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Comparative Study of Analytical Treatment for HYDRAM

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ABSTRACT

This paper describes analytical & mathematical treatment of hydraulic ram pump. It includes two methods of mathematical calculation which is being made for obtaining output parameter of hydraulic ram pump or HYDRAM like discharge at delivery head 'Qd' etc, by using various combinations of independent design parameters. Within these Method-1 includes use of various fluid imperial formulas for flow calculation. Method-2 includes use of mathematical model equations for obtaining complete behavior of flow. Finally comparison between results of these two methods has been carried out for further conclusion.

KEYWORDS: *HYDRAM, Hydraulic ram pump, Delivery head, Mathematical model.*

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I. INTRODUCTION

A hydraulic ram (also called HYDRAM) is a pump which 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 external is required and as long as there is a continuous flow of falling water, the pump will work continuously and automatically. 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 pump (HYDRAM) is an alternative pumping device that is relatively simple technology that uses renewable energy, and is durable.

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. An air chamber is necessary to prevent these high intermittent pumped flows into a continuous stream of flow. The air valve allows air into the HYDRAM to replace the air absorbed by the water due to the high pressures and mixing in the air chamber.

II. Literature review

1. The paper entitled by Piyush B. Shende, A. P. Ninawe, & Dr. S. K. Choudhary, is studied the design of HYDRAM, basic concepts of HYDRAM and analytical calculation using individual head losses of HYDRAM with the related search. The study specifies individual head losses influencing the efficiency of the HYDRAM. These are based on a systematic study of the all parameters affecting the HYDRAM.
2. The paper entitled by Abhinav P.Ninawe, Dr. C.C.Handa, Dr.A.V.Vanalkar studied that for new developed Hydraulic Ram pump actual experimental data is recorded and executed as per the approach suggested by Hilbert Schenk Jr. Also various proper implementation of experimentation of dependent and independent parameters are identified. Various variables using dimensional analysis, test planning, design of experimental set-up etc is described in detail.

3. The paper entitled by Dr. C.C. Handa, A. P. Ninawe and Seemin Sheikh is studied that 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 common forms for lots of its performance limitations. This type of pump is a blessing to rural areas, farmers and middle class for its zero running cost.
4. Shuaibu Ndache MOHAMMED is studied that the design and fabrication of a Hydraulic Ram Pump is undertaken. It is meant to lift water from a depth of 2m below the surface with no other external energy source required.
5. Sudipto Shekhor Mondol is studied that, A hydraulic ram is a pump in which the momentum of a driving stream of water undergoing a small head drop is used to pump a small portion of the stream to a head considerably greater than that of the supply. In the current study, a hydraulic ram was designed, manufactured and tested.

III. Methodology

Within these two different methods of flow calculation have been used.

A. Method-1

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:

Sample Calculations

By taking reference of research paper [1]

Nomenclature- Hs= Supply head, Hd= Delivery head, ds= Diameter of drive pipe,Dd= Diameter of delivery pipe, Ld= Length of drive pipe, ld= Length of delivery pipe, dwv= Diameter of waste valve, Q= Volumetric flow rate, A= Area of pipe, V= Supply velocity

The following factors need to be considered in hydraulic Ram pump system design.

Supply head (Hs) =3 ft., Diameter of drive pipe=3", Diameter of delivery pipe= 1.5"

1. Supply Rate

   Q=AxV=18.5 lit/sec

2. Velocity Of Supply

   $$Vd=\frac{Q}{Ad}=4.056 \text{ m/sec}$$

3. Reynolds Number

   $$Re=\frac{Vd}{\upsilon}=309067 \quad Re>4000$$

Flow is turbulent. Hence selecting the value of friction coefficient as follows.

