EFFECT OF DIAMETER OF AIR VESSEL ON EFFICIENCY OF HYDRAULIC RAM

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ABSTRACT

A hydraulic ram is a water pump that uses the energy of falling water to lift a smaller amount of water to a higher elevation. The efficiency of a hydraulic ram is dependent on various factors, including the diameter of the air vessel. This paper presents an abstract of a study that investigates the effect of the diameter of the air vessel on the efficiency of a hydraulic ram. The study was conducted by varying the diameter of the air vessel of a hydraulic ram and measuring the water output and the efficiency of the pump. The results showed that increasing the diameter of the air vessel increased the efficiency of the hydraulic ram. The optimal diameter of the air vessel was found to be 10-20% of the inside diameter of the supply pipe. This study highlights the importance of selecting the appropriate diameter of the air vessel for a hydraulic ram to achieve optimal efficiency. The findings could be useful in the design and optimization of hydraulic ram systems for various applications, including irrigation, water supply, and wastewater treatment.

Keywords: Hydraulic, Water, Pump, vessel, Diameter, pressure

1. INTRODUCTION

The diameter of the air vessel in a hydraulic ram can have a significant impact on its efficiency. Specifically, increasing the diameter of the air vessel can lead to higher efficiency by reducing the amount of energy lost due to water hammer. Water hammer is a phenomenon that occurs when a flow of water in a pipeline is suddenly stopped, causing a pressure wave to propagate back through the pipeline. This pressure wave can cause significant energy losses, reducing the efficiency of the hydraulic ram. By increasing the diameter of the air vessel, the pressure wave can be dissipated more effectively, reducing the energy losses and improving the efficiency of the ram. In terms of nomenclature, the diameter of the air vessel can be denoted by the symbol "D". Other relevant parameters include the flow rate of water through the ram (Q), the height of the water source above the ram (H), and the head of water that the ram is able to lift (h). Overall, the efficiency of a hydraulic ram is a complex function of many different parameters, including the diameter of the air vessel. Careful design and optimization of these parameters can help to maximize the efficiency and effectiveness of the ram.

2. METHODOLOGY

2.1 Factors need to be considered

>Area suitability (head and flow rate)
>Flow rate and head requirement
> Intake design
> Drive system
>Pump house location.
>Delivery pipes routing
>Distribution system

2.2 Maintenance and service life considerations

The critical parts that require frequent maintenance are bolts, studs and nuts. Therefore, it is usually preferable to have stainless steel bolts, studs and nuts. even though they are costly and difficult to source.

2.3 General considerations

Shape of hydram has little effect on performance
> Valve design considerations.
> The correct design of valves is a criticalfactor in the overall performance of ram pumps.
Hence, this needs special consideration.
>Strength considerations. This determines thickness of hydram body and air chamber.

2.4 Basic Parts

From the figure it shows a typical hydraulic ram installation that comprises
> Supply

>Supply pipe (drive pipe)
>Impulse valve/ waste valve/snifter valve
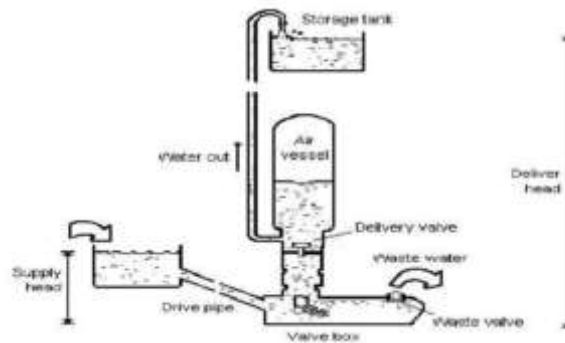> Delivery valve
> Air chamber
>Delivery pipe

Fig 2.1 basic parts

2.5 Pipe consideration

For all pipes being used and the hydram body, the material that we suggested is commercial steel pipe based on the following reason:

>Strength and flexibility
>high resistance to direct heat
>Resistant to very high pressures
> Easy to install, maintain, operate and connect
>Perfect for the extension work in pumping stations, riverbanks, steep
>sloping crossings and reservoirs
> Feature of withstanding traffic vibrations and shocks

Specifically, the types of steel pipe we suggest to use is Galvanized steel since this type of steelis coated with zinc layer to protect steel pipes from conoding. This form of steel provides resistance to corrosion and rust thereby making it highly preferred to make pipes. This also helps in increasing the overall life term of the pipe fittings as well.

