# Design and Fabrication of A Hydraulic Ram Pump

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*Abstract :-* **The idea of the project is to build a pump called Hydraulic Ram Pump [HRP] that delivers water to higher altitudes with the use of its Kinetic Energy [KE] at inlet and then converting it to pressure energy [PE]. Unlike other pumps, this pump is based on utilization of KE of water at inlet rather than simply being operated by an electrical supply. Through the implementation of this project one could now easily pump to high terrains without of use of any external supply. The pump makes use of simple piping equipments and is adaptable to work in various areas.**

***Keywords : HRP, KE, PE.***

## I. INTRODUCTION

A hydraulic ram pump is a pump that makes use of kinetic energy of water at inlet and converts it into pressure energy and this pressure is used to lift water to higher elevations. No other energy is required and as long as there is a continuous flow of falling water, the pump will work continuously and automatically. Unlike other pumps that use electricity for its working, this pump doesn't make use of any electrical input for its operation and hence it can be used in areas where there is lack of electrical connections but have unlimited source of flowing water bodies like rivers, lakes etc. The pump can be used in agricultural areas for pumping of water to farm lands and providing water to livestock.

Provision of adequate domestic water supply for scattered rural populations is a major problem in many developing countries. Fuel and maintenance costs to operate conventional pumping systems are becoming prohibitive. The hydraulic ram pump is an alternative pumping device that is relatively simple technology that uses renewable energy, and is durable. The Hydram has only to moving parts and can be easily maintained. This pump is already in operation in countries like Nepal, Sri Lanka and Nigeria.

## II. PRINCIPLE

The working of a hydraulic ram pump is based on the **first law of thermodynamics,** where the kinetic energy of water at inlet is being converted into pressure energy using the pump setup [Fig 1].

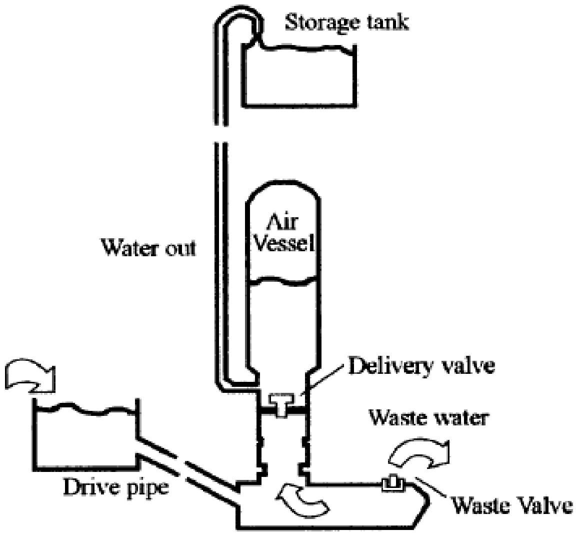


Fig 1. Hydraulic Ram Pump.

## III. DESIGN SPECIFICATIONS

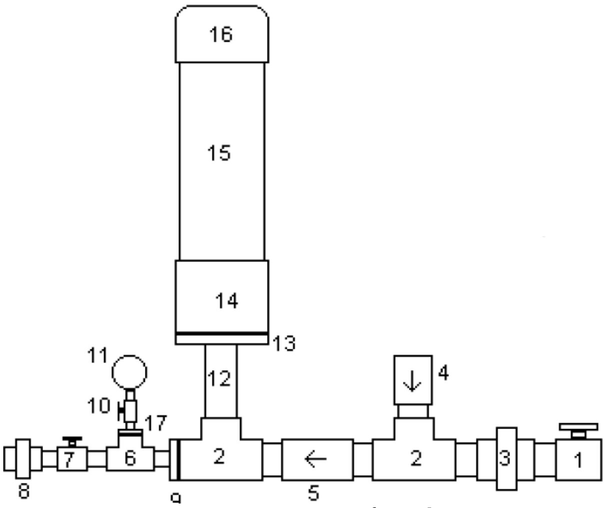


Fig 2. Parts of a Hydram.

