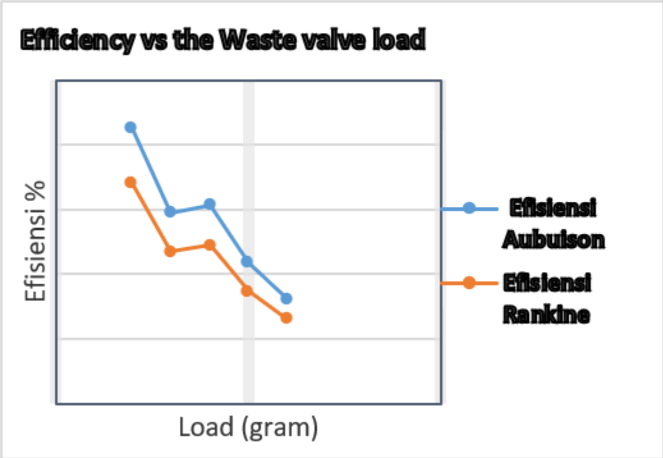

Fig. 6. Efficiency against the load.

TABLE III. THE NUMBER OF BEATS

Testing / beats	load (g)				
	200	*300*	*400*	*500*	*600*
	Time (s)	*Time (s)*	*Time (s)*	*Time (s)*	*Time (s)*
1/3	4	6	7	7	11
2/3	4	9	7	8	12
3/3	4	6	7	8	12
4/3	4	6	7	8	11
Average	4	7	7	8	12

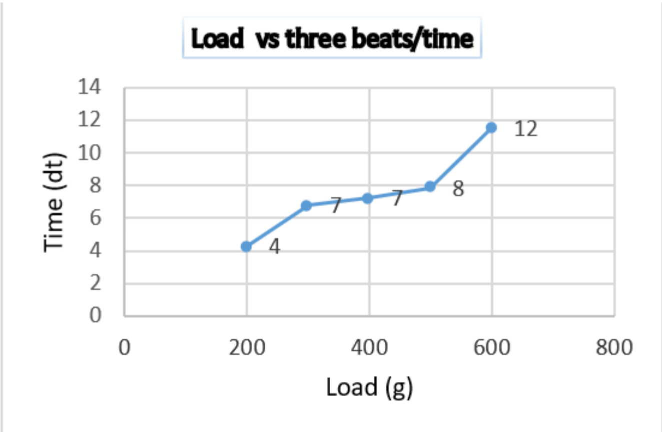

Fig. 7. The number of beats.

- From the graph, it can be seen that the number of beats increases as the load is added.

IV. CONCLUSION AND SUGGESTION

In conclusion, the results of the study show that the lowest output discharge at the variation of 200 g waste valve load was 1.118 l/s. Whilst, the highest pump discharge at the variation of 400 g waste valve load was 0.063 l/s. For the best waste valve beat, the occurrence was at 400 g waste valve load with 3/7 beats/second. Hence the highest Rankine was 6.5% at 600 g waste valve load, and the highest D'Aubuisson efficiency was 21.24% at 200 g load.

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