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Research Paper

DESIGN METHODOLOGY FOR HYDRAULIC RAM PUMP (HYDRAM)

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The availability and cost of electric power is a great concern to comman man. Conventional energy is also a great concern for environment. Hence more attention of designers is diverted towards use of unconventional energy or other forms of energy than conventionenergy. Water pump is a more utility item. The hydraulic ram pump is the mechanical pump which runs on kinetic energy of flowing water. Though the pump is in use since long, it is not seen in comman forms for lots of its performance limitations. This type of pump is a blessings to rural areas, farmers and middle class for its zero running cost. The paper after study the literature available aim to present generalised design methodology for hydraulic ram pump (HYDRAM) covering design parameters, design procedure along with the mathematical relationship used for the design work.

Keywords: Conventional energy, Design methodology, Hydraulic ram pump, Design parameters

INTRODUCTION

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 consists of an air chamber and an air valve. The operation of a hydram is intermittent due tothe cyclic opening and closing of the waste and delivery values. The closure of the waste valve creates a high pressure rise in the drivepipe. An air chamber is required to transform the high intermittent pumped flows into acontinuous 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. 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 commonly used kind of industrial equipment after the electric motors (Working, 1996).

WORKING PRINCIPLE

The energy required to make a Ram lift water to a higher elevation comes from water falling

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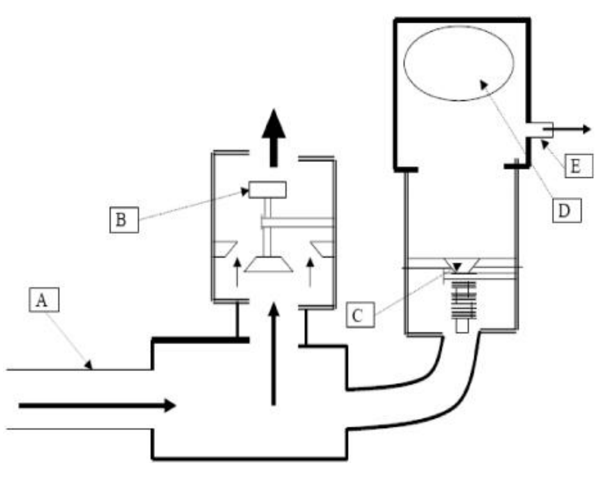
downhill due to gravity. As in all other water powered devices, but unlike a water wheel or turbine, the ram uses the inertia of moving part rather than waterpressure and operates in a cycle based on the following sequences.

Sequence I

Water from the source flow through the drive pipe (A) into the ram pump body, fills it and begins to exit through the waste or "impulse" valve (B). The check valve (C) remains in its normal closed positions by both the attached spring and water pressure in the tank (D) and the delivery pipe (E) (no water in the tank prior to start up). 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 (see Figure 1).

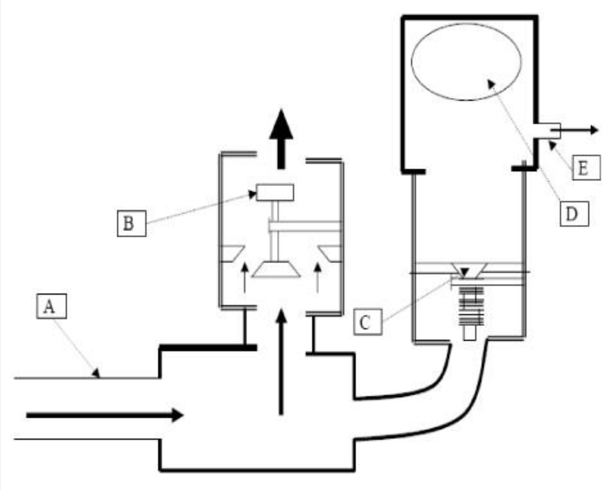
Figure 1: Hydraulic Ram Sequence I



Sequence II

Water entering the pump through the drive pipe (A) has its velocity and pressure being directed out of waste valve (B) as illustrated in Figure 2.

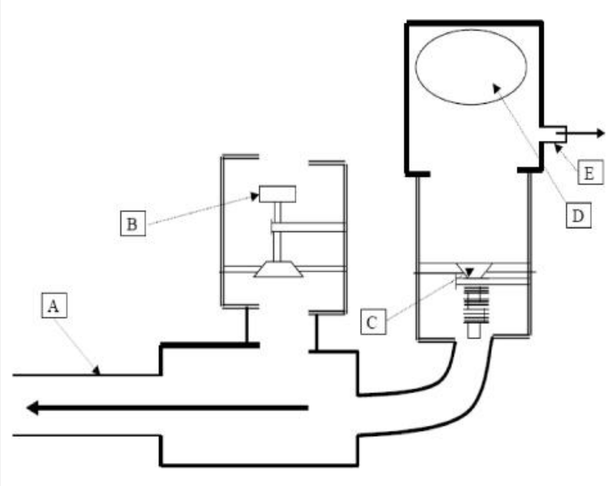
Figure 2: Hydraulic Ram Sequence II



Sequence III

Water has stopped flowing through the drive pipe (A) as a "shock wave" created by the "water hammer" travels back up the drivepipe to the settling tank. The waste valve (B) is closed. Air volume in the pressure tank (D) continues expanding toequalize pressure, pushing a small amount of water out of the delivery pipe (E). See the illustration in Figure 3.

