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Experimental Study on the Effect of Waste Valve Load and the Volume of Air Chamber on the Performance of the Hydraulic Ram Pump

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Abstract

This 2019 DIPA Grand's research designed and fabricated the size of hydraulic ram (hydram) pump utilized in Pakandangan, Padang Pariaman Regency. There is a water source in this area which has not been functioned adequately to irrigate the paddy field of 10 hectares due to the location of the paddy field which is higher than the water source. However, the use of designed hydram pump has no been maximized as the pump's optimal performance was not determined yet. Therefore, a hydram pump was designed by varying the load of waste valve in the weight of 400 g, 600 g, 800 g, 1,000 g, and 1,200 gr. It was also varied in the volume of the chamber when the pump operated which were 4.86 lt, 5.76 lt, 6.48 lt, 7.29 lt, and 8.1lt. The height (Hd) of the inlet pipe was 1 m, and the lift height (Hs) of the outlet pipe was 5 m. The results obtained from Pump performance increases with increasing cylinder volume. The increase in the load of the exhaust valve volume of the tube remains a significant decrease. Hydram pump performance occurs at a load of 400 g with a tube volume of 8.1 l with an efficiency of 53%

Keywords: Hydram pump, Paddy field, Efficiency

Abstrak

Pada Penelitan Dana Dipa Tahun 2019 telah dirancang dan design ukuran pompa Hidram yang akan digunakan pada daerah Pakandangan Kabupaten Padang Pariaman terdapat sumber air yang belum dapat dimanfaatkan untuk mengaliri sawah sekitar 10 Ha, karena lahan sawah lebih tinggi dari sumber air. Hasil rancangan pompa hidram belum maksimal berakibat kepada kinerja pompa yang belum optimum. Untuk itu dibuatlah pompa hidram dengan menvariasikan beban katup limbah. Variasikan beban katup limbah ukuran 400 gram, 600 gram, 800 gram, 1000 gram dan 1200 gram dan variasi volume tabung adalah 4,86 liter, 5,67 liter, 6,48 liter, 7,29 liter, dan 8,1 liter pada saat pengoperasian pompa hidram. Sedangkan ketinggian pipa masuk (hd) adalah 1 meter dan ketinggian tinggi angkat pipa keluar (Hs) 5 meter. Hasil dari pengujian kinerja pompa meningkat dengan bertambahnya volume tabung. Kenaikan beban katup buang dengan volume tabung tetap terjadinya penurunan yang significant. Kinerja pompa hidram optimum pada beban 400 gram dengan volume tabung 8,1 l dengan efisiensi 53 %

Kata kunci: Pompa hidram, Sawah, Efisiensi

1. 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.

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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].

The Components of Hydram Pump

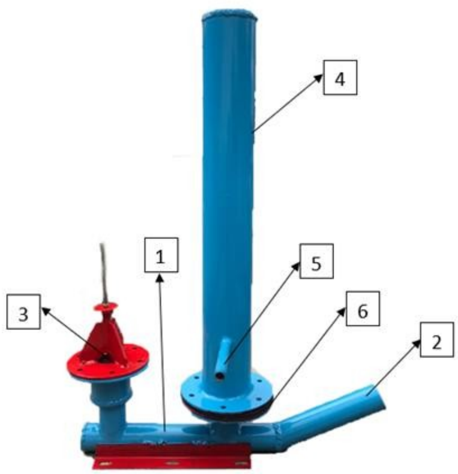

Figure 1. The Components of Hydram Pump [5]

The Components of Hydram Pump can be showed at Figure 1, and 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 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 non-return valve.

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 [4] equation, that is:

$$\eta = \frac{q * h}{Q * H}$$

With :
q = delivery flow
Q = supply flow
H = supply head
h = delivery head

possibility of using a hydraulic ram pump (HRP) as a means of utilizing its energy to produce high head for pump has been investigated. To make such a system economically competitive, it is necessary to improve the performance of HRPs. To achieve this improvement, it is also necessary to understand the parameters that marked out the design of conventional HRPs. Performance is presented in dimensionless terms as the head ratio H∗ or discharge head to drive head and flow-rate ratio Q∗ or discharge flow rate to drive flow rate. The experiments on HRPs were conducted by which each of the following factors could be varied independently: (a) supply head, (b) air chamber pressure, and (c) waste valve beats per minute. An increase in the supply head tends to increase the supply flow rate, delivery flow rate, delivery head, and the overall efficiency of the pump. An increase in air chamber pressure tends to decrease the overall efficiency of the pump. However, there was no significant difference on the HRP performance over a wide range of flow conditions when air chamber pressure was varied. An increase in waste valve beats per minute tends to decrease the supply flow rate, delivery flow rate, and delivery head. But it tends to increase the head ratio, the flow- rate ratio, and the overall efficiency of the pump.)e experimental data reveal that the HRP characteristics are functions of the waste valve beats per minute and the supply head [5].

