International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Analysis Effect of Supply Head and Delivery Pipe Length toward the Efficiency Hydraulic Ram 3 Inches

Muhamad Jafri[1], Arifin Sanusi[2]
[1, 2]Department Mechanical Engineering, Nusa Cendana University, Kupang, NTT, Indonesia-85000

Abstract— *Efficiency of hydraulic ram is affected by the delivery flow rate, waste flow rate, supply flow rate, supply head effective, delivery head effective. The supply head is a parameter in the head suction analysis and delivery pipe length is a parameter in discharge head analysis. The purpose of this study was to analyze of the effect of supply head and delivery pipe length toward the efficiency hydraulic ram 3 inches. The experimental method used is descriptive analysis using mathematical equations. The results showed the efficiency of hydraulic ram 3 inches influenced by the height of the water level of the water source and the diameter of the discharge pipe length. The highest D'Aubuisson efficiency at 48.47% was found at the height of the water level of 1.9 m and a length of the discharge pipe 12 meters. For the Rankine efficiency is obtained at the height of the water level of 1.9 meters and a length of pipe between 12 meters at 40.62%. While D'Aubuisson lowest efficiency is obtained at the height of the water level of 1.3 m and a length of the introductory pipe 10 meters at 17.19%. For Rankine efficiency, low efficiency in water level height of 1.3 meters and a length of pipe 10 meters at 14.48%*

Keywords— *Hydraulic ram; the height of water levels; the discharge pipe length, the efficiency of the pump.*

I. INTRODUCTION

The method to lift water on to an area which has high elevation is to use a pump. The electric pump usually uses to solve this problem. But many areas in Indonesia, especially in the remote area, do not have electrical access to operating the pump [1]. Many developing countries are faced with this problem. Recently, the interest toward this device is renewed due to its practical installation in remote areas of developing regions, e.g. Tanzania, Kenya and Zambia [2]. To solve this matter, we can use a hydraulic ram pump because this technology is appropriate in a developing country. The use of these pumps, it is hoped that it can solve the problems of lack of adequate water for drinking, agriculture and animal husbandry, etc. and therefore be useful in preventing rural to urban migration [3]. A hydraulic ram functions by a water hammer caused by closing a valve that interrupts the water flow from a supply to a higher hydraulic head [4], with the lifting of water through no outside power source. According to [5], the hydraulic ram does not need any external power source; maintenance and function are simple, without any need of specialized manpower; costs and deployment are low, and it may be run 24 h a day. The hydraulic ram is used in low-head hydropower and highly suitable on small farms.

The simplicity of its structure and the negligible operating costs are the two main reasons why the HRP is currently very interesting, although it was invented more than 200 years ago [6]. The hydraulic ram pump is widely used in farms, for water pumping, especially where there is plenty of water and no energy or powering conventional pumps [7]. Since 1980's research contributions have been proposed to optimizing its efficiency through a number of modifications [8]. This device could then be exploited for the supply of fresh water in some areas of the world allowing the use of land for food. In this context, an important factor demanding focus and improvement is the operating efficiency of the hydraulic ram, see e.g., [9] about recent investigations on hydraulic ram parameter optimization.

The stroke of wastewater valve and a load of wastewater valve can influence the efficiency of hydraulic ram pump. In many cases operation of hydraulic ram pump is found the stroke of wastewater valve does not open properly. It caused by the stroke of the wastewater valve to short or long, the diameter and a load of wastewater valve does not fit to the design. Besides that, in the mechanism of hydraulic ram pump, there is an energy conversion from kinetic energy to a dynamic pressure inside the air chamber. The function of a chamber is to increase the pressure so the water can lift inside the discharge pipe to the top.

II. THEORY AND FORMULA

A hydraulic ram or hydram is a pump that utilizes momentum energy from a constantly falling quantity of water to pump some of it to an elevation much higher than the original level at the source. No other external energy is required as long as there is a constant supply of water, the pump will remain to work continuously and automatically [10]. Components of hydraulic ram pump are water supply tank, drive pipe, pump body, waste valve, delivery valve, snifter valve, air chamber, and delivery pipe (Figure 1).

