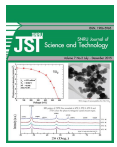
SNRU JST
Sakon Nakhon Rajabhat University
Journal of Science and Technology
Journal home page: snrujst.snru.ac.th



Effects of size of drain valves on flow rate of the hydraulic ram pump using for agriculture

Nuttakit Saenthong*

Department of Mechanical Technology, Faculty of Techonology, Udon Thani Rajabhat University, 64 Thaharn Road, Mueang District, Udon Thani, 41000, Thailand

* **Corresponding Author**: Nutkitt@gmail.com

Received: 24 June 2015; **Revised:** 1 September 2015; **Accepted:** 15 October 2015; **Available online:** 15 December 2015

Paper selected from Sakon Nakhon Rajabhat University - International Conference 2015 (SNRU-IC 2015)

Abstract

The objective of this study was to test the effects of drain valves sizes on the flow rate of the Hydraulic ram pump using for agriculture. This study was conducted using a pipe of 2 m height and size 50 mm diameter of the inlet pipe connected into the Hydraulic ram pump with 12 m of inlet hose and 19 mm of outlet hose. Three sizes of drain valves of 25, 38 and 50 mm connected into the air chamber with 102 mm diameter, and 450 mm height. The results showed that 38 mm of diameter of the drain valve and mass pressure on the valve of 900 g showed the highest flow rate of 25 liters per hour.

Keywords: Drain valves, Hydraulic ram pump, Energy saving pumps

1. Introduction

A hydraulic ram pump is the equipment that is best suited for the development of agriculture because it works automatically without wasting energy by running through the principle of water hammer. About 243 years ago, a British scientist named John Whitehurst (A.D. 1772) observed that quick and sudden changes in pressure of a pipe. The sudden change in the momentum speed of fluid can damage valves and wall pipes. The equipment will be damaged if they are affected more than their material strength to resist. In 1793, Montgolfier and his colleagues developed the use of the automatic valve. Later in 1840, that principle had spread to Europe and America [1]. This principle was useful to the study and design of hydraulic ram pumps used to suit local areas, because there are parts of the mechanism which are not complicated to install. It is easy to fit its application to agriculture in local areas. Shuaibu Ndache Mohammed adopted hat principle and studied the performance of the hydraulic ram pump, using a head of 1.5 m. From that test, the water inlet diameter pipe of 0.025 m showed that the flow rate out of water is 3.83×10^{-5} m^3/s, and had a coefficient of 57.3% [2]. Phyo Min Than had also studied the efficiency of the hydraulic ram pump using an inlet diameter pipe of 1.524 m and 0.0762 m respectively, the air chamber size diam of 0.1524 and 0.4572 in height. As the result, it produced a head of water flow rate higher at 9.144 m. That test found that the pump was produced the flow rate in at 1.24×10^{-3} m^3/s and the flow rate out at 1.05×10^{-5} m^3/s, representing the coefficient of 60% [3]. According to the research it was determined that

the effect of changing the sizes of the different drain valves how to affect the flow rates. This operation was used the obtained information to design and develop the hydraulic ram pump to use in agriculture as shown in fig. 1

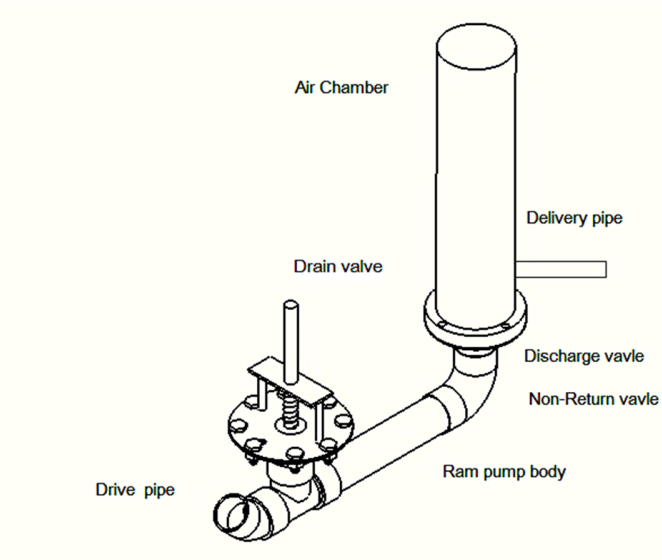


Fig. 1 The body and parts of hydraulic ram pump

2. Materials and Methods

The hydraulic ram pump is designed and constructed using local recycled materials which are easy to find and inexpensive, and with a structure made of galvanized steel pipe. However, the drain valve area uses stainless steel because it is resistant to corrosion when compared with those constructed from steel [4], as shown in Fig. 1. A hydraulic ram pump was designed to be developed and optimized for agricultural activities. The hydraulic ram pump is used to pump water properly. This technology is used to solve problems based on renewable energy [5]. The operation of the hydraulic ram pump uses the principles of fluid movement of a mass of water due to the gravity through the pipe causing water pressure and momentum. In this study, it is necessary to use fluid theory and drain valve pressure to investigate the flow rate using the following related equation [6]

