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RESEARCH PAPER

Performance evaluation of hydraulic ram

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Abstract : A hydraulic ram, is a cyclic water pump powered by hydropower. It takes in a water at one "hydraulic head" (pressure) and flow rates and outputs water at a higher hydraulic head and lower flow rate. The device uses water hammering effect to develop pressure and allows a portion of input water that powers a pump to be lifted to a point higher than the water originally started. The hydraulic ram was developed using the materials such as PVC pipe, swing check valve, PVC elbow, PVC tee, threaded fittings, plastic bottle, rubber pipe, hose connector valve, etc. The developed hydraulic ram was tested for its performance for different supply heads, such as 0.5 m, 1.0 m, 1.5 m and 2.0 m, respectively. Maximum discharge of 3.84 l/min was obtained at 3 m delivery head of 2 m supply head. The maximum efficiency of 67.00 per cent was obtained at 0.5 m supply head with 1.5 m delivery head.

Key Words : Hydraulic, Ram, Performance, Head, Supply, Delivery

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INTRODUCTION

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 is an alternative pumping device that is relatively simple technology that uses renewable energy (Balgude *et al.*, 2015). A hydraulic ram uses energy from a falling quantity of water to pump some of it to an elevation much higher than the original level at the source. No other energy is required and as long as there is a continuous flow of falling water, the pump will work continuously and automatically (Satyanarayaana *et al.*,2016). It improves crop production, extensive landscaping and gardening. But with the advent of electrical pumps and fossil fuel operated engines, interest in using the hydraulic ram became dormant (Shende *et al.*, 2015). Cost was the major factor in the growth of ram use. Not only was the machine inexpensive to buy, but it also was simple to install and they were almost maintenance free (Arnold *et al.*, 2007).

Hydraulic ram is mechanical source of pollster that converts mechanical power into hydraulic energy. When a hydraulic ram operates, it creates a vacuum at the pump inlet which forces liquid from the reservoir into the inlet line. Mechanical action delivers this liquid to the pump outlet and forces it in to the hydraulic system (Pathak *et al.*, 2016). Hydrostatic pumps are positive displacement pumps which are of various types, working on the principle of Pascal's law. It is stated that, "the

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pressure at one point of the enclosed liquid is in equilibrium with the rest of the liquid transmitted equally to all points of the liquid unless effect of gravity is neglected" (Swankar and Singh, 2013).

The hydraulic ram is a natural technology, used over the last two centuries. However, in those days, they used the most complicated design of the pump. Due to this, more time and investment was required to use this technology. Now-a-days it is designed in a simple manner with a simple design and by using the locally available materials. This helps to increase the use of this ram pump locally (Sheikh *et al.*, 2013). Electric pumps are very costly due to their complicated design and manufacturing. In rural areas, there is always problem of load shedding. At that time, electric pump cannot be used. Automatic hydraulic ram pump is found to be more beneficial for such place, as it does not require electricity or any other source of energy to operate. Therefore, growing and simplifying the technology in irrigation is more helpful to the farmers (Sakhare, 2016). Hydraulic ram uses the principle of water hammering *i.e.* considering the water is flowing with its own kinetic velocity through the pipe (Sampath *et al.*, 2015). As the flow is suddenly stopped, it creates the back pressure waves which helps to compress the air in the pressure chamber. Using the kinetic energy of flowing water, inlet source on some height with higher flow rate, give outputs water at a higher outlet head and lower flow rate (Yang *et al.*, 2014).

Material and Methods

Fig. A shows the developed hydraulic ram using the materials such as PVC pipe, swing check valve, PVC elbow, PVC tee, threaded fittings, plastic bottle, rubber pipe, hose connector valve, etc.

Performance evaluation of developed hydraulic ram:

The developed hydraulic ram was tested for its performance for different heads, such as 0.5 m, 1.0 m, 1.5 m and 2 m, respectively. The discharge was measured at the outflow of different combinations of delivery heads. Also, the discharge at respective supply heads was measured and the efficiency was determined using the following formula:

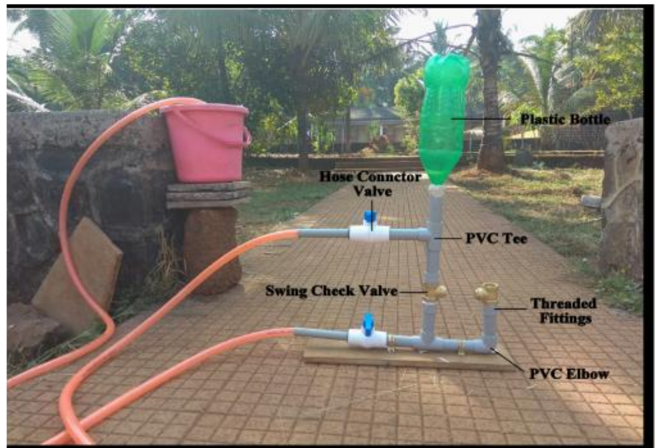

Fig. A : Developed hydraulic ram

$$\eta = \frac{Q \times H}{q \times h} \times 100$$

where,
η = Efficiency (%)
Q = Discharge at delivery head (l/min)
H = Delivery head (m)
q = Discharge at drive pipe (l/min)
h = Supply head (m).

