IFERP

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 6, June 2017

# Design of Hydraulic Ram Pumps for Irrigation

[1]Etkaf Hasan Khan
[1]Department of Mechanical Engineering, Galgotias University, Yamuna Expressway Greater Noida, Uttar Pradesh
[1]etkaf.hasankhan@galgotiasuniversity.edu.in

**Abstract: The hydraulic train is one of the oldest mechanical equipment for lifting water designed two and a halve centuries ago. The first implementation used the water supply principle of a brasserie. A valve had to be closed manually in this system. Upgrades have very soon been modified to automatically run the system. The ram was also improved with technological advances, but electric and fuel pumps were superseded. Today, the ram is a reliable, low-care, durable alternative to motor-driven pumps. The hydraulic ram is able to pump up approximately 10 percent of the fiber energy from a driver pipe to a higher altitude. No external input of energy is needed. Since numerous studies were conducted to build hydraulic railways with autonomous valves and high water supply systems, the aim of this research was to build a reliable, low cost ram made of off - the-shelf parts available locally. Various valves on the driver pipe were tested in the laboratory at different elevations of the water column. To assess the efficiency of the ram, pumping pressure and water flow was recorded in the supply pipe. An off-stage clapper valve has been shown to be reliable and over 30 percent effective. For six weeks, the hydraulic ram worked freely and entirely independently of maintenance, which supplied the field enough water during this period with pumping efficiency of 44%.**

**Keywords: Gravity pump, Hydraulic ram, Hydram, Water lifting.**

## INTRODUCTION

Although oil prices have recently decreased, energy costs are expected to increase in future. For pumping water into their fields, many farmers rely on fuel or electricity. The use of self-alimenting water lifting equipment could provide an escape from this dependency. Such an instrument is the hydraulic ram, which is also known as the hydraulic. For the transport of part of that water to a higher altitude than origin, the hydraulic energy uses falling water. Therefore the water hammer effect is used by the hydraulic ram. The hammer is a pressure surge caused by the inertia of the pipeline. Water can be viewed as a pillar inside the pipes. If the water inside a pipe will flow out of a suddenly closed outlet, the column can not immediately stop its movement. It continues to flow to the vent, where pressure increases. This pressure is then mirrored in the closed outlet and passes backwards on the tube as the pressure wave, so that it can cause serious damage, unless neutralized [1][2].

This effect is deliberately provoked in the hydraulic ram and used by the pressure wave to force water up. The ram includes a pulse valve which provokes the water hammer and a supply valve to pass the pressure wave and prevent pumped water from running back. The figure shows a typical hydram setup and its configuration in the field as in figure 1. The drive pipe feeds the water into the engine. To allow water to accelerate by gravity a certain fall has to take place. The pulse truck, which is her centerpiece, flows through the ram. The pulse valve is driven by the flowing water as the speed increases. A hammer may occur as the impulse valve closes. When pressure in the ram exceeds the pressure in the supply line, the supply valve opens and the pressure released to the supply line. The transmission valve shuts when the pressure reduces. Because of the low ram pressure and its own weight or spring, the impulsion valve will open, and the water will flow again, so a new cycle will begin.

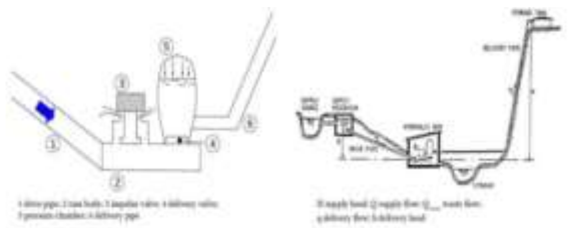

**Figure 1. Typical Construction of a hydram (left, according to Abate and Botrel 2002) and its set-up in the field (right, according to tacke 1988)**

A buffer, absorbing the water hammer and converting the intermittent pump into a very steady flow, is the air-full pressure chamber. Whitehurst, which had to be manually powered, installed the first hydraulic ram. Montgolfier invented the first construction in 1797 automatically. The hydraulic ram's pumping capacity depends on the size and therefore on water supply and height of supply. Normally, some 10% of the conducting water is pumped upwards, which decreases with increased delivery. The method is not sufficient in situations in which water is scarce, as the majority of water is not drained (and so to speak is waste). The objective of this study was to build a low-cost reliable ram made of off-shelf parts available locally [3]. Construction, and assembly and removal should not affect the durability of the structure as much as possible. Different valves were tested using the resulting hydram prototype for suitability to use on a test stand on a ram and one ram for reliability and durability was installed.

