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Design and Analytical Calculation for a Hydram using Individual Head Losses

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Abstract

This paper presents 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.
Keywords: Hydram, Individual Head Losses, Efficiency, Parameters Affecting Hydram

I. INTRODUCTION

A. Design Components

(Combination of galvanized and PVC as indicated).

- 2” 40 PVC Pipe.
- 2” PVC Pipe Cap. (Rounded high pressure, not waste grade).
- 2” slip to 1.5” female pipe thread PVC reducer / adaptor.
- Main body T (4”)
- Taper openings (2” and 1.5”)
- GI pipe nipples (2”, 1.5” and 1”)
- GI Coupler (1.5”, 2”)
- Reducer (2”-1.5”, 1.5”-1”)
- Adapter (2”)
- Ball (40mm)
- GI T (1.5mm)
- Waste valve (4”)
- Aluminum piston (70mm)
- Piston rod (20mm)
- Lock Clip with washer
- Delivery pipe (1”)
- Teflon thread tape

B. Part Specification

Table – 1
Part Specification

Sr. no	*Parts used*	*Material*	*Dimensions*	*Quantity*	*Machine used*
1	*Main body T*	*M S*	*4’’*	*1*	*Lathe*
2	*Waste valve*	*M S*	*4’’*	*1*	*CNC,EDM*
3	*Taper opening*	*M S*	*2” and 1.5”*	*2*	*Lathe*
4	*Piston disc*	*Aluminum*	*70 mm*	*1*	*CNC, Drilling and lathe m/c*
5	*Piston rod*	*M S*	*20 mm*	*1*	*Lathe*
6	*Lock nut*	*M S*	*22 mm*	*2*	*Tapping wrench and taps*
7	*O ring*	*Rubber*	*70 mm*	*2*	*-*

Above table indicates the various parts used and its altogether specifications. In the fabrication process of ram pump the operation sequence required is first of all estimated and according to that the various materials is supplied to the machine.