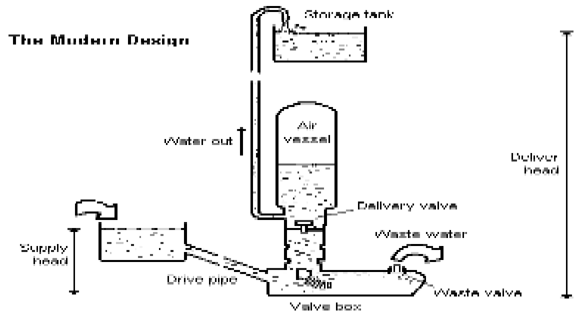

Fig. 1. Diagram of the modern pump [11]

The working principle of the hydraulic ram pump is starting from the flows water from the supply reservoir down the drive pipe into the valve box. Initially, the waste valve is

Muhamad Jafri and Arifin Sanusi "Analysis effect of supply head and delivery pipe length toward the efficiency hydraulic ram 3 inches" *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 2, pp. 263-266, 2019.

open and allows water to flow through it and back into the stream. As the water flow increases, it causes the waste valve to quickly close. The closing of the waste valve creates high pressure within the pump, also known as water hammer. This redirects the water past the delivery valve and out the supply line to the storage tank or trough. The water flow within the valve box rapidly slows, opening the waste valve and starting the cycle again. Figure 1 illustrates, schematically, typical configuration a hydraulic ram pump, highlighting its essential parts, [12].

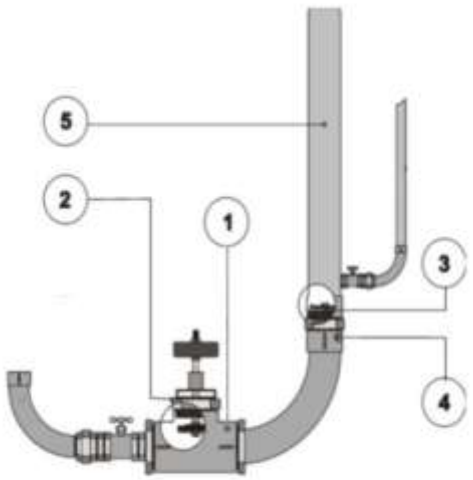

Fig. 2. The main component of the ram hydraulic pump, 1) Valve box (2) Waste valve (3) Delivery valve (4) Air valve, (5) Air vessel

Were designed and researched the effect of variations in the air tube and intake pipe length on the performance of hydraulic ram. Variation of the height of the air tube is 40 cm and 60 cm for diameter 6.35 cm. Length variation of intakes pipe are 8 m, 10 m, and 12 m. Height of the supply channel is 2.3 m and the height of the pressure line is 8 m. Results of the analysis were showed that the maximum capacity of the pump is 0.0000346666 m3 / s and a hydraulic ram efficiency is 29.55% at a height of 60 cm and a length of tube inlet pipe 10 m [13]

III. EXPERIMENTAL SETUP

A. Design of Experiment

The purpose of this study was to analyze of the effect of supply head and delivery pipe length toward the efficiency hydraulic ram 3 inches. The experimental method used is descriptive analysis using mathematical equations. Testing installation is the total head above the waste valve opening 6 meters, delivery pipe diameter 1 inch, valve stroke 1,5 cm, valve weight 1,5 kg and size of the air chamber 6500 ml. The independent variable in this study is the supply head (1.3 m, 1.5 m, 1.7 m and 1.9 m) and delivery pipe length (6 m, 8 m, 10 m, 10 m). The data measured is derived flow rate, the waste flow rate, and delivery flow rate. The data were analyzed using the measurement results of descriptive analysis of the flow velocity, head loss, and pump efficiency.

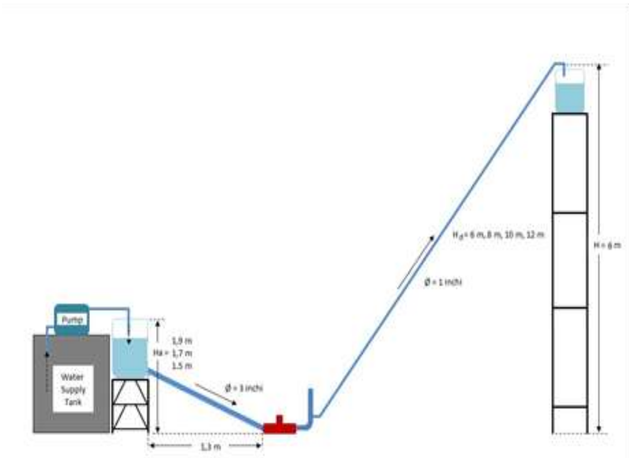

Fig. 3. Installation hydraulic ram pump

The water in the tub poured into the first container bath water sources using a centrifugal pump to keep the height of the water level is always stable and that the debit entry equal to the discharge exit. Then the water is supplied to the hydraulic ram and the water in the container compression towards the end.