## MATERIALS AND METHODS

**Layout of the ram:**

The ram design was in large part specifications. The pressure chamber did not consist of a PET bottle but of a PVC tube piece with an ending cap deviating from these. In addition to the "do - it-yourself" solutions, valves available commercially have been used [4], [5]. The layout of the construction is shown in figure. 2. The design was carried out in a nominal one-inch pipe size (NPS), the inner diameter of the drive pipe being 30 mm. The brazen valve is positioned in the opposite direction as an impulse valve, so that the palpation first opens because of its own weight and is forced to close by the flow of the water.

**Figure 2. Layout of the described low-cost hydraulic ram to be tested at a test stand and installed remote mountainous areas ( in parts and assembled)**

Threads were sealed by Teflon tape, PVC parts were grounded with solvent welding cement. Hose was fixed with customary hose clamps.

**Test stand at university:**

For trials of the performance of the constructed hydraulic ram a test stand was established at the campus of Chiang Mai University (Fig. 3). A concrete water tank acted as the water source, height of the water column inside it simulated the supply head. Drive pipe was attached about 10cm above the bottom of the tank, so water was accelerated by pressure rather than dropping. This model that has been used successfully in other investigations has not influenced the efficiency of the ram[6]. The driven rope was long straight and went horizontally along the ground, leading to the ram of 5.3 meters (length total was 6.5 meters). At the exit from the tank, a water meter for monitoring the supply flow was built into the drive shaft. On concrete blocks the ram itself and pipe have been installed. A storage vessel adjusted to various heights simulated the supply end. In this vessel a tube was installed as an automatic siphon, emptying the vessel when it was complete. It was six liters, its average head was 2.3 m and its maximum head was 5.65 m. The amount was recovered [3], [7]–[9].

**Different pressure chamber sizes:**

Three different pressure chambers have been proven at the test stand: a small chamber, with 0.6 liters, (made of 250 mm 2" tubing, analog end coat, and a reducer fitting). On the test stand various tests were performed:

At medium size one (450 mm pipe, analog end cap plus reduction fitting), volume is 2.3 liters. Big pressure chamber with a capacity of 3.6 liters (made from 3 "pipe and end cap of 700 mm and fitted with reduction).

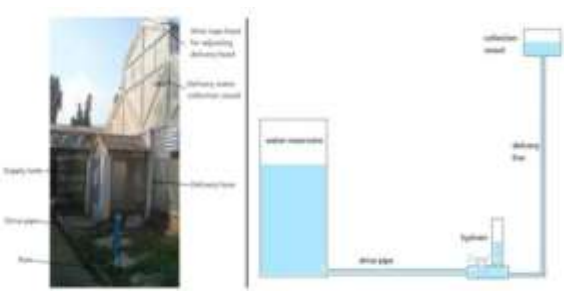

**Figure 3. Photography (left) and schematic layout of a test stand used to evaluate different valve types for usage as impulse valve in the construction of a hydraulic ram**

The Various valve styles are known as an impulse valve: There are a great many different types of valves which are to be used as an impulse valve. However, only two types have been tested: an off-shelf clap valve and three distinct inlet valve manifestations. The clap valve was made of 1" brass, and had to be rotated and positioned vertically to use the impulse mechanism, so that the clap could be opened by gravity. It has also been designed as a supply valve [10]. The inlet valves had to be modified for use as an impulse valve to cause the valve to be opened through the spring (the spring is usually supposed to close the valve until water is swallowed up). The spring must therefore be put in a different position. In the figure you can see the various valves and a schematic view in figure 4.


**Figure 4. Different valves tested as impulse valve in the construction of a hydraulic ram, schematic view and disassembled manipulated inlet valve**

A brazen inlet valve in 1" (brass 1) was checked in one valve. There is a screw to be connected to the spring. Two PVC inlet valves were tested, one of which was smaller and the other of which was larger in 1⁄2" (PVC 1⁄2') and the other in 3/2.' Various configurations of the valve in different positions as shown in figure, an impulse valve can be mounted 5. For valve configuration I, the supply flow to leave the impulse valve is redirected upwards. It must also be pushed up in the valve arrangement IIv, but the pipe is driven and not rebound on a barrier. The valves powered by spring can also be positioned horizontally (IIh), so that there are no redirectional water flows and they can pass directly through the valve in line.

