Design of Hydraulic Ram Pump

Atharva Pathak
UG Student
Department of Mechanical engineering
Dr. Babasaheb Ambedkar college of engineering

Aniruddha Deo
UG Student
Department of Mechanical engineering
Dr. Babasaheb Ambedkar college of engineering

Santosh Khune
UG Student
Department of Mechanical engineering
Dr. Babasaheb Ambedkar college of engineering

Sagar Mehroliya
UG Student
Department of Mechanical engineering
Dr. Babasaheb Ambedkar college of engineering

Ms. Mamta Pawar
Assistant Professor
Department of Mechanical engineering
Dr. Babasaheb Ambedkar college of engineering

Abstract

In today's world water is of a great concern to the human beings because we can't survive without it. Hydraulic ram can be one of the solutions to this problem of a mankind. Mostly in India where villages are situated far away from the water source it is not possible to the people living there to go miles away carrying away the buckets of water. Especially at those places this pump has a much utility because it is cheap, without electricity and easy to maintain. As it requires no external energy other than kinetic energy of flowing water it can be considered as a pump which uses Renewable energy. Though the pump is in use since long time, it is not seen in common forms for lots of its performance limitations. This type of pump is truly a blessing to the rural areas, farmers and middle class for its zero running cost. The paper after study the literature available, aims to present generalized design methodology for hydraulic ram pump (HYDRAM) covering design parameters, design procedure along with the mathematical relationship used for the design work.
Keywords: Hydraulic Ram Pump, cyclic water pump, Hydram

I. Introduction

A hydraulic ram or hydram is a cyclic water pump powered by hydro-power. It takes in water at one "hydraulic head"and delivers the water at a higher hydraulic head and lower flow rate. The device uses the water hammer effect to develop pressure that allows a portion of the input water that powers the pump to be lifted to a point higher than where the water is originally present. The hydraulic ram is used in remote areas especially hilly areas and in the villages which are located at the greater heights from altitude, where there is both a source of low-head water and a need for pumping water to a destination higher in elevation than the source. In this situation, the ram is often useful, since it requires no outside source of power other than the kinetic energy of flowing water.

A hydram is a structurally simple unit consisting of only two moving parts. These are the impulse valve (or waste valve) and the delivery valve or check valve. The unit also consists of an air chamber and an air valve or snifter valve. The operation of a hydram 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 and this occurs very fastly within fraction of seconds. An air chamber is required to transform the high intermittent pumped flow into a continuous stream of flow. The air valve allow air into the hydram to replace the air absorbed by the water due to the high pressure and which is mixed in the air chamber but this snifter valve does not have as much effect than the other two valves. Pumps are among the oldest of the machines. They were used in ancient Egypt, China, India, Greece and Rome. Today, pumps are the second most widely used in various industries.

II. Design Factors

The ram pump consists essentially of two moving parts, the impulse and delivery valves. The construction, basically consist of pipe fittings of suitable designed size.
The main parameters to be considered in designing a hydraulic ram include:
1) The difference in height between the water source and pump site (called vertical fall).
2) The difference in the height between the pump site and the paint of storage or use (life).
3) The quantity (Q) of flow available from the source.
4) The length of the pipe from the source to pump site (called the drains pipe).
5) The quantity of water required.

6) The length of pipe from the storage site (called the delivery pipe)

Once this information has been obtained, a calculation can be made to see if the amount of water needed can be supplied by a ram.

The formula is: D=(S x F x E)/L

Where:

D = Amount delivered in litres per 24 hours.

S = Quantity of water supplied in litres per minute.

F = The fall or height of the source above the ram in meters.

E = The efficiency of the ram (for commercial models use 0.66, for home built use 0.33 unless otherwise indicated).

L = The lift height of the point of use above the ram in meters.

Determination of Design Parameters for the Hydram

Since a hydram makes use of sudden stoppage of flow in a pipe to create a high pressure surge, the volumetric discharge from the drive pipe is given by:

$$Q = \pi r^2 L \frac{n}{60} \quad (1)$$

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

Also the velocity of fluid flow in the driven pipe is given by

$$V_d = \frac{Q}{A_d} \quad (2)$$

where, V_d = velocity of fluid flow and A_d = area of pipe.

In order to ascertain the nature of the flow (that is whether laminar or turbulent), it was necessary to determine the Reynolds number given by

$$Re = \frac{Vd}{\upsilon} \quad (3)$$

where, V = velocity of fluid flow, d = pipe diameter and υ = kinematic viscosity.

The friction factor *f* can be derived mathematically for laminar flow, but no simple mathematical relation for the variation of *f* with Reynolds number is available of turbulent flow. Furthermore, Nikuradse et al. found that the relative roughness of the pipe (the ratio of the size of the surface imperfection to the inside diameter of the pipe) affects the value of *f* too.

For smooth pipes Blasius suggested that for turbulent flow

$$f = \frac{0.316}{Re^{0.25}} \quad (4)$$

where, *f* = frictional factor of the pipe and Re is Reynolds number.

The Darcy–Wersbach formula is the basis of evaluating the loss in head for fluid flow in pipes and conduits and is given by

$$\text{Heat loss} = f \frac{L}{d}\left(\frac{V^2}{2g}\right) \quad (5)$$

where, g = acceleration due to gravity, L = length of the pipe, V= fluid velocity and d = pipe diameter.