For smooth pipe Blasins suggest that for turbulent flow

$$F=\frac{0.316}{Re^{0.25}}=0.013 \quad \text{friction factor of pipe.}$$

L\D=500

4. Head Losses= $Fx\frac{L}{D}x\left[\frac{V^2}{2g}\right]=3.4\text{m}$

   Length of drive pipe Ld =500x76.2=38.1m

5. Velocity of fluid flow in T junction

   $$Vt=\frac{Q}{At}=4.056 \text{ m/sec} \quad \text{(Waste valve dia.=3")}$$

6. Losses due to sudden enlargement at T junction

   $$Ht=\frac{(Vd-Vt)}{2g}=0.1\text{m}$$

7. Other Miscellaneous Losses

   $$Hl=Kt\ X\ \frac{(Vt^2)}{2g}=0.07\text{m}$$

   Acceleration in driven pipe,

   $$H\text{-}F\ x\ \frac{L}{D}x\left[\frac{V^2}{2g}\right]\text{-}\Sigma\ K\ X\frac{(V^2)}{2g}=\frac{L}{D}X\ \frac{dv}{dt},\ \frac{dv}{dt}=-6.85\ X10^{-3}$$

   The drag force is given by

   $$Fd=Cd\ x\ A\ x\ \rho\ x\ \frac{Vt^2}{2g}=4.28\text{ N}$$

   Accelerating force Fa= ρ x A x L x$\frac{dv}{dt}$ = -1.19N

8. Required power can be given by

   P= ρgQHd = 276.58 w

9. Efficiency $\eta=\frac{Qh}{(Q+Qw)Hd}=20.05\ \%$

   h = Hd-Hs = 0.6096, Qw = AtxVt =0.0184

10. Delivery flow rate

    $$Qd=\frac{\eta\ xQxHs}{Hd}=2.2\text{ lit/sec}$$

On similar way number of observation calculated and tabulated as per below.

Calculation Table

Table-1- Analytical calculation table

So no	Input Parameters				Output Parameters			
	Supply Head (ft)	Drive pipe dia. (mm)	Waste valve dia. (mm)	Delivery head(m)	Supply Rate (m^3/sec)	Velocity Of Supply m/s	Delivery Flow Rate l/s	Efficiency %
1	3	76.2	76.2	5	18.5x10-3	4.056	2.22	20.05
2	3	76.2	76.2	5.2	18.5x10-3	4.056	2.26	21.21
3	3	76.2	76.2	5.4	18.5x10-3	4.056	2.29	22.28
4	3	76.2	76.2	5.6	18.5x10-3	4.056	2.31	23.28
5	3	76.2	76.2	5.8	18.5x10-3	4.056	2.32	24.2
6	3	76.2	76.2	6	18.5x10-3	4.056	2.32	25.07
7	3	76.2	76.2	6.2	18.5x10-3	4.056	2.32	25.88
8	3	76.2	76.2	6.4	18.5x10-3	4.056	2.31	26.63
9	3	76.2	76.2	6.6	18.5x10-3	4.056	2.3	27.35
10	3	76.2	76.2	6.8	18.5x10-3	4.056	2.29	28.02

B. Method-2

Many researchers have made deep research for complex flow analysis. Using these exhaustive research they have obtain empirical relation & mathematical modeling which help to understand complex behavior of existing HYDRAM.

By taking reference of research paper [2]

Nomenclature- Qd= Quantity of water delivered, QW= Quantity of water wasted.

$$(Q_d) = 2.88\ x_{10^{-7}}.\left(g^{1/2}.h^{5/2}\right)\left(\left(\frac{d_s.L_s.d_{wv}.d_d L_d}{(h)^5}\right)^{0.5529}\left(\frac{d_A.L_A}{h^2}\right)^{0.0535}\left(\frac{H_d}{h}\right)^{-2.0119}\left(\frac{\rho_p}{\rho_w}\right)^{16.2891}\right)$$

$$(QW) = 1.274\ x_{10^{-13}}\left(g^{1/2}.h^{5/2}\right)\left\{\left(\frac{d_s.L_s.d_{wv}.d_d L_d}{(h)^5}\right)^{0.976}\left(\frac{d_A.L_A}{h^2}\right)^{-0.057}\left(\frac{H_d}{h}\right)^{0.5473}\left(\frac{\rho_p}{\rho_w}\right)^{70..831}\right\}$$