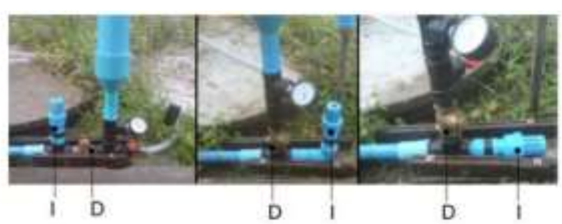


**Figure 5. Different valve arrangement in the construction of a hydraulic ram (from left to right:I , IIv , IIh; eith l impulse valve; D delivery valve)**

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 6, June 2017

The efficiency of the ram is calculated by the following formula in order to determine its efficiency:

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

µ is nothing more than the ratio of the potential energy of the pumped water to the potential energy of the supplied source water.

**Installation of the ram in the field:**

A laboratory was placed on the foothill in a valley, supplied by a small stream coming from just above the hill, to assess the output of a ram in the field. The built-in ram, described earlier, was used as both impulse and delivery valves for medium pressure chamber and brazen palp control valves. A concrete block was mounted on the ram. Two cement blocks, located two meters and five feet in front of the ram were also attached to the pipe. The drive pipe was quite long (80 m), performed in 1 the entrance was mounted with a little mesh pulled over directly into the streamlet to avoid large objects. Head of supply was 3.5 m, head of supply 9 m above the ram. The supply and delivery flow was calculated by water collection and the time necessary for a ship to be filled. Water was collected in a vessel for the irrigation of a small test plot. An incorporated bell siphon enabled irrigation, emptying the vessel at once when the vessel was full.

## RESULTS AND DISCUSSION

With a total cost of less than 700 THB (approximately 20 US$) for the ram itself, the specified ram was easy to assemble, when made of PVC only.

- Different pressure chambers

A brazing clap test valve as an impulse valve and a 2.35 m and 5.65 m distribution head have been carried out for measurements. When performed using the wide (3.6L) and small (2.3L) pressurized chamber (33.1% and 32.6% respectively), there was no significant difference in ram output. The ram could not pump water to the specified height with the smallest pressure chamber attached, so strokes produced further shocks, as the pressure chamber was filled with water, so that the air was not buffered. The volume of the pressure chamber was therefore found from a certain size to be not necessary for the function of the ram and this aspect was not studied further. The median pressure chamber provided a means for the replenishment of the snifter valve, which several authors recommended, when using a small pressure chamber, for the replacement of dissipated air.

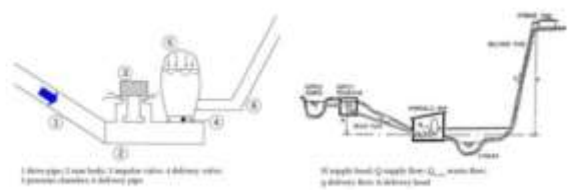

**Figure 6 Result of the ram tested at the test stand with different valves (means and standard deviation); A, B, C, D valves; l, llv, llh valve arrangement,vertical/horizontal**

- Different valve types and valve arrangements

The various valves were tested in various arrangements that greatly affected rams ' behavior (Fig. 6). Because no different springs were available suitable for the various valves, each valve had a different spring and only with this one was tested. During the experiments, it became clear that the valves triggered by the spring behaved erratically. The brazen inlet valve, in particular, was not working very well and not reliable. Adapted springs should therefore be used for an acceptable performance, the spring voltage adjusted and the reliability probably improved. Thanks to too strong a spring, the 3⁄4 "PVC entry valve operated only a little less erratic. The 11⁄2 "PVC inlet valve produced the best performance. This one had a relatively soft spring and therefore the driving water was securely closed. But water hammer has caused the valve to be visibly shocked and is not expected to last for very long as it is made from plastics.