The equation of flow in closed pipes:

Applying Bernoulli's equation for a circular duct with $D_h = D$

$$p_1 - p_2 = \frac{\rho}{2}(V_2^2 - V_1^2) + \rho g(z_2 - z_1) + \frac{fL}{D}\frac{\rho V^2}{2} \quad (1)$$

Where :

$p_1 - p_2$ = Hydraulic pressure drop in pipe [N/m^2]

V = Aaerage velocity [m/s]

f = Friction Factor in Pipe Flow

L = Pipe length [m]

D_h = D = Pipe diameter or hydraulic diameter of conduit [m]

ρ = Density water is 1000 kg/m^3

g = The gravity 9.81 m/s^2

The principle of operation of hydraulic ram pumps that use the principle of the mass of water from the supply tank flowing into inlet of hydraulic ram pump which is at lower level causing a higher pressure. This process of the pressure pump causes water hammer. As the result, the water flows up to a higher level. This amount of water per day for this operation is calculated as follows [7]:

$$D = \frac{Q_2 \times H \times E}{h} \tag{2}$$

Where:

D = Amount delivered in liters per 24 hours. [m^3/s]

Q_2 = Quantity of water supplied in liters per minute. [m^3/s]

H = Fall or height of the source above the ram [m]

E = Efficiency of the ram

h = Lift height of the point of use above the ram [m]

A hydram makes use of sudden stoppage of flow in a pipe to produce a high pressure surge; the volumetric discharge from the drive pipe is given by:

$$Q = VA \tag{3}$$

Where,

A = Area [m^2]

V = Velocity of flow. [m^3/s]

Q = Volumetric flow rate through the pipe. [m^3/s]

The velocity of fluid flow in the driven pipe is given by:

$$V_d = \frac{Q_d}{A_d} \tag{4}$$

Where,

V_d = Velocity of fluid flow [$m^{2/}s$]

Q_d = Delivered volume [m^3/s]

A_d = Area of the driven pipe [m^2]

The efficiency E of the hydram is given by:

$$E = \frac{Q_d \times H_d}{[(Q + Q_w) \times H]} \quad (5)$$

Where,

E = Efficiency of the hydram

Q_d = Pumped flow [m3/s]

Q_w = Wasted flow [m3/s]

H = Pump drive/supply head

H_d = Total head above the waste valve opening

= (H+h) [m]

H = Delivery head [m]

The operation time for the drain valve, i.e. time during which velocity in supply pipe builds is given by;

$$t_1 = L \frac{v_d}{(h - H)g} \quad (6)$$

Where,

H = Supply head [m]

h = Delivery head [m]

L = Drive pipe length [m]

g =The gravity 9.81 m/s^2

Methodology

The test was set of water flowing from a supply tank at a stable 2 m height flowing through a 50 mm diameter pipe into the hydraulic ram pump. The length of supply pipe was 12 m through the drain valve with 25, 38, and 50 mm into the air chamber with a diameter of 102 mm and 450 mm of height. The water flowed out through 20 mm diameter of pipe, and 30 m long up into a reservoir at a constant level of 15 m height and then recorded the data. The test then changed the size and the mass pressure of the drain valve and then observed the results for the record. This test was to study the effects of various sizes of drain valves and the mass pressure of the drain valve and how the flow rate was changed in order to improve the data used to design the

highest flow rate. The test will be conducted over ten times by recording the data each time in one minute. (Fig. 2.The operation of hydraulic ram pump)

The test results and flow rates have been analyzed.