Table-2- Mathematical model input parameter table

SR. NO	ds(m)	Ld(m)	Dwv(m)	Dd(m)	ld(m)	dA(m)	LA(m)	Hd(m)	h(m)	ρp	ρw
1	0.0762	38.1	0.0762	0.038	19.05	0.1016	0.5121	1.5239	0.61	1467	1000
2	0.0762	38.1	0.0762	0.038	19.05	0.1016	0.5121	1.5849	0.67	1467	1000
3	0.0762	38.1	0.0762	0.038	19.05	0.1016	0.5121	1.6458	0.73	1467	1000
4	0.0762	38.1	0.0762	0.038	19.05	0.1016	0.5121	1.7068	0.79	1467	1000
5	0.0762	38.1	0.0762	0.038	19.05	0.1016	0.5121	1.7678	0.85	1467	1000

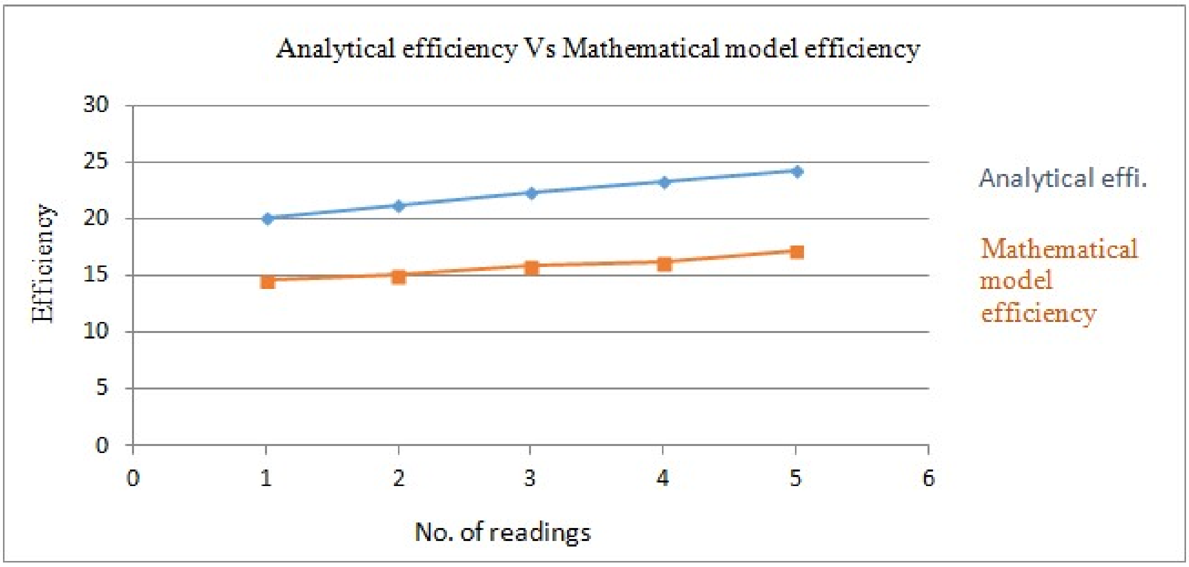
By substituting the value in equation efficiency is calculated.

IV. Comparison table for Analytical efficiency Vs Mathematical model efficiency

Table-3 Comparison table

Sr. No	Analytical Efficiency	Mathematical Efficiency
1	20.05	14.6
2	21.21	15.1
3	22.28	15.9
4	23.28	16.2
5	24.2	17.2

V. Graph



VI. Conclusion

By considering average losses it is seen that performance of the HYDRAM flow affected drastically. By varying the delivery head will change the outlet discharge. Therefore optimum dimension could be determined by experimentation. For this it is found that, using analytical and mathematical modeling equations, various output parameter can be easily predict for different combination of various input parameters for HYDRAM.

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