The brazen clap valve as the pulse valve, which worked even more reliably, was surprisingly able to achieve an efficiency ram similar to the Th 1 1⁄2" PVC valve. Furthermore, it is not surprising that the output will be increased by improvement in the valve arrangement I-II. It was predicted that the gap would be even greater. All systems have their advantages and their adverse effects: The moving water flows through at the end of the tube under Valve Arrangement II and the flow of the tube is not interrupted except for the outlet. When the valve is horizontally orientated, water even drains in its flow direction straight, further decreases friction losses and increases ram efficiency. Besides this, the flow path of water in the valve system is changed to flux the pulse valve and cushion the surge. The downside is that the water hammer can be activated directly by the distribution mechanism, the flow of the water supply must not be diverted. It is presumed that the two effects neutralize one another more or less, so that variations between the two settings appear negligible. Spring stress affects the valve closing actions and tends to influence ram output to the greatest extent. The spring tension has to be adapted to real conditions in order to ensure effective ram operation. The clap valve again didn't have to be adjusted and works most confidentially. This valve can also just be purchased off - the-shelf and must not be manipulated as a possible source of intake valves misadjustment. Therefore it is recommended to use the clap control valve.

**Results of the ram in the field:**

The hydraulic ram in the stream worked very well. The first six and then eight weeks of continuous operation were due to a heavy rain failure, moving the driving tube not well fixed over its total length. Because no professional strainer has been used, much of the waste has been found in the water pumped. However, that wasn't the ram itself. The wastewater flow (= supply flow–distribution flow) was about 1.3 liters per minute at 6.25 liters per minute. This results in an efficiency of approximately 44% with a supply and delivery head of 3.5 and 9 m.

## CONCLUSION

The described hydraulic ram construction was relatively inexpensive and simple to assemble. PVC components and clap valves in Thailand are readily available. The ram has proved extremely reliable work behavior with the brazen clap control valves. It can be mounted at appropriate sites to improve crop protection or even make it possible to crop at remote sites. As people are acquainted with the equipment and become familiar with the set-up, deployment and maintenance should not be very difficult. Therefore the hydraulic ram is a good alternative with a lower initial financial effort to conventional pumping devices.

## REFERENCE

[1] R. S. Devendran and A. Vacca, "Optimal design of gear pumps for exhaust gas aftertreatment applications," *Simul. Model. Pract. Theory*, 2013, doi: 10.1016/j.simpat.2013.06.006.

[2] M. A. Jiménez-Bello, F. Martínez Alzamora, V. Bou Soler, and H. J. B. Ayala, "Methodology for grouping intakes of pressurised irrigation networks into sectors to minimise energy consumption," *Biosyst. Eng.*, 2010, doi: 10.1016/j.biosystemseng.2009.12.014.

[3] M. Inthachot, S. Saehaeng, J. F. J. Max, J. Müller, and W. Spreer, "Hydraulic Ram Pumps for Irrigation in Northern Thailand," *Agric. Agric. Sci. Procedia*, 2015, doi: 10.1016/j.aaspro.2015.08.015.

[4] H. Kumar *et al.*, "Pollution Free Design and Manufacturing of Hydraulic Ram Pump for Villages in Hill Areas," *Int. J. Mech. Eng. Res. Tech*, 2016.

[5] W. B. Smith and C. E. Service, "Home-Made Hydraulic Ram Pump for Livestock Water," *Agric. Eng. Coop. Ext. Serv.*, 2017.

[6] R. S. Devendran and A. Vacca, "A novel

design concept for variable delivery flow external gear pumps and motors," *Int. J. Fluid Power*, 2014, doi: 10.1080/14399776.2014.977699.

[7] M. Moshelion, O. Halperin, R. Wallach, R. Oren, and D. A. Way, "Role of aquaporins in determining transpiration and photosynthesis in water-stressed plants: Crop water-use efficiency, growth and yield," *Plant, Cell and Environment*. 2015, doi: 10.1111/pce.12410.

[8] K. Osakada, K. Mori, T. Altan, and P. Groche, "Mechanical servo press technology for metal forming," *CIRP Ann. - Manuf. Technol.*, 2011, doi: 10.1016/j.cirp.2011.05.007.

[9] A. Mills, "The hydraulic ram (or impulse) pump," *Phys. Educ.*, 2014, doi: 10.1088/0031-9120/49/2/211.

[10] A. Pathak, A. Deo, S. Khune, S. Mehroliya, and M. Pawar, "Design of Hydraulic Ram Pump," *Int. J. Innov. Res. Sci. Technol.*, 2016.