Effect of Water Hammering Action on Performance of Hydraulic Ram Pump

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Abstract- The hydraulic ram pump is a simple durable pump that can be used to deliver water from one source to another. The pump has the following characteristics flow, drive that is how much water is available to run the pump; drive head is the drop from the water level in the drive tank to the pump; delivery flow is the amount of water flowing into the delivery tank while the delivery head is the height from the pump up to the delivery tank. The normal operation range of this pump is 0.5 to10 litres/minute. The ram pumps are durable and either made from iron casting or welded steel pipe. The readily available local materials have been used to build the pump. No electricity or any power fuel is required to run the pump, therefore, it is less expensive to own and operate.

The results from the study have shown that the impulse valve frequencies have a major impact on the discharge of a hydraulic ram pump. When impulse valve frequency increased from 65 beats / minute to 76 beats per minute, it was found that the quantity of waste water increased 47.20% but the quantity of useful water decreased by 74.50 %.

Index Terms- Hydram; Efficiency; Head Ratio; Discharge of Waste Water; Discharge of Useful Water.

I. INTRODUCTION

The need for water has always been a basic motivation of mankind, which frequently had to be lifted from a lower height to a upper height. This ever increasing need of water ultimately resulted in the development of various pumping aids. The increasing need of water is always being closely associated with the demands of domestic water supply for rural populations, irrigation etc. which is a very vital input for development of mankind. With a view to meet above requirements, the following specific objectives have been taken up to test the performance of hydraulic ram pump.

1. To study the performance evaluation of Hydraulic Ram pump at different operating conditions.
2. To find out the efficiency of Hydraulic Ram pump.
3. To determine the characteristic curve of hydraulic ram pump.

II. OPERATIONAL PRINCIPLE

Hydraulic ram pump works on the principle of water hammering action. The water is caught by the spring catchment (or the stream catchment) and driven to the header tank by the feed pipe. The spring or stream catchment is the first barrier to prevent organic matters to enter in the system and to reduce the efficiency of the system. The header tank allows a continuous flow to the drive pipe and the pump and it the last barer to prevent sediments to enter in the pump. The drive pipe is made from galvanized iron (G.I.). It has to support the water hammer effect which is running continuously. The drive pipe is designed to conduct water as fast as possible to the pump and it must be straight. The Hydram is the most critical infrastructure of the system. The Hydram is attached to the pump basement. It has to absorb the shocks of the water hammer effect. The pump basement has to be carefully design because it is subject to the fatigue of the water hammer effect and is very difficult to maintain without stopping the pump from running. The delivery pipe conducts the water from the pump to the storage tank. The storage tank is used to hold water before it is delivered to communities.

III. EXPERIMENTATION

It includes the procedure for the performance evaluation of the hydraulic ram pump under different operations conditions. The experimental setup consists of a Hydraulic ram having a cylindrical air vessel connected to a small rectangular chamber through a non returning valve. A waste valve is also provided in the rectangular chamber to discharge the excessive water to the collecting tank. The chamber is connected to an elevated supply tank. A delivery pipe is connected to the foot of air chamber to deliver the water to collecting tank to measure the discharge delivered by the ram.

The hydraulic ram pump under test was first checked to have the leak proof suction line. The supply tank was filled with the clear water up to a top of the header tank and was maintained throughout the experiment. The hydraulic ram pump under test was then run at the normal conditions. While starting the pump in the beginning, the discharge valve was kept closed to develop the full head under no load conditions. The valve was then open gradually to prevent the sudden surge in the discharge line.

Once the operating conditions ware established the actual test was performed. In order to conduct the test to find out the efficiency of hydraulic ram pump, the volume of waste water and the volume of useful water at different pressure head ware recorded. There was no change in the water level of supply tank throughout the experiment.

While taking the observations to determine the efficiency of hydraulic ram pump, the discharge valve was set at the maximum opening and the observations at different pressure head were recorded. The same time, for a particular pressure head the observations were taken at different discharge rates also by regulating the discharge valve. The same process was repeated for the different pressure heads to get the observations of waste water flow rate and useful water flow rate of hydraulic ram pump.

These are the following governing equations for calculating amount of water pumped per day.

For discharge of waste water:

$$R = \frac{R_2 - R_1}{100} \quad \text{...(1)}$$

Where,

R = rise of water level in measuring tank in time ($\Delta t = t_2 - t_1$), cm

R_1 = initial level of water in measuring tank at time t_1, cm

R_2 = final level of water in measuring tank at time t_2, cm

$$Q = \frac{R \times A}{\Delta t} \quad \text{...(2)}$$

Where,

Q = discharge of waste water, m^3/sec.