1. 1-1/4" valve 10 1/4" pipe cock.
2. 1-1/4" tee 11 100 psi gauge.
3. 1-1/4" union 12 1-1/4" x 6" nipple.
4. 1-1/4" brass swing check valve.
5. 1-1/4" spring check valve 14 4" coupling.
6. 3/4" tee 15 4" x 24" PR160 PVC pipe.
7. 3/4" valve 16 4" PVC glue cap.
8. 3/4" union 17 3/4" x 1/4" bushing.

9. 1-1/4" x 3/4" bushing.
10. 1/4" pipe cock.
11. 100 psi gauge.
12. 1-1/4" x 6" nipple.
13. 4" x 1-1/4" bushing.
14. 4" coupling.
15. 4" x 24" PR160 PVC pipe.
16. 16. 4" PVC glue cap.
17. 3/4" x 1/4" bushing.

## IV. DETERMINATION OF DIFFERENT PARAMETERS

1. The volumetric discharge from the drive pipe is given by,

$$Q = r^2 L\ n/60.$$

Q = volumetric flow rate through the pipe
r = pipe radius,
L = pipe length
n =speed of revolution.

2. The velocity of fluid flow in the driven pipe is given by,

$$Q = V/A_d$$

$V_d$ = velocity of fluid flow
$A_d$ = area of pipe.

3. Head loss = $fLV^2/2gd$

*g* = acceleration due to gravity
*L* = length of the pipe
*V* = fluid velocity

4. The velocity of fluid flow in the T–junction is given by

$$V_T = Q/A_T$$

*Q* = is the volumetric fluid discharge
$A_T$ = pipe x-sectional area at T-junction.

5. Velocity of fluid flow in the driven pipe is given by

$$V_d = Q/A_d$$

*Q* = is the volumetric fluid discharge
$A_d$ = Area of pipe

6. Loss due to sudden enlargement at the T junction is expressed as

$$H_{LT} = (V_d - V_t)^2/2g$$

7. Other losses of head in pipe fittings are expressed as

$$H_L = K_T (V/2g)^2$$

8. Reynolds number for determining type of flow is given by

$$Re = V_d /v$$

9. Efficiency of ram pump is given by formula

$$E = Q*h/((Q + Q_w)*H)$$

## IV. WORKING PRINCIPLE

A Hydraulic ram pump is a unique device that uses the energy from a stream of water falling from a low head as the driving power to pump part of the water to a head much higher than the supply head. With a continuous flow of water, a hydraulic ram pump operates automatically and continuously with no other external energy source.

A hydraulic ram pump is a simple unit consisting of two moving parts, the waste valve and delivery (check) valve. The unit also consist an air chamber in which pressure is build up. The operation of a hydraulic ram pump is intermittent due to the cyclic opening and closing of the waste and delivery valves. The closure of the waste valve creates a high pressure rise in the drive pipe. An air chamber is necessary to prevent these high intermittent pumped flows into a continuous stream of flow.

The working cycle of a hydraulic ram pump can be divided into three phases; acceleration, delivery and recoil.

**Acceleration-** When the waste valve is open, water accelerates down the drive pipe and discharges through the open valve. As the flow increases it reaches a speed where the drag force is sufficient to start closing the valve. Once it has begun to move, the valve closes very quickly.

**Delivery** - As the waste valve slams shut, it stops the flow of water through it. The water that has been flowing in the drive pipe has considerable momentum which has to be dissipated. For a fraction of a second, the water in the body of the pump is compressed causing a large surge in pressure. This type of pressure rise is known as water hammer. As the pressure rises higher than that in the air chamber, it forces water through the delivery valve (a non-return valve). The delivery valve stays open until the water in the drive pipe has almost completely slowed and the pressure in the pump body drops below the delivery pressure. The delivery valve then closes, stopping any back flow from the air vessel into the pump and drive pipe.

**Recoil** - The remaining flow in the drive pipe recoils against the closed delivery valve- rather like a ball bouncing back. This causes the pressure in the body of the pump to drop low enough for the waste valve to reopen. The air sits under the delivery valve until the next cycle when it is pumped with the delivery water into the air vessel. This ensures that the air vessel stays full of air. When the recoil energy is finished, water begins to accelerate down the drive pipe and out through the open waste valve, starting the cycle again. Throughout the cycle the pressure in the air vessel steadily forces water up the delivery pipe. The air vessel smoothens the pulsing flow through the delivery valve into an even outflow up the delivery pipe. The pumping cycle happens very quickly.