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

For the supply head 0.5 m:

Table 1 shows the discharge (l/min) for various

Table 1: Discharge (l/min) for various delivery heads with 0.5 m supply head

Elevation difference (m)	Delivery head (m)	Discharge (l/min)	Efficiency (%)
1.00	1.5	1.10	66
1.50	2	0.84	67.20
2.00	2.5	0.49	49
2.50	3	0.42	50.40
3.00	3.5	0.30	42
3.50	4	0.18	28.80

delivery heads by increasing corresponding elevation difference by 0.5 m each, for 0.5 m supply head. From Fig. 1, it is observed that the discharge decreases gradually as the head increases. The maximum discharge 1.1 l/min was obtained at 1.5 m delivery head and the minimum discharge 0.18 l/min was obtained at 4 m delivery head.

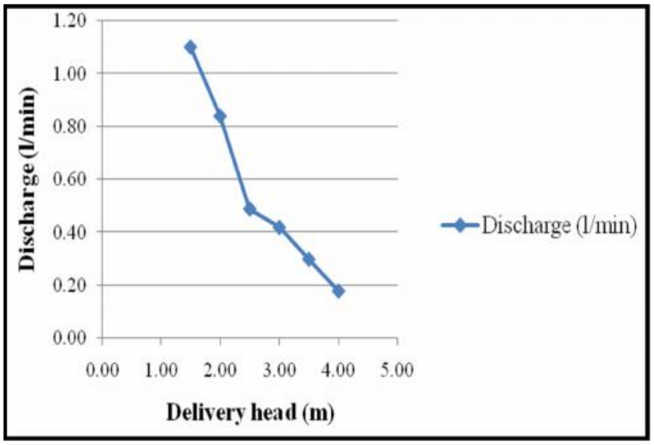

Fig. 1 : Graph of discharge (l/min) vs delivery head (m)

Fig. 2 shows the efficiencies (%) for various delivery heads with 0.5 m supply head. The maximum efficiency 67.20 per cent was obtained at 2 m delivery head and the minimum efficiency 28.80 per cent was obtained at 4 m delivery head.

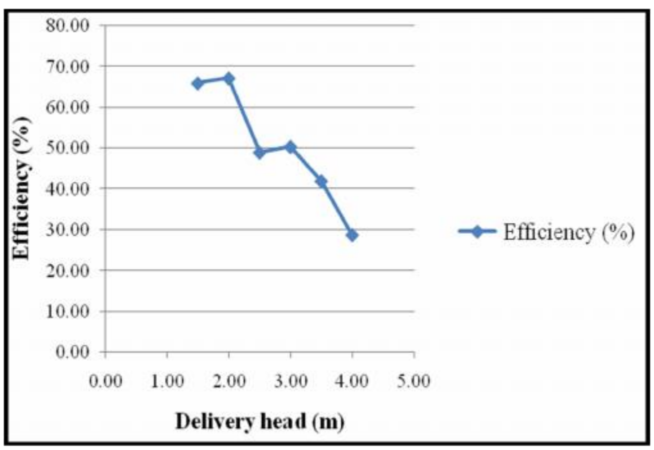

Fig. 2 : Graph of efficiency (%) vs delivery head (m)

For the supply head 1 m:

Table 2 shows the discharge (l/min) for various delivery heads by increasing corresponding elevation difference by 0.5 m each, for 1 m supply head. From Fig. 3, it is observed that the discharge decreases gradually as the head increases. The maximum discharge 1.64 l/min was obtained at 2 m delivery head and the minimum discharge 0.56 l/min was obtained at 4.5 m delivery head.