2.6 Snifter valve

It is a device to allow the air to enter the air vessel located above delivery valve but below delivery pipe. Is it very important for air to enter because air in the air vessel mixes with water while hydram is running. As a result, the volume of air in the air vessel decreases and bring about the reduction in the pump's efficiency, thus it is important to have snifter valve.

2.7 DESIGN

When we design water system using ram pumps, we like to know before we build it, how much water it will deliver to how much head and with what efficiency manually manipulating these parameters using design methodology for different input parameters .After that, we then design the hydram using SOLIDWORKS software which a CAD (computer aideddesign) software as…
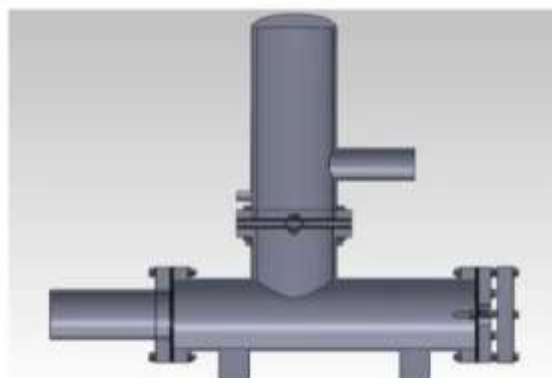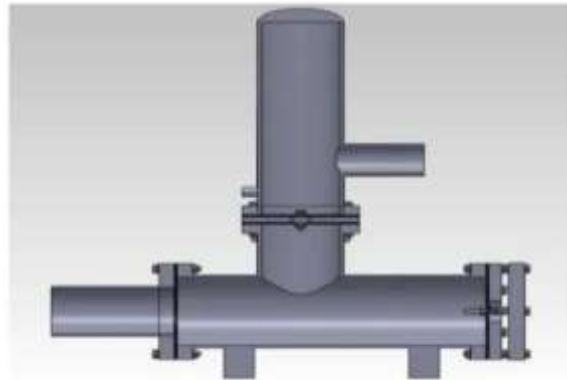

Fig 1.2 isomertric view of hydraulic ram

Fig.1.3 cross sectional view of hydraulic ram
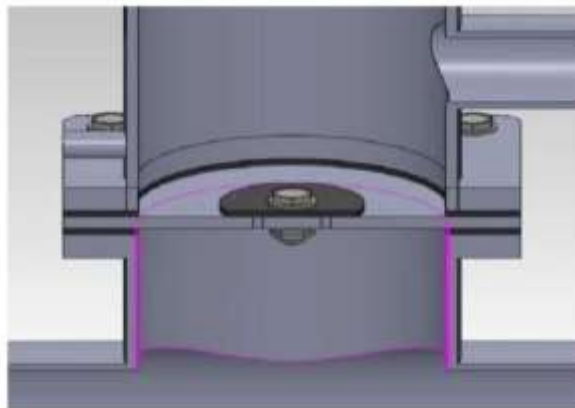

Fig.1.4 sectional view of hydraulic ram pump

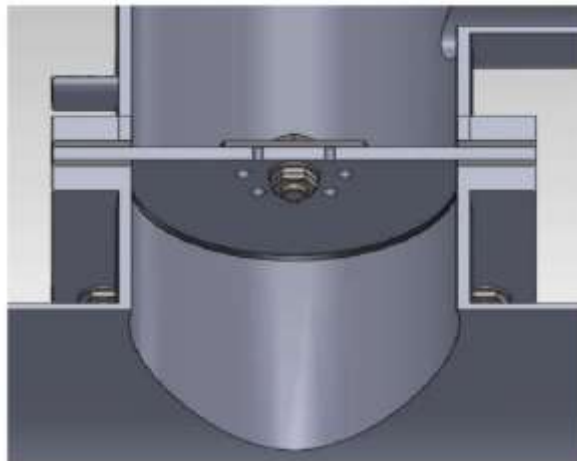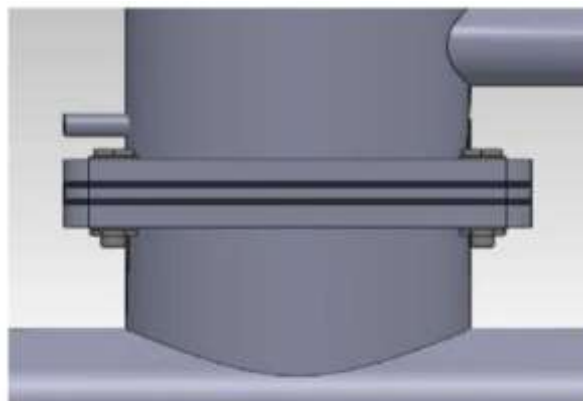**Fig. 1.5** sectional view of delivery valve