R = rise in water level of water measuring tank of waste water, m

A = area of measuring tank (0.42m x 0.289m)

Δt = time taken for R, sec

For discharge of useful water:

$$r = \frac{r_2 - r_1}{100} \quad \text{...(3)}$$

Where,

r = rise of water level in time Δt ($\Delta t = t_2 - t_1$), cm

r_1 = initial level of water in measuring tank at time t_1, cm

r_2 = final level of water in measuring tank at time t_2, cm

$$q = \frac{A\ X\ r}{\Delta t} \quad \text{...(4)}$$

Where,

q = discharge of useful water, m^3/sec

Δt = time taken for collecting useful water(r), sec

D' Aubuisson's efficiency

$$\eta_a = \frac{q h_d}{(Q+q) h_s} x100 \quad \text{...(5)}$$

Rankine's Efficiency

$$\eta_r = \frac{q(h_d - h_s)}{Q h_s} x100 \quad \text{...(6)}$$

Where,

η_a = D' Aubuisson's efficiency of hydraulic ram pump, per cent (%)

η_a = Rankine's efficiency of hydraulic ram, per cent (%)

h_s = height of water in supply tank, m

h_d = delivery head, m

Q = discharge of waste water, m^3/s

q = discharge of useful water lifted up, m^3/s

IV. RESULT AND ANALYSIS

After performing the test on hydraulic ram pump we got following results for different operating conditions. Waste water discharge increases and varies from 2.33 x 10^{-4} m^3/sec. to 3.43 x 10^{-4} m3/sec with maximum value of 3.43 x 10^{-4} m3/sec at 3.52 kg/cm^2 pressure and useful water discharge decreases from 0.263 x 10^{-4} m^3/sec. to 0.046 x 10^{-4} m^3/sec with maximum value of 0.263 x 10^{-4} m^3/sec at 0.71 kg/cm^2 of operating pressure.

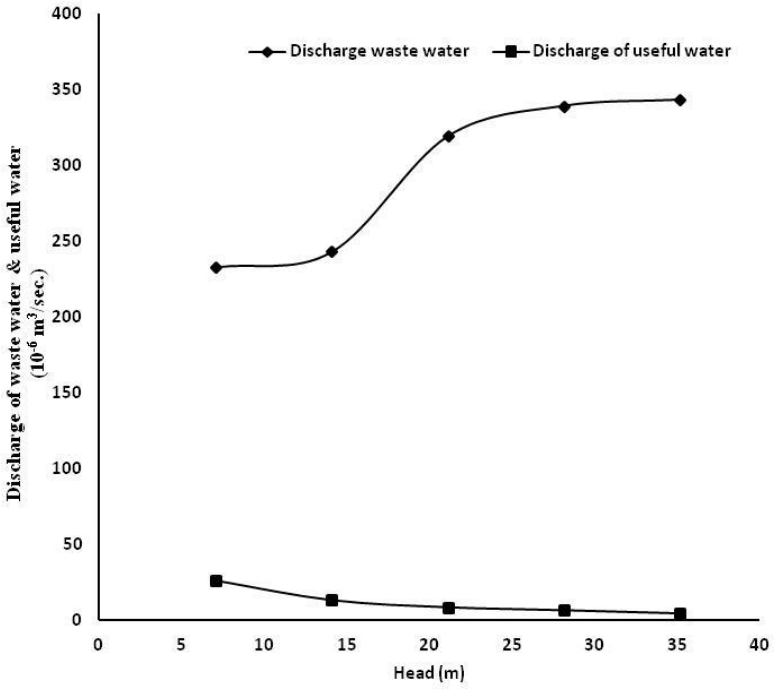

Fig: 1 Relationship between head and discharge

Hydraulic ram pump has a maximum efficiency of D' Aubussion's efficiency and Rankine's efficiency 51.49% and 48.88% and a minimum efficiency of D' Aubussion's efficiency and Rankine's efficiency 33.23% and 32.34% for a pressure range of 0.70 to 3.52 kg/cm^2 respectively. However, the highest efficiency was not obtained at highest discharge although thelowest efficiency was obtained at lowest discharge.

Characteristic curves of hydraulic ram working under conditions of constant waste valve lift, constant supply head and varying delivery head. With increase of delivery head the number of impulse frequency beats increases. Keeping the input unaltered, as the head increases the quantity of useful water per beat decreases. With increase in head the waste water per beat decreases slightly.