During each pumping cycle only a very small amount of water is pumped. However, with cycle after cycle continuing over 24 hours, a significant amount of water can be lifted. While the ram pump is operating, the water flowing out the waste valve splashes onto the floor or the pump house and is considered' waste' water. Although waste' water is not delivered by the ram pump, it is the energy of this water that pumps the water which is delivered.

## V. OPERATING SEQUENCE

Water from the source flows through the drive pipe (A) into the ram pump body, fills it and begins to exit through the waste valve (B).
The Check Valve (C) remains in its normally closed position by both the attached spring and water pressure in the Tank (D) and the Delivery Pipe (E).
(No water in the tank prior to startup) At this starting point there is no pressure in Tank (D) and no water is being delivered through exit Pipe (E) to the holding tank destination.

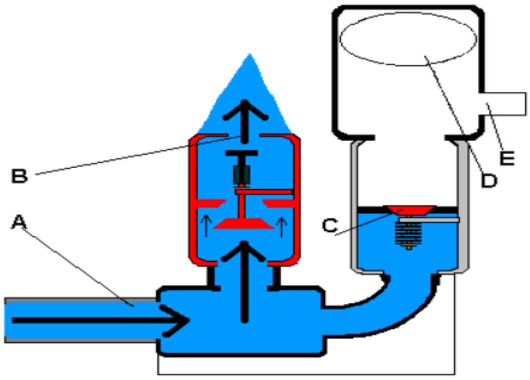

Fig 3. Sequence 1

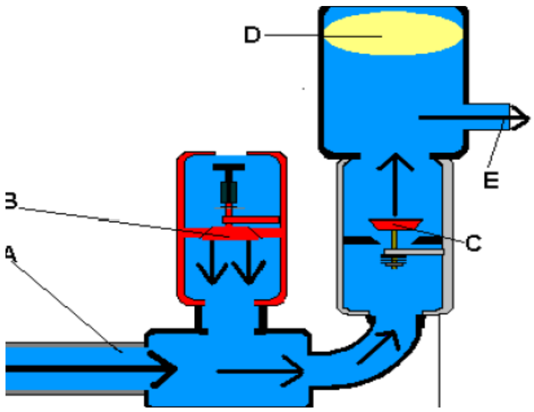

Fig 4. Sequence 2

Water is entering the pump through the Drive Pipe (A). The velocity and pressure of this column of water is being directed out the Waste Valve (B) which is overcome, causing it to close suddenly. This creates a momentary high pressure "water hammer" that in turn forces the Check Valve (C) to open allowing a high pressure "pulse" of water to enter the Pressure Tank (D). The air volume in the pressure tank is compressed causing water to begin flowing out of the Delivery Pipe (E) and at the same time closing the Check Valve (C) not allowing the water a path back into the pump body. As the air volume in the Pressure Tank (D) continues to re-expand, water is forced out of the Delivery Pipe (E) to the holding tank.

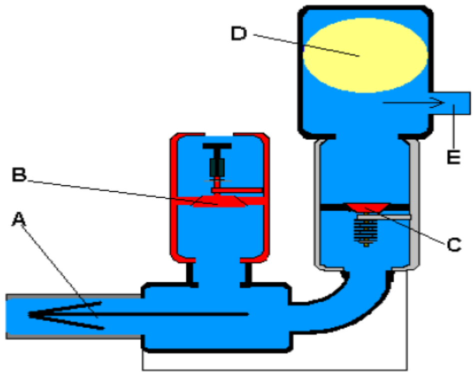

Fig 5. Sequence 3

Water has stopped flowing through the Drive Pipe (A) as a "shock wave" created by the "water hammer" travels back up the Drive Pipe to the settling tank. The Waste Valve (B) is closed. Air volume in the Pressure Tank (D) continues expanding to equalize pressure, pushing a small amount of water out the Delivery Pipe (E).