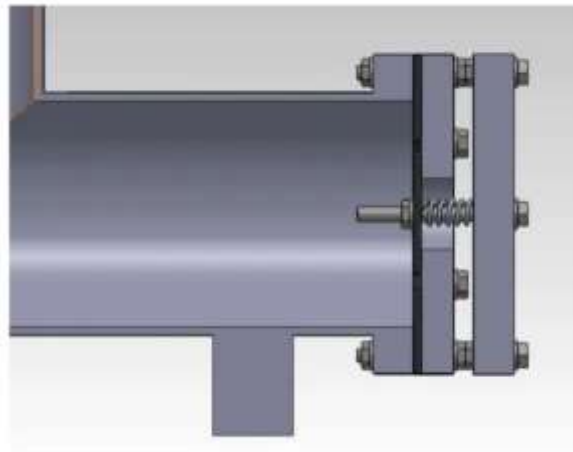**Fig.1.6** Outer view of delivery valve

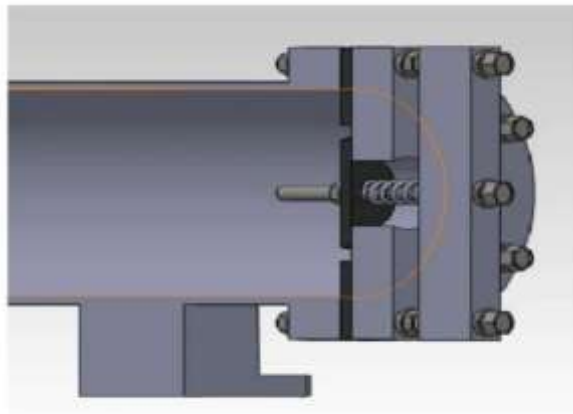**Fig.1.7 Cross sectional view of waste valve**

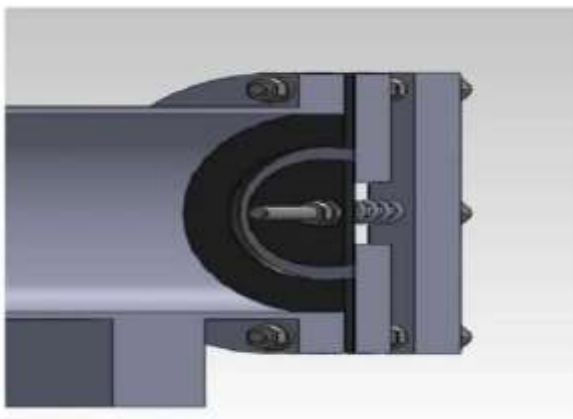**Fig.1.8 sectional view of waste valve**

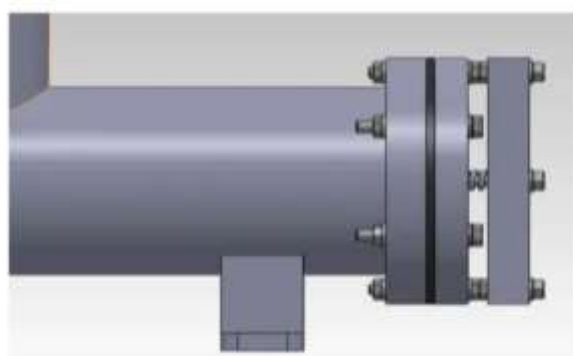**Fig.1.9 sectional view of waste valve**