B. Experimental Procedure

1. Installation hydraulic ram 3 inches starting from the installation of the reservoir, pump filler reservoir steering, reservoir steering, suction pipe, measuring tools debit inflows, hydraulic ram 3 inches, bathtub waste, measuring instruments flow valves sewage, plumbing introductory 1-inch, tool measuring flow out.
2. The first test starts from the delivery pipe length of 12 meters and the supply head of 1.9 meters of water resources.
3. The pump is run by opening the stop valve on the suction pipe and simultaneously turned the steering pump reservoir to maintain the water level in the reservoir steering.
4. When the pump has been running normally the data flow rates in the derive flow rate (Q_{in}), waste flow rate (Q_w), and delivery flow rate (Q_{out}), in the range 30 seconds are recorded simultaneously.
5. Data recorded in the table, and after the pump is turned off by closing the stop tap on the suction pipe.
6. Step on C to E carried back to a height of the water source 1, 7, 1.3, and 1.5 meters.
7. Step on B through F performed again for the length of pipe to press 6, 8 and 10 meters.

Data results derive flow rate (Q_{in}), waste flow rate (Q_w), delivery flow rate (Q_{out}) dan free variable data used to analyze, head loss of major and minor head loss. The equation used to analyze the major head loss [14];

$$h_f = f.\frac{L}{D}.\frac{v^2}{2g} \Rightarrow f = 0{,}020 + \frac{0{,}0005}{D} \quad (1)$$

Minor losses are energy losses due to changes in the channel cross-section, connections, bends, valves, and other accessories. The equation is often used [15].

$$h_m = k\frac{v^2}{2g} \quad (2)$$

Further analysis of the efficiency of the pump. The data used in the analysis of the efficiency of the pump are derived flow rate Q_{in}, waste flow rate Q_w, delivery flow rate Q_{out} and head of analysis result in data loss. The equation used is equation D'Aubuisson [16]

$$\eta_D = \frac{(Q_{Out} \times h_d)}{(Q_{Out} + Q_w)H\ ef,in} \times 100\ \% \quad (3)$$

and

$$\eta_R = \frac{Q_{in}(h_d - h_s)}{(Q_w)h_s} \times 100\ \% \quad (4)$$

IV. Result Discussions

The data of the average waste flow rate (Q_w), the average delivery flow rate (Q_{out}), and the average derive flow rate (Qin), as shown in fig.4 and fig 5.

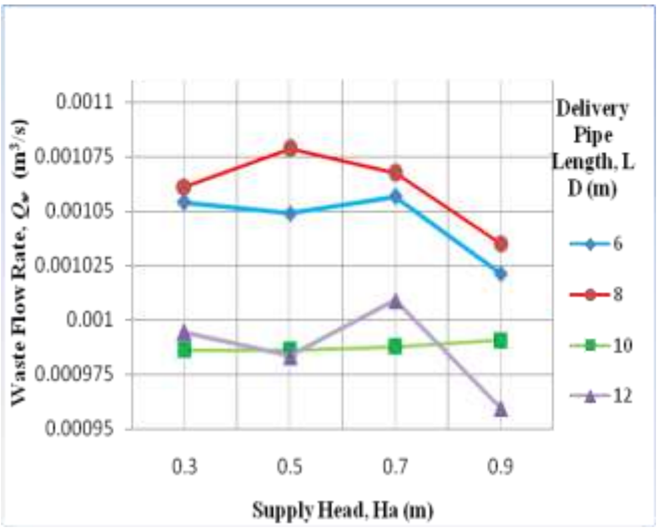

Fig. 4. Relationship between supply head and waste flow rate for each delivery pipe length variation

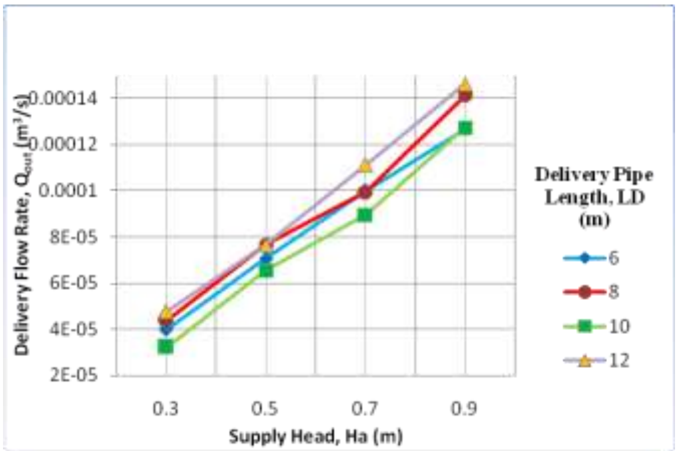

Fig. 5. Relationship between supply head and delivery flow rate for each delivery pipe length variation.