These variations provided different results in:

i. Diameter of the three valves 25, 38, 50 mm

ii.Weight of pressure of waste valves 800, 900, 1100 g

iii. The flow rate available

iv. The quantity of water to be delivered

v. Pressures in the air chamber

vi. Waste valve frequency (strokes per second) [8]

Fig. 2 The operation of hydraulic ram pump

3. Results and Discussion

The study to resize drain valves effecting flow rate of hydraulic ram pump used for agriculture by discharging water into the hydraulic ram pump design at a stable level of 2 m height. The use of the delivery pipe was designed with a diameter of 50 mm and 12 m long connected into the hydraulic ram pump. Three diam of drain valves at 25, 38, 50 mm and the three mass pressures of 800 g, 900 g, 1100 g which pushed the valve, and a delivery pipe with diameter of 20 mm and 15 m height as shown in Fig. 3. The results were as follows:

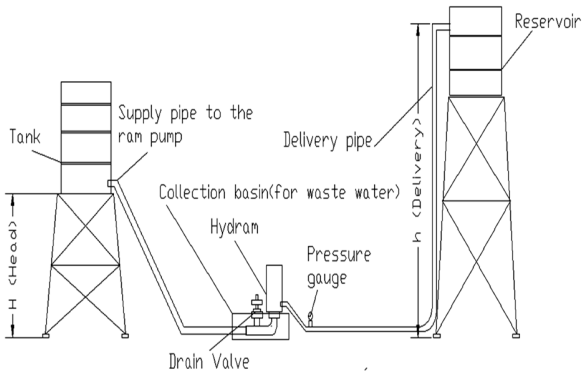


Fig. 3 Installation layout of hydraulic ram pump and equipment

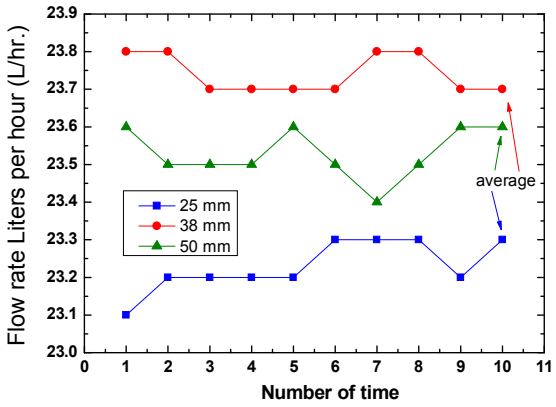


Fig. 4 A graph of test results at 15 m and mass push the valve is 800 g

The results showed the mass pressure of the drain valve, 800 g and diameter of 25 mm, the average flow rate was at 23.23 liters/hour. The diameter of drain valve, 38 mm, and the average flow rate was 23.74 liters/hour. The diameter of drain valve, 50 mm, and the average flow rate was 23.53 liters/hour. As the result, the diameter of drain valve, 38 mm produced the highest flow rate was at 23.74 liters/hour. (Fig.4)

The results showed the mass pressure of the drain valve, 900 g and diameter of 25 mm, the average flow rate was at 24.08 liters/hour. The diameter of drain valve, 38 mm, and the average flow rate was 25 liters/hour. The diameter of drain valve, 50 mm, and the average flow rate was 23.53 liters/hour. As the result, the diameter of drain valve, 38 mm produced the highest flow rate was at 25 liters/hour. (Fig.5)