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 [6].

Water is one of the factors which is very important and necessary in the life of living creatures. Therefore, water must be available whenever and wherever in the quantity, timing, and sufficient quality. Hydraulic ram pump (Hydram) is a pump which does not require external energy as the power source. The purposes of this research are to understand the influence of input pipe angle on the output generated volumetric rate and efficiency. This research used a hydrant pump with a compressor dimension of 3 inch in diameter and 60 cm in height. The input pipe angles varied were 35°, 40°, 45°, 50° and 55°. The water heights were ranging from 1 to 5 m. The method of analysis was conducted by analyzing the data obtained during the experiments. The results show that the best output volumetric rate is 0.079 l/s with the input pipe angle of 35° and the water height of 3 m. The lowest output volumetric rate of 0.01 l/s is obained from the pump with the input pipe angle of 55° and the water height of 5 m. The best efficiency is 6.10% in at the input pipe angle of 35 ° and water height of 3 m. The lowest efficiency is 1.24% at the input pipe angle of 55° and water height of 5 m [7].

Hydraulic ram pump is an automatic water-pumping equipment generally used to pump drinking and irrigation water in mountainous and rural areas having short of power. In the past, it has been analyzed and optimized by fabricating various prototypes and conducting experiments and comparisons. This process is time and labor consuming and detailed flow features cannot be determined except efficiency, discharge, and period. In this paper, a method for the optimal design and performance analysis of hydraulic ram pump system with numerical simulation and physical experiment is presented to shorten the number of prototypes and develop high-performance product. The proposed evaluation indexes include head loss coefficient, drag coefficient, eccentric distance of pressure, and velocity distribution uniformity. Two types of structures, named front-enlargement and back-enlargement, were initially designed. According to the numerical simulation, the latter one has lower head loss coefficient and drag coefficient, larger eccentric distance of pressure and higher velocity distribution uniformity and was adopted in the novel hydraulic ram pump. Then, the design theory and method on adjustable and high-head experimental platform have been developed, so that the delivery head can be easily controlled and regulated in laboratory. Experiments were carried out for the delivery heads of 2.0 m and 2.7 m and comparisons were conducted with other products. The results show that, when the delivery head is less than 50 m, the efficiency of the new product ranges from 50% to 70% while the delivery flow is the largest. Its application in Liangshui River, Beijing, indicates that the novel hydraulic ram pump is a practical tool in fountain sight and for irrigation purpose without external power input [8].

2. Research Method

This research was conducted from June to December 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. The flow chart of this research as Figure 2.

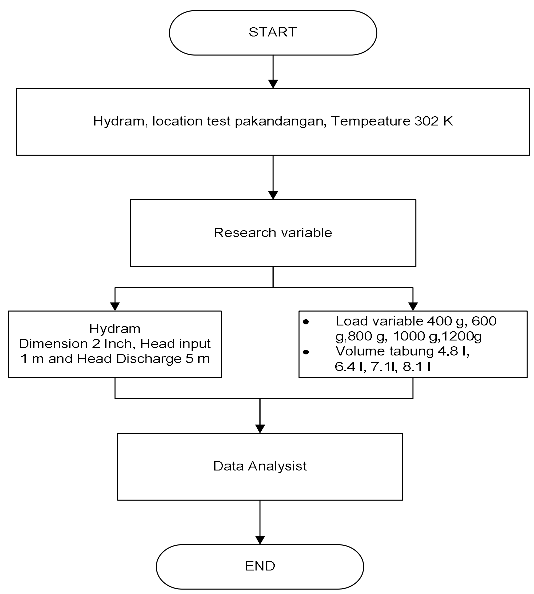

Figure 2. Research's Flowchart

2.1 Tools and Materials

Hydram pump, measuring cup, stopwatch, pipes, and 400 gram, 600 gram, 800 gram, 1000gram and 1200 gram valve load. Pressure chamber sebesar 4,86 liter, 5,67 liter, 6,48 liter, 7,29 liter, dan 8,12 liter.