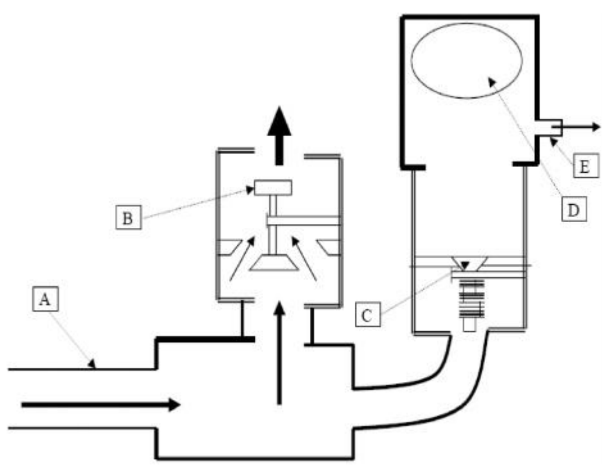
Figure 3: Hydraulic Ram Sequence III



Sequence IV

The shock wave reaches the holding tank causing a "gasp" for water in the drive pipe (A). The waste valve (B) opens and the water in the drive pipe (A) flows into the pump and out of the waste valve (B). The check valve (C) remains closed until the air volume in the pressure tank (D) has stabilized and water has stopped flowing out of the delivery pipe (E). At this point sequence 1 begins all over again.

Figure 4: Hydraulic Ram Sequence IV



DESIGN PARAMETERS

The detailed mechanics of hydram operation are not wellunderstood. Several parameters relating to the operation of the hydram are

- Drive pipe length (L);
- Cross-sectional area of the drive pipe (A);
- Drive pipe diameter (D) and thickness;
- Supply head (H);
- Delivery head (h);
- Friction head loss in the drive pipe;
- Friction head loss through the waste valve;
- Friction head loss at the delivery valve;
- The velocity in the drive pipe when the waste valve begins to close (V0);
- The steady flow velocity (VS) through the waste valve when fully open;
- Valve weight (W);
- Valve stroke (S);
- Valve opening orifice area (A0);
- Valve cross sectional area (AV); and
- Size of the air chamber.

DESIGN PROCEDURE

- Before a ram can be selected, several design factors must be known. These are shown in
- Figure 1 and include:
  - The difference in height between the water source and the pump site (called vertical fall).
  - The difference in height between the pump site and the point of storage or use (lift).
  - The quantity (Q) of flow available from the source.
  - The quantity of water required.
  - The length of pipe from the source to the pump site (called the drive pipe).
  - The length of pipe from the pump to 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 liters per 24 hours.
- S = Quantity of water supplied in liters per minute.
- F = The fall or height of the source above the ram in meters.

DETERMINATION OF DIFFERENT PARAMETERS OF 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:

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

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

$$\mathrm{Re} = \frac{V_d}{³} \quad ...(3)$$

where, V = velocity of fluid flow, d = pipe diameter and ³ = kinematic viscosity. The friction factor f can be derived mathematically for laminar flow, but no simple mathematical relationfor the variation of f with Reynolds number is available of turbulent flow.

For smooth pipes Blasius suggested that for turbulent flow

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

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

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

here, g = acceleration due to gravity, L = length of the pipe and V = fluid velocity

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

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

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

$$f_d = C_d x A_v x° x \frac{V_T}{2g} \quad ...(10)$$

The force that accelerates the fluid is given by

$$F = ma = °ALx\frac{dv}{dt} \quad ...(11)$$

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

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

The power required can *k* calculated using this expression

$$P = °gQh \quad ...(13)$$

The efficiency of the hydram is given by

$$E = \frac{Qxh}{(Q + Qw)xH} \quad ...(14)$$

CONCLUSION

With the design parameters for the hydraulic ram pump like drive pipe diameter from drive pipe length, flow discharge indrive pipe, total head losses in the system, pressure at waste valveand powerdeveloped by the hydram. We willmathematically calculated the efficiency of the hydraulic ram pump and the suitable design of the hydraulic ram pump is produced. The result will be compare with experimental model.

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