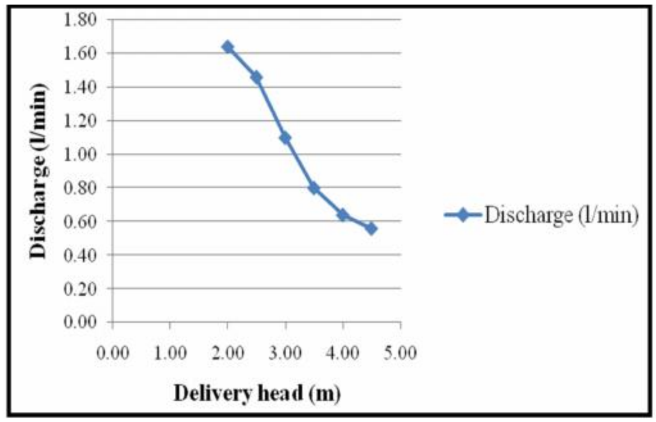

Fig. 3 : Graph of discharge (l/min) vs delivery head (m)

Fig. 4 shows the efficiencies (%) for various delivery heads with 1 m supply head. The maximum efficiency 45.63 per cent was obtained at 2.5 m delivery head and the minimum efficiency 31.50 per cent was obtained at 4.5 m delivery head.

For the supply head 1.5 m:

Table 3 shows the discharge (l/min) for various delivery heads by increasing corresponding elevation difference by 0.5 m each, for 1.5 m supply head. From Fig. 5, it is observed that the discharge decreases gradually as the head is increased. The maximum discharge 3.32 l/min was obtained at 2.5 m delivery head

Table 2: Discharge (l/min) for various delivery heads with 1 m supply head

Elevation difference (m)	Delivery head (m)	Discharge (l/min)	Efficiency (%)
1	2	1.64	41
1.5	2.5	1.46	45.63
2	3	1.1	41.24
2.5	3.5	0.8	35
3	4	0.64	32
3.5	4.5	0.56	31.50

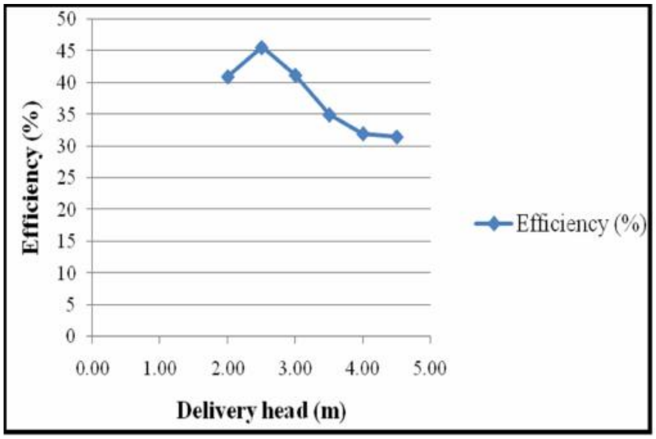

Fig. 4: Graph of efficiency (%) vs delivery heads (m)

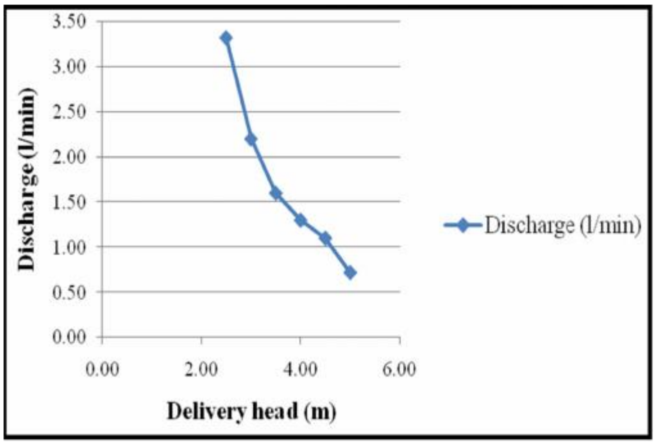

Fig. 5 : Graph of discharge (l/min) vs delivery head (m)

and the minimum discharge 0.72 l/min was obtained at 5 m delivery head.

Fig. 6 shows the efficiencies (%) for various delivery heads with 1.5 m supply head. The maximum efficiency 55.33 per cent was obtained at 2.5 m delivery head and the minimum efficiency 24 per cent was obtained at 5 m delivery head.

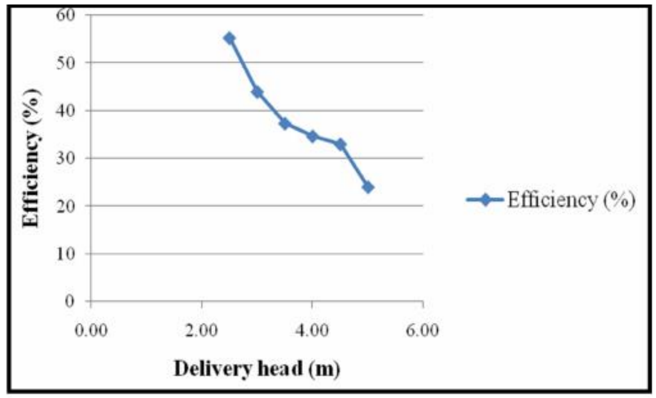

Fig. 6: Graph of efficiency (%) vs delivery heads (m)