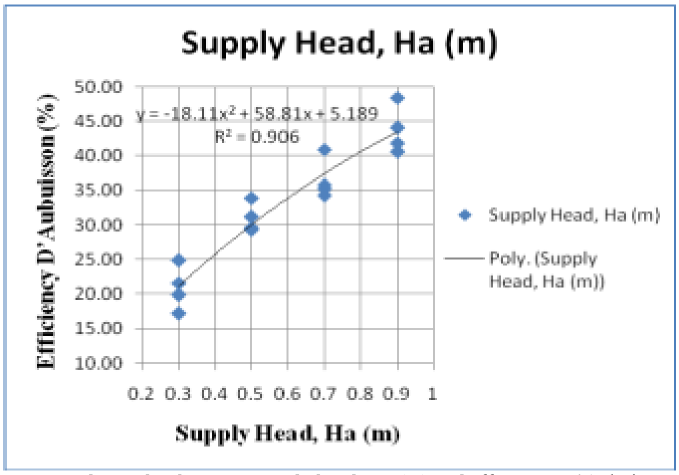

Fig. 6. Relationship between supply head, Ha (m) and efficiency D'Aubuisson for each delivery pipe length

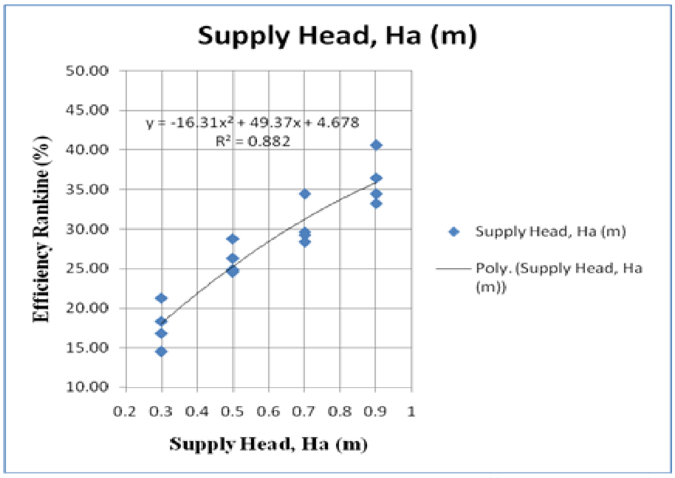

Fig. 7. Relationship between supply head, Ha (m) and efficiency Rankine for each delivery pipe length

Figure 6 and 7 shows that the length of the output channel and height of water source resources are affected to the D'Aubuisson efficiency and Rankine efficiency at 3-inch hydraulic ram. The longer the channel of outlet, the higher the efficiency of a hydraulic ram. These results were presented in the graph in Fig. 5, where the more the length of the outlet, the higher the flow rate of the outlet. The flow rate when time constant is proportional to the channel volume. The volume of the channel is found from wide of channel multiplied by the length of the channel. In this research, the extensive fixed line that is 1 inch, while the length of the channel is changing. So that every addition of exit channel length, the higher the flow rate. Similarly to the exit channel length, the higher the source of water, the higher the efficiency hydraulic ram. This is happening because the water level is directly proportional to the potential energy generated by the source of water. The greater the potential energy, the higher the efficiency produced

The D'Aubuisson highest efficiency is obtained at the height of the water level of 1.9 m and a length of 12 meters conducting pipe that is 48.47%. Rankine's highest efficiency is obtained at the height water level of 1.9 meters and a length of pipe 12 meters at 40.62%. While D'Aubuisson lowest efficiency is obtained in the high water level of 1.3 m and a length of 10 meters of pipe introduction of 17.19%. For Rankine efficiency, the lowest efficiency is obtained in the height water level of 1.3 meters and a length of pipe 10 meters by 14.48%.

Based on Fig. 6 (efficiency D'Aubuisson), the highest of the water level pump affecting efficiency. The coefficient of determination (R2) = 0.906, this means that the average value of 90.6% efficiency hydraulic ram is determined by the height of the water level, through the regression equation Y = -18.11x2 + 58.81x + 5.189. While 9.4% is determined by other factors.