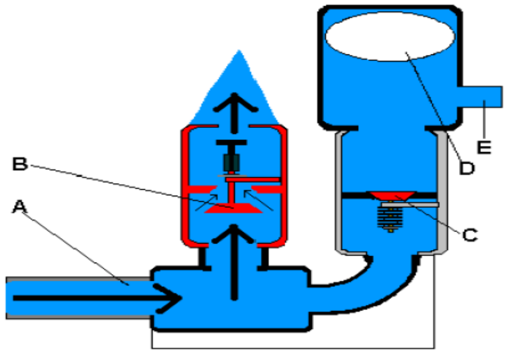

Fig 6. Sequence 4

The "shock wave" reaches the holding tank causing a "gasp" for water in the Drive Pipe (A). The Waste Valve (B) falls open and the water in the Drive Pipe (A) begins to flow into the pump and out the Waste Valve (B). The Check Valve (C) remains closed. The air volume in the Pressure Tank (D) has stabilized and water has stopped flowing out the Delivery Pipe (E). At this point Sequence 1 begins all over again.

## VI. ADVANTAGES

For any particular site, there are usually a number of potential water lifting options.
Choosing between them involves consideration of many different factors. Ram pumps in certain conditions have many advantages over other forms of water-lifting, but in others, it can be completely inappropriate.
The main advantages of ram pumps are:
1. Use of a renewable energy source ensuring low running cost.
2. Pumping only a small proportion of the available flow has little environmental impact.
3. Simplicity and reliability give a low maintenance requirement.
4. There is good potential for local manufacture in the rural villages.

5. Automatic, continuous operation requires no supervision or human input.
6. The valve openings are wide and that makes them self-cleansing and not easily clogged by sand, grit and debris.
7. The waste valve and discharge valve guides can be replaced in case they wear out and enlarge at a very small cost.
8. The sniffing or air valve design is easy to unclog and even replace if the hole enlarges.
9. The design is easy to fabricate and fix with minimum workshop facility and can be maintained by unskilled users.
10. The pump is low cost as compared with available commercial models.

## VII. DISADVANTAGES

1. They are limited in hilly areas with a year-round water sources
2. They pump only a small fraction of the available flow and therefore require source flows larger than actual water delivered
3. As it contains mechanical parts, wear and tear of the waste valve occurs.
4. Requires sufficient kinetic energy of water at inlet for its working.
5. The operation is noisy due to frequent closing and opening of the waste valve.
6. The wastage of water through the waste valve is another disadvantage of the Hydraulic Ram Pump.

## VIII. APPLICATIONS

Specific situations in which other technologies may prove more appropriate are:
1. In terrain where streams are falling very rapidly, it may be possible to extract water at a point above the village or irrigation site and feed it under gravity.
2. If the water requirement is large and there is a large source of falling water (head and flow rate) nearby, turbine-pump sets can provide the best solution. Many ram pumps could be used in parallel to give the required output but at powers over 2KW.
3. In small-scale domestic water supply, the choice can often be between using a ram pump on a stream or using cleaner groundwater. Surface water will often need to be filtered or treated for human consumption, increasing the cost of a system and requiring regular filter maintenance. Under these conditions, we select a hydram pump.

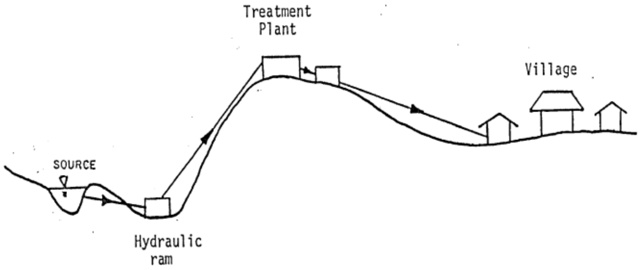


FIG 7. Application of Hydram in Villages.

## IX. CONCLUSION

Thus the Hydraulic Ram Pump proves to be a device that is efficient in its working and at the same time is economically viable. The pump can be made domestically with the help of simple piping tools and doesn't require any sophisticated equipments. Another advantage of the Hydraulic Ram Pump is that its adaptability to work on various terrains with simple operation. As far as the efficiency of Hydram is considered, the amount of water delivered at outlet is comparatively low, but as the device doesn't make use of any electricity, this process is a boon in areas where water has to be pump to greater heights without use of electricity.

## X. REFERENCES

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