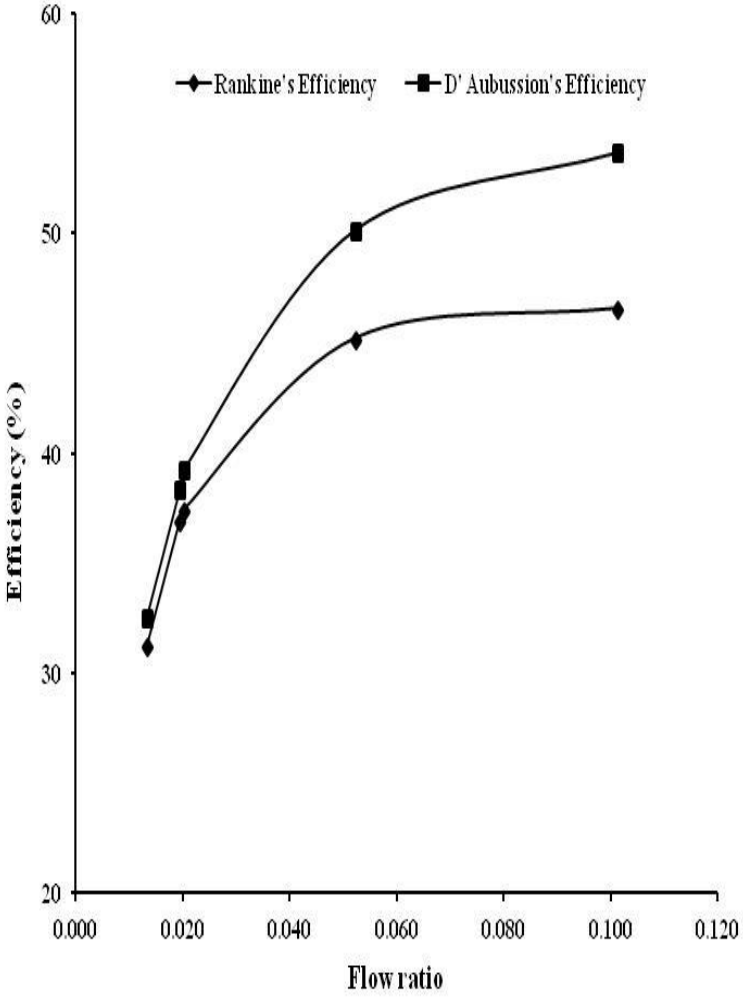

Figure 2: Relationship between flow ratio and efficiency

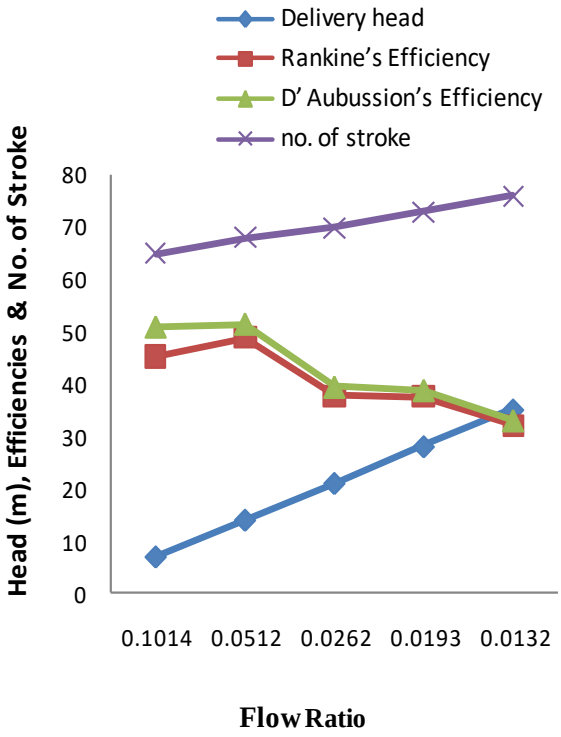

Figure 3: Characteristic curves of hydraulic ram pump

V. CONCLUSION

We concluded that hydraulic ram pump have a maximum efficiency of 51.49 % (D' Aubussion's efficiency) and a minimum of 32.00 % occurring at discharge of 0.134 x 10^{-4} m^3/ sec. and 0.046 x 10^{-4} m^3/ sec respectively. However the pump has a maximum discharge of 0.263 x 10^{-4} m^3/ sec. The pump also has an optimum no. of strokes of 68 beats per minute. The results have also show that as the impulse valve frequency increase the discharge also increases up to an optimum point beyond which the discharges begin to decrease.

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