For the supply head 2 m:

Table 4 shows the discharge (l/min) for various delivery heads by increasing corresponding elevation difference by 0.5 m each, for 2 m supply head. From Fig. 7, it is observed that the discharge decreases gradually as the head is increased. The maximum discharge 3.84 l/min was obtained at 3 m delivery head

Table 3: Discharge (l/min) for various delivery heads with 1.5 m supply head

Elevation difference (m)	Delivery head (m)	Discharge (l/min)	Efficiency (%)
1.00	2.5	3.32	55.33
1.50	3	2.20	44.00
2.00	3.5	1.60	37.33
2.50	4	1.30	34.67
3.00	4.5	1.10	33.00
3.50	5	0.72	24.00

Table 4: Discharge (l/min) for various delivery heads with 2 m supply head

Elevation difference (m)	Delivery head (m)	Discharge (l/min)	Efficiency (%)
1.00	3	3.84	44.00
1.50	3.5	3.44	46.30
2.00	4	2.90	44.60
2.50	4.5	2.24	38.76
3.00	5	1.90	36.53
3.50	5.5	1.46	30.88

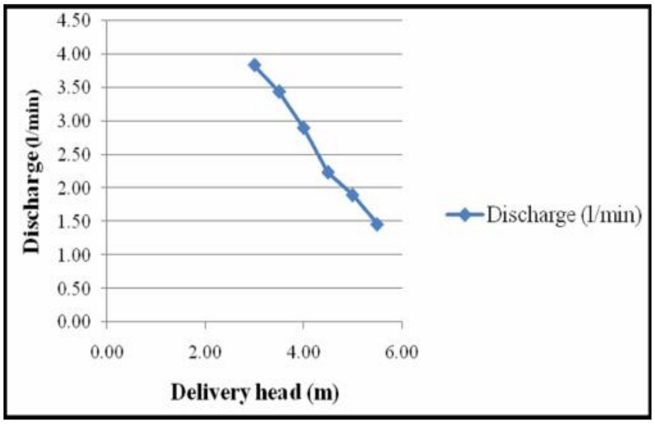

Fig. 7 : Graph of discharge (l/min) vs delivery head (m)

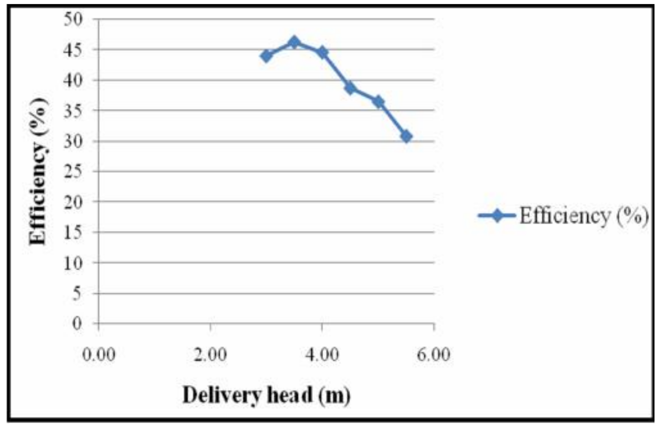

Fig. 8: Graph of efficiency (%) vs delivery heads (m)

and the minimum discharge 1.46 l/min was obtained at 5.5 m delivery head.

Fig. 8 shows the efficiencies (%) for various delivery heads with 2 m supply head. The maximum efficiency 46.30 per cent was obtained at 3.5 m delivery head and the minimum efficiency 30.88 per cent was obtained at 5.5 m delivery head.

Conclusion:

– For 0.5 m supply head maximum discharge of 1.1 l/min was obtained at 1.5 m delivery head and the minimum discharge of 0.18 l/min was obtained at 4 m delivery head.

– For 1 m supply head, maximum discharge of 1.64 l/min was obtained at 2 m delivery head while the minimum discharge of 0.56 l/min was obtained at 4.5 m delivery head.

– For 1.5 m supply head, maximum discharge of 3.32 l/min was obtained at 2.5 m delivery head and the minimum discharge of 0.72 l/min was obtained at 5 m delivery head.

– For 2 m supply head, maximum discharge of 3.84 l/min was obtained at 3 m delivery head while the minimum discharge of 1.46 l/min was obtained at 5.5 m delivery head.

– The maximum efficiency of 67.00 per cent was obtained at 0.5 m supply head with 2 m delivery head and minimum efficiency of 24.00 per cent was obtained at 1.5 m supply head with 5 m delivery head.

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