While in Fig. 7 (efficiency Rankine), the highest factor affecting the efficiency the height of water level pump. The coefficient of determination (R2) = 0.882, this means an average value of 88.2% efficiency hydraulic ram is determined by the height of the water level, through the regression equation Y = -16.31x2 + 49.37x + 4.678. The remaining 11.8% is determined by other factors

V. Conclusion

The experimental results and data analysis concluded that: length of output channel and height of water source resources are affected to the D'Aubuisson efficiency and Rankine efficiency at 3-inch hydraulic ram. The D'Aubuisson highest efficiency is obtained at the height of the water level of 1.9 m and a length of 12 meters conducting pipe that is 48.47%. Rankine's highest efficiency is obtained at the height water level of 1.9 meters and a length of pipe 12 meters at 40.62%. While D'Aubuisson lowest efficiency is obtained in the high water level of 1.3 m and a length of 10 meters of pipe introduction of 17.19%. For Rankine efficiency, the lowest efficiency is obtained in the height water level of 1.3 meters and a length of pipe 10 meters by 14.48%.

Acknowledgment

The authors gratefully acknowledge the support of the Ministry of Research, Technology and Higher Education of Indonesia as a Grant of Research 2018.

References

[1] Muhamad Jafri, Gusnawati, Apriyanto Banamtuan, Analisa Beda Tinggi Katup dan Variasi Diameter Pipa Inlet Terhadap Unjuk Kerja Pompa Hidram Ukuran Dua Inchi, *LJTMU*, vol. 03, no. 01, hal. 71-76, 2016.

[2] Manuscript Report IDRC-MR102eR, Proceedings of a Workshop on Hydraulic Ram Pump (Hydram) Technology, Arusha, Tanzania, 29 May–1 June 1984. Available online: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/6625/IDL-6625.

[3] Fatahi-Alkouhi R, Lashkar-Ara B, Keramat A., Determine the efficiency of hydraulic ram-pumps. E-proceedings of the 36th IAHR World Congress 28 June – 3 July 2015, The Hague, the Netherlands pp. 1-7, 2015.

[4] Abate C, Botrel TA., Carneiro hidráulico com tubulação de alimentação em aço galvanizado e em PVC. Sci. Agríc. Piracicaba 59(1):197-203, 2002.

[5] Horne B, Newman C., Hydraulic ram. The centre for alternative technology,2005 http://store.cat.org.uk/product_info.php?products_id=855

[6] Veljko Filipan, Zdravko Virag, Anton Bergant, Mathematical Modelling of a Hydraulic Ram Pump System, *Journal of Mechanical Engineering*, 49(2003)3,137-149 ISSN 0039-2480, Slovennia, (2003)

[7] Mario O. M. de Carvalho, Alberto C. G. C. Diniz, Fernando J. R. Neves, Resonant Behavior of a Hydraulic Ram Pump, *International Review of Mechanical Engineering (I.RE.M.E.)*, Vol. xx, n. X, 2009.

[8] Starmer, C. Blake's Hydram or the rise and fall of the hydraulic ram. Chart. Mech. Eng., 28, 19–21, 1981.

[9] Sarma, D.; Das, M.; Brahma, B. Investigation and Parameter Optimization of a Hydraulic Ram Pump Using Taguchi Method. *J. Inst. Eng. Ser.* C, 97, 551–559, 2016. doi:10.1007/s40032-016-0295-0.

[10] M N Harith, R A Bakar, D Ramasamy, Ma Quanjin. A significant effect on flow analysis & simulation study of improve design hydraulic pump, *4th International Conference on Mechanical Engineering Research*, 2017 doi: 10.1088/1757-899X/257/1/012076.

[11] Rohan.D.Balgude,"Designing of Hydraulic Ram Pump, *International Journal Of Engineering And Computer Science* ISSN:2319-7242 Volume 4 Issue 5 May,2015, Page No. 11966-11971.

[12] Hanafie, J,. de Longh, H., Teknologi Pompa Hidraolik Ram Buku Petunjuk Untuk Pembuatan dan Pemasangan. PTP-ITB Ganesha, Bandung, 1979.

[13] Panjaitan, D.O. and Sitepu, T., Rancang Bangun Pompa Hidram dan Pengujian Pengaruh Var iasi Tinggi Tabung Udara dan Panjang Pipa Pemasukan Terhadap Unjuk Kerja Pompa Hidram. e- Dinamis, 2012.

[14] Munson, B.R,. Young, D.F,. Okiishi, T.H., Mekanika Fluida. Erlangga, Jakarta, 2005.

[15] Sularso,. Tahara, H,. Pompa Dan Kompresor Pemilihan, Pemakaian dan Pemeliharaan. Pradya Paramita, Jakarta, 2004.

[16] A. M. Michael,. S. D. Kheper, Water Well Pump Engineering, McGraw Hill Publishing Compact Limited, New Delhi,1997.