Fig. 1.10 outer view of waste valve

Fig.1.11 Entire assembled figure

2.8 Mechanism

When we design a water system using ram pumps, we like to know before we build it, how much water it will deliver to how much head and with what efficiency manually manipulating these parameters using design methodology for different input parameters. After that, we then design the hydram using SOLIDWORKS software which a CAD (computer Aidedd sign) software.
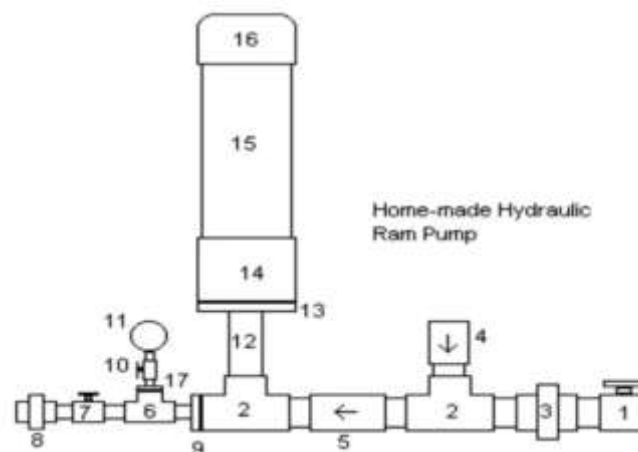

Fig 1.12. Hydraulic ram pump

Experiment set up

Installation Materials

>Long section of 1-1/4" PVC ("drive pipe", connects pump to water supply)

>Garden Hose (male end threads into 3/4" union, supplies pumped water)

>Bricks blocks,

>rocks to prop up and anchor pump .

>Shower Drain assembly (must be able to attach to 1-1/4" pipe, for attaching pipe to water supply)

Build Materials and Tools

>PVC Primer (I used Oatey Purple Primer)

>PVC Cement (Oatey again, just what they had)

>Teflon Thread Tape

> Hacksaw

> Measuring Tape Clamps Pocket Knife

>Lab gloves (keeps the chemicals on the pipe and off your hands)

>Bike Pump (to inflate the inner tube).

3. OPERATIONAL FIGUERE EXPLINATION

As shown in below figures operation perform under these

1) Water (blue arrows) starts flowing through the drive pipe and out of the "waste" valve (#4 on the diagram), which is open initially. Water flows faster and faster through the pipe and out of the valve.