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

$$V_T = \frac{Q}{A_T} \quad (6)$$

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

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

$$H_{LT} = \frac{(V_d - V_T)^2}{2g} \quad (7)$$

Other losses of head, as in pipe fittings are generally expressed as

$$H_L = K_T\left(\frac{V^2}{2g}\right) \quad (8)$$

Since the head (H) contributed to water acceleration in the driven pipe, this acceleration is given by

$$H - Fx\frac{L}{D}\left(\frac{V^2}{2g}\right) - \sum\left(Kx\frac{V^2}{2g}\right) = \left(\frac{L}{D}\right)x\frac{dv}{dt} \qquad (9)$$

The value of K and *f* can be found from standard reference handbooks/textbooks. Eventually this flow will accelerates enough to begin to close the waste valve this occurs when the drag and pressure in the water equal the weight of the waste value. The drag force given by equation

$$f_d = C_d x A_v x \rho x \frac{V_T}{2g} \qquad (10)$$

The force that accelerates the fluid is given by

$$F = ma = \rho A L x \frac{dv}{dt} \qquad (11)$$

The pressure at point is obtained by divided the force F in Equation (11) by the area A.

$$P_3 = \frac{F}{A} \qquad (12)$$

A. Different components with specifications

Table – 1

Sr no.	*Part*	*Description*	*Quantity*
1	*Air vessel*	*UPVC pipe*	*1 piece 2"*4"* ***or*** *3"*6" Thickness =0.5mm*
2	*Reducer*	*UPVC pipe*	*2"* ¾"* ***or*** *3"* ¾"*
3	*Tee joint*	*UPVC pipe*	*2 pieces each ¾"*
4	*Air vessel head*	*UPVC pipe*	*2"*4"* ***or*** *3"*6"*
5	*Non return valve*	*Brass*	*2 pieces as per pipe sizes*
6	*PVC pipe cutted piece joint*	*UPVC pipe*	*As per the requirement of supply and delivery Usually 4 to 5 pieces*
7	*Elbow 90°*	*UPVC pipe*	*1 each size as per supply pipe Diameter*
8	*Supply tank*	*Plastic*	*100* ***or*** *200 liter*
9	*Delivery tank*	*Plastic*	*Greater than supply tank 300 liter*
10	*Pipe*	*Plastic*	*Supply pipe = 8m minimum* *Delivery pipe list =2 to 5 m*

III. Figure

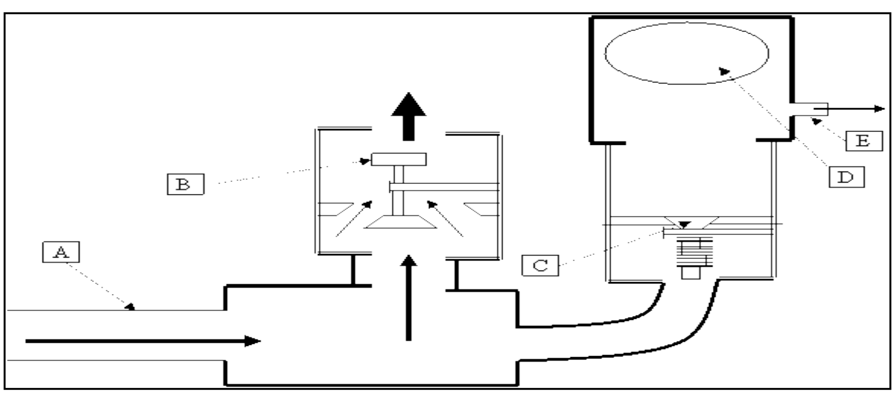

Fig. 1:

Where:
A: Inlet Valve
B: Waste Valve
C: Non- Return valve
D: Compressed air
E: outlet pipe

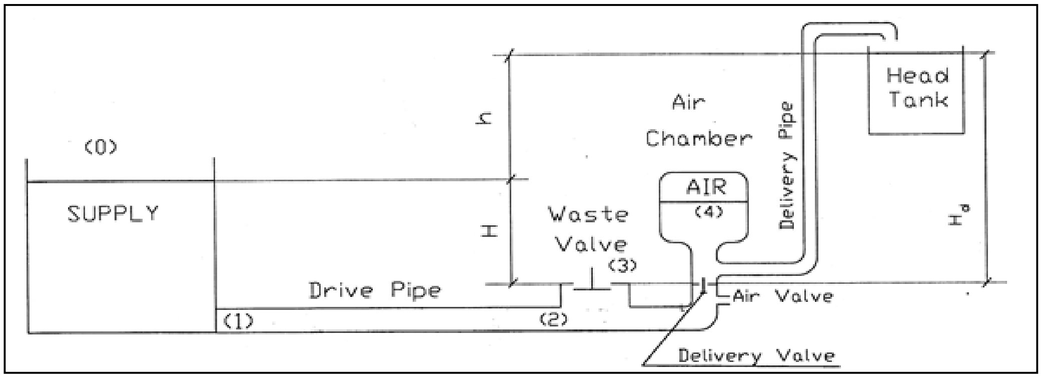

Fig. 2:

Design Aspects
Where:
H: Height of Source
h: Height of delivery tank from supply tank
H_d: Height of delivery tank
H_d = H + h

IV. Conclusion

The present study is centred towards the development of a hydraulic ram pump that would conveniently alleviate the problem of water supply to the mass populace. Ideally, different combinations of the supply and delivery heads and flows, stroke length and weight of the impulse valve, length to diameter ratio of the drive pipe, volume of the air chamber and size of the snifter valve, etc. We have tried to come up with an optimum size of a hydram pump presented in this study

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