2.2 Procedure of the Research

The test procedure varied the load of waste valve and the cylinder volume during the operation of the hydram pump (Figure 3) . 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.

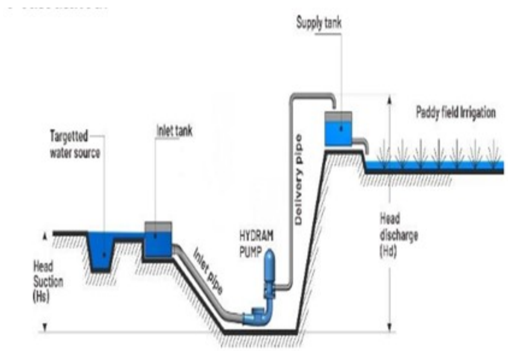

Figure 3. Testing of Procedure

3. Result and Discusion

The obtained data from the results then was presented into the Table 1 untill Table 4 as follows :

Table 1. The linkage of the chamber's volume and waste discharge

volume (lt)	Beban (g) 400	600	800	1000	1200
	Qw (lt/s)	Qw (lt/s)	Qw (lt/s)	Qw (lt/s)	Qw (lt/s)
4,86	1,059	1,09	1,43	1,04	1,783
5,67	0,99	1,296	1,44	1,573	1,733
6,48	1,018	1,376	1,4	1,379	1,766
7,29	0,949	1,175	1,42	1,242	1,88
8,1	1,005	1,262	1,57	1,66	2,15

Seen from the table 1 that the increase of the load and the chamber's volume causes the increase on the waste discharge. The highest discharge occured on the load of 1,200 and the chamber's volume of 8.1 lt.

Table 2. The linkage of the load on the volume of the chamber against the output discharge

volume (lt)	Beban (g) 400	600	800	1000	1200
	Qs (lt/s)	Qs (lt/s)	Qs (lt/s)	Qs (lt/s)	Qs (lt/s)
4,8	0,103	0,104	0,102	0,098	0,1
5,6	0,11	0,116	0,115	0,109	0,11
6,4	0,102	0,113	0,114	0,124	0,114
7,2	0,105	0,12	0,134	0,117	0,12
8,1	0,17	0,12	0,12	0,118	0,124

The Table 2 described that the higher the volume of the chamber and the load, the more increase the output discharge. The data showed that on the load of 800 g, and the volume of 7.2 lt, there is an output discharge on 0.134 lt/d.

Table 3. The linkage of the load on the volume of the chamber against the discharge ratio (Qs/Qw)

volume (lt)	Beban (g) 400	600	800	1000	1200
	ratio debit	ratio debit	ratio debit	ratio debit	ratio debit
4,86	0,097	0,095	0,071	0,094	0,056
5,67	0,111	0,090	0,080	0,069	0,063
6,48	0,100	0,082	0,081	0,090	0,065
7,29	0,111	0,102	0,094	0,094	0,064
8,1	0,169	0,095	0,076	0,071	0,058

The table 3 shows that the higher the volume of the chamber and the load, the bigger the discharge ratio when the the load of the waste valve decreases and the chamber's volume increases.

Table 4. The linkage of efficiency and the changes on the volume of the chamber against the load of the waste valve

volume (lt)	Beban (g) 400	600	800	1000	1200
	efisiensi	efisiensi	efisiensi	efisiensi	efisiensi
4,86	0,44	0,44	0,367	0,44	0,3
5,67	0,49	0,414	0,372	0,326	0,32
6,48	0,46	0,383	0,393	0,412	0,33
7,29	0,5	0,464	0,437	0,435	0,36
8,1	0,53	0,437	0,357	0,332	0,309

The table 4 described that the bigger the volume of the chamber, and the lesser the load, the more increase the efficiency on the volume of 8.1 lt at the load of 400 gram.

CONCLUSION

Pump performance increases with increasing cylinder volume. The increase in the load of the exhaust valve volume of the tube remains a significant decrease. Hydram pump performance occurs at a load of 400 gram with a tube volume of 8.1 l with an efficiency of 53%

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