Step 1

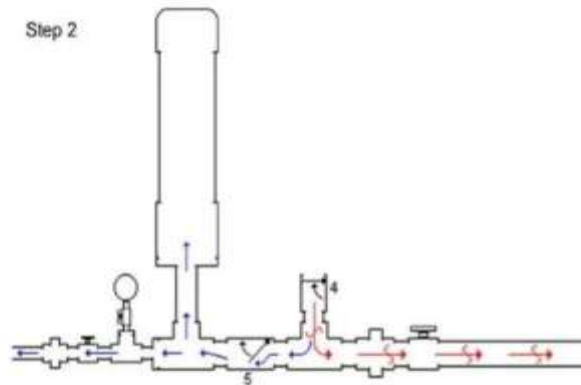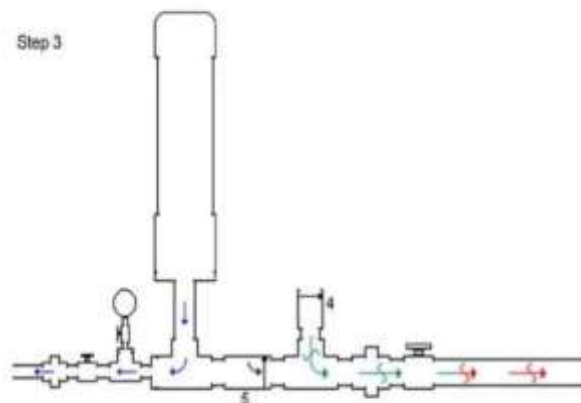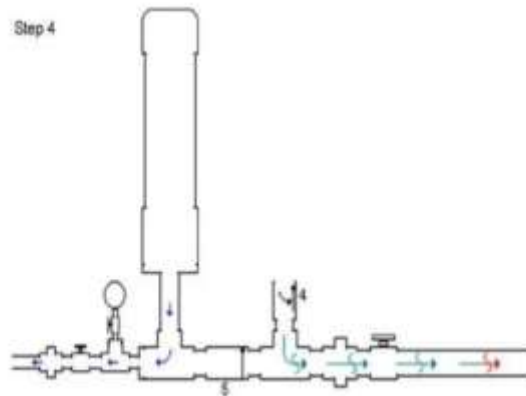(2) At some point, water is moving so quickly through the brass swing check. "waste" valve (#4) that it grabs the swing check's flapper, pulling it up and slamming it shut. The water in the pipe is moving quickly and doesn't want to stop. All that water weight and momentum is stopped, though, by the valve slamming shut. That makes a high pressure spike (red arrows) at the closed valve. The high pressure spike forces some water (blue arrows) through the spring check valve (#5 on the diagram) and into the pressure chamber. This increases the pressure in that chamber slightly. The pressure "spike" the pipe has nowhere else to go, so it begins moving away from the waste valve and back up the pipe (red arrows). It actually generates a very small velocity backward in the pipe.
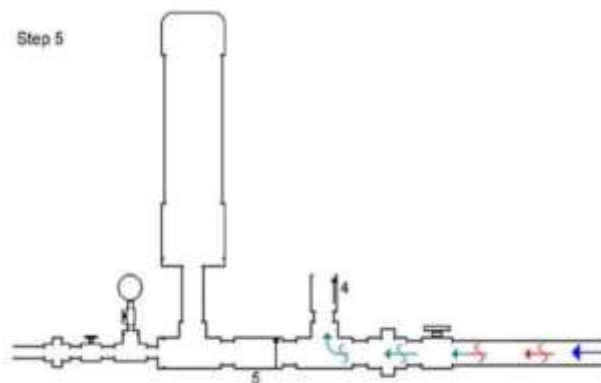

Step 2

(3)As the pressure wave or spike (red arrows) moves back up the pipe, it creates a lower pressure situation (green arrows) at the waste valve. The spring-loaded check valve (#5) closes as the pressure drops, retaining the pressure in the pressure chamber.

Step 3

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Vol. 03, Issue 04, April 2023, pp : 1099-1109

e-ISSN : 2583-1062

Impact Factor : 5.725

(4)At some point this pressure (green arrows) becomes low enough that the flapper in the waste valve (#4) falls back down, opening the waste valve again.

(5) Most of the water hammer high pressure shock wave (red arrows) release at the drive pipe inlet, which is open to the source water body. Some small portion may travel back down the drive pipe, but in any case after the shock wave has released, pressure begins to build again at the waste valve (#4) simply due to the elevation of the source water above the ram, and water begins to flow toward the hydraulic ram again.

(6) Water begins to flow out of the waste valve (#4), and the process starts over once again.

4. MODELING AND ANALYSIS

A hydram is a structurally simple unit consisting of two moving parts. These are the impulse valve (or waste valve) and the delivery (check) valve. The unit also includes an air chamber and an air valve. The operation of a hydram is intermittent due to the cyclic opening and closing of the waste and delivery values. The closure of the waste valve creates a high pressure rise in the drive pipe. An air chamber is required to transform the high intermittent pumped flows into a continuous stream of flow. The air valves allow air into the hydram to replace the air absorbed by the water due to the high pressure and mixing in the air chamber.

Figure 4.1 : Hydraulic Ram Pump

4.1 Working

Working Principle: A simplified hydraulic ram is shown in Figure .Initially, the waste valve is open, and the delivery valve is closed. The water in the inlet pipe starts to flow under the force of gravity and picks up speed and kinetic energy until the increasing drag force closes the waste valve. The momentum of the water flow in the inlet pipe against the now closed waste valve causes a water hammer that raises the pressure in the pump, opens the delivery valve, and forces some water to flow into the delivery pipe. Because this water is being forced uphill through the delivery pipe farther than it is falling downhill from the source, the flow slows; when the flow reverses, the delivery check valve closes. Meanwhile, the water hammer from the closing of the waste valve also produces a pressure pulse which propagates back up the inlet pipe to the source where it converts to a suction pulse that propagates back down the inlet pipe. This suction pulse, with the weight or spring on the valve, pulls the waste valve back open and allows the process to begin again. A pressure vessel containing air cushions the hydraulic pressure shock when the waste valve closes, and it also improves the pumping efficiency by allowing a more constant flow through the delivery pipe. Although the pump could in theory work without it, the efficiency would drop drastically, and the pump would be subject to extraordinary stresses that could shorten its life consider .One problem is that the pressurized air will gradually is solve into the water until none remains. One solution to this problem is to have the air separated from the water by an elastic diaphragm (similar to an expansion tank); however, this solution can be problematic in developing countries where re placements are difficult to procure. Another solution is to have a mechanism such as a shifting valve that automatically inserts a small bubble of air when the suction pulse mentioned above reaches the pump. Another solution is to in certain inner tube of a car or bicycle tire into the pressure vessel with some air in it and the valve closed. This tube is in effect the same as the diaphragm, but it is implemented with more pulse mentioned above reaches the pump. Another solution is to in certain inner tube of a car or bicycle tire into the pressure vessel with some air in it and the valve closed. This tube is in effect the same as the diaphragm, but it is implemented with more widely available materials . The air in the cushion the shock water tube the same as the other configuration does .
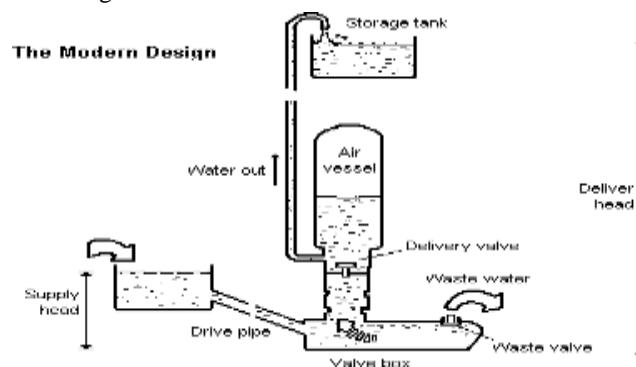

fig 2.1 modern design

4.2 Testing

Methods to calculate efficiency:

There are two ways of assessing the overall efficiency of

a hydraulic ram

1) D'Aubuisson's efficiency

2) Rankine's efficiency

1) D'Aubuisson's efficiency

In this system the datum may be taken to be passing through the waste valve, and hence the energy input during one cycle is and the useful output during the same cycle is. The corresponding overall efficiency then becomes

D'Aubuisson's efficiency = q (H+h) / h (Q+q)

Which is known as D'Aubuisson's efficiency, and its value is always more than Rankine's efficiency.

2) Rankine's efficiency:

In the Rankine system the water surface in the supply reservoir is taken as datum and hence the energy input during one cycle is (wQh), and the useful output during the same cycle is (wqH) ,where w is the specific weight of water. Thus,

Rankine's efficiency = wqH /wQh

h = level of water in the supply tank above the waste valve

H =level of water in the delivery tank above that in the supply tank q = rate of discharge of water actually lifted by the ram

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Vol. 03, Issue 04, April 2023, pp : 1099-1109

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Q = rate of discharge of water flowing through past the waste valve

Specifications of air vessel:

length   = 62 cm   Diameter = 8.5 cm

volume   =   3518.19 cm3

Supply pipe

length= 259 cm   Diameter = 0.5 inch

Delivery pipe

Length =335 cm   Diameter = 1 inch

Sr.No	Time required to 1 lit water to flow through waste valve.(sec)	Average time required for 1 lit water to flow through waste valve(sec)	Time required to 1 lit water to flow through delivery valve(sec)	Average time required for 1 lit water to flow through delivery valve(sec)
1	10.4		28	
2	11.1	10.9	29	28.33
3	11.2		28	

Discharge of water flowing

through Waste valve   =   volume/time   = 1/10.9 *60

= 5.50 lit/min

Discharge of water actually

lifted by the ram (q)   = 1/28.33*60   = 2.12 lit/min

Discharge of water flowing

through past the waste valve (Q) = 5.50 + 2.12 = 7.72 lit/min

Sr.NO	Q (lit/min)	q (lit/min)	Discharge through Waste valve (lit/min)
1	7.72	5.50	2.12

1) D'Aubuisson's efficiency= w*q*(H+h)/w*(Q+q)*h

= 2.12(94.48+137.16)

137.16(7.72)

= 0.46*100

=   46 %

2) Rankine's efficiency   = w*q*H/w*Q*h

= 2.12(94.48)

7.72(137.16)

= 0.19*100

= 19 %
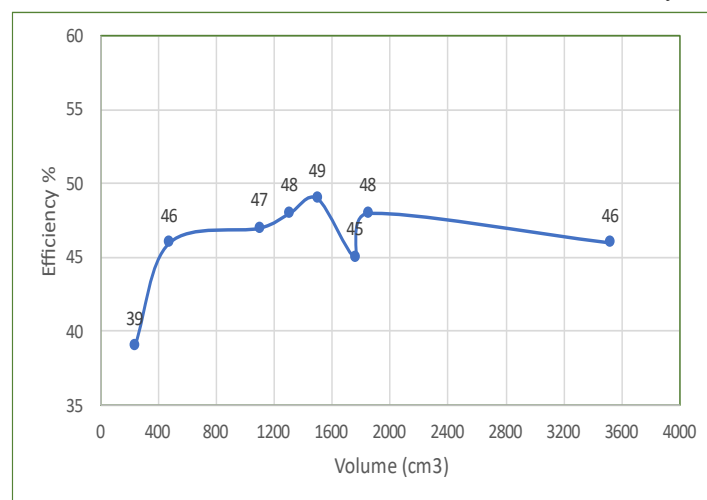
5. RESULTS AND DISCUSSION

In the Rankine system the water surface in the supply reservoir is taken as datum and hence the energy input during one cycle is (wQh), and the useful output during the same cycle is (wqH), where w is the specific weight of water. Rankine's efficiency = wqH /wQh

Table 1.

Sr. no	Air vessel specification	Air vessel volume	Rankine's fficiency	D'Aubuisson's efficiency
1	Length = 62 cm Diameter = 8.5 cm	Volume = 3518.19 cm3	19 %	46%

2	Length = 31 cm Diameter = 8.5 cm	Volume = 1759.10 cm3	18%	45%
3	Length = 53 cm Dimeter = 6 cm	Volume = 1498.54 cm3	20%	49%
4	Length = 69 cm Dimeter = 4.5 cm	Volume = 1098 cm3	19 %	47 %
5	Length =34 cm Dimeter =7 cm	Volume = 1305 cm3	20 %	48 %
6	Length = 48 cm Dimeter = 7 cm	Volume = 1847 cm3	20 %	48 %
7	Length =30 cm Dimeter = 4.5 cm	Volume = 477 cm3	19 %	46 %
8	Length = 15 cm Diameter =4.5 cm	Volume = 239 cm3	16 %	39 %

(1) It is observed that the every time the D'Aubuisson's efficiency is less than the rankine's efficiency.

(2) When the smallest air vessel the pump does not work because air chamber full with water and it unable to create enough pressure on water.

(3) In hydraulic ram the maximum efficiency of 49 % got for the air vessel having length 53 cm, diameter 6 cm which is the medium size diameter we have considered.

(4) It get minimum efficiency of 38 % for the air vessel having length 15 cm and diameter 4.5 cm, but when length is doubled its efficiency reaches to 46 %.

(4) In some cases of air vessel the efficiency of hydraulic ram remains same,but by selecting proper size of air vessel we can reduce the material and cost.

(5) i.e , Here for the volume 3518.19 cm3 and volume 477 cm3 have the same efficiency of 46 %.

6. CONCLUSION

There is broad prospect of utilizing the country's abundant surface water run off potential for various purposes or requirements using locally designed and manufactured hydraulic ram ipumps and other similar appropriate technologies. To disseminate hydrams at potential sites throughout the country, there is a need to create awareness through training and seek integrated work with rural community, government institutions like water, energy and mines bureau of local regions and non-governmental organizations. Hydraulic Ram pumps made by casting have many advantages, but they could be expensive. In addition, considering the cost of civil work and pipe installation, the initial investment could be very high. To reduce cost of hydrams made by casting, there is a need for standardization.

ACKNOWLEDGEMENTS

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