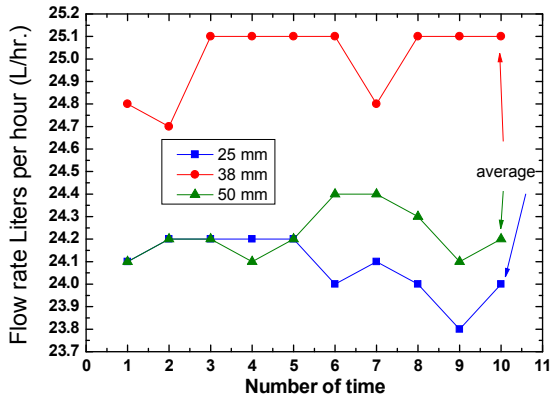


Fig. 5 A graph of test results at 15 m and mass push the valve is 900 g

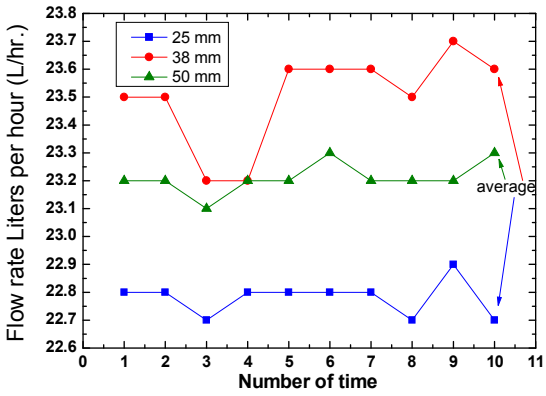


Fig. 6 A graph of test results at 15 m and mass push the valve is 1100 g

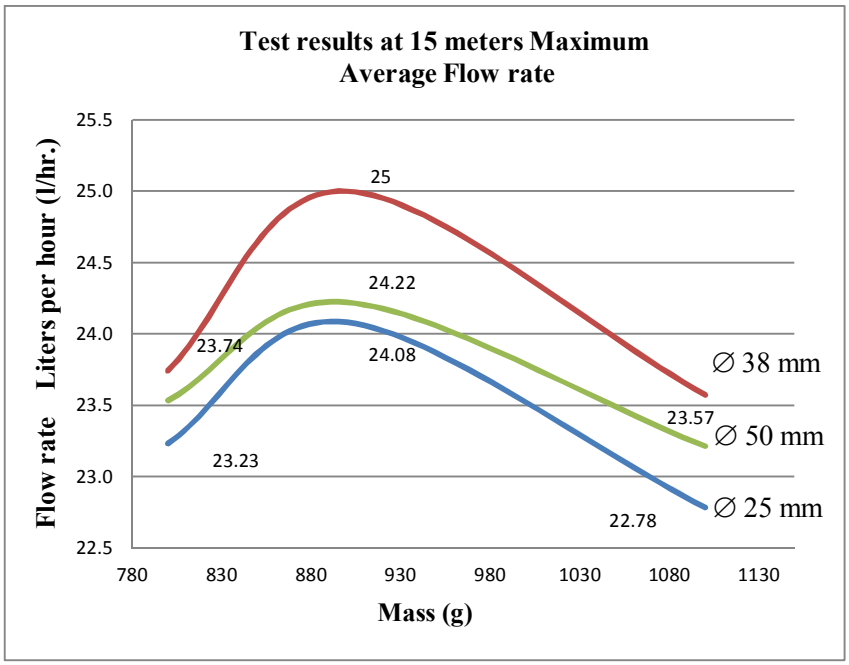


Fig. 7 A graph of Test results at 15 m average Flow rate

The results showed the mass pressure of the drain valve, 1100 g and diameter of 25 mm, the average flow rate was at 22.78 liters/hour. The diameter of drain valve, 38 mm, and the average flow rate was 23.50 liters/hour. The diameter of drain valve, 50 mm, and the average flow rate was 23.21 liters/hour. As the result, the diameter of drain valve, 38 mm produced the highest flow rate was at 23.50 liters/hour. (Fig. 6)

The results showed that 38 mm of diameter of the drain valve and mass pressure on the valve of 900 g produced a maximum flow rate at 25 liters per hour. The study suggests that varying both different diam of the drain valves and the mass pressure which pushed the valves, resulted in the flow rates. Consequently, the hydraulic ram pump optimum design for the highest flow rate should take into account the size of the diameter of the drain valve and mass pressure of valves. (Fig.7)

4. Conclusion

The results of the study the effects of size of drain valves on the flow rate of the Hydraulic ram pump used for agriculture showed that 38 mm of diameter of the drain valve and mass pressure on the valve of 900 g produced a maximum flow rate at 25 liters per hour. It was found that varying both different diam of the drain valves and the mass of the drain valves resulted in changes of the flow rates. The study suggests that varying both different diam of the drain valves and the mass pressure to push the valves resulted in the flow rates.

Consequently, the hydraulic ram pump optimum design for the highest flow rate should take into account the size of the diameter of the drain valve and mass pressure to push valves.

5. References

[1] S.J. William, Introduction to fluid mechanics, 3rd Ed., PWS Publishing Company, Redwood, 1993.

[2] N.M. Shuaibu, Design and Construction of a Hydraulic Ram Pump, Leonardo El J Pract Technol. 6(11) (2007) 59-70.

[3] M.T. Phyo, Construction and Performance Testing of the Hydraulic Ram Pump, GMSARN International Conference on Sustainable Development, (2008) 12-14.

[4] Hydraulic Ram Pump, http://en.wikipedia.org/wiki/Hydraulic_ram, 28 November 2013

[5] H.W. Iversen, Analysis of the Hydraulic Ram, J FLUID ENG-T ASME. (1975) 191–196.

[6] S.J. William, Introduction to fluid mechanics, 3rd Ed., PWS Publishing Company, Redwood, 1993.

[7] W.F. Robert, T.Mc. Donald, Introduction to Fluid Mechanics, 3rd Ed., the United Educational, Scientific and Cultural organization, Mexico, 1996.

[8] R.N. Mbiu, S.M. Marangga, M. Mwai, Proceedings of the Sustainable Research and Innovation (SRI) Conference 6-8 May 2015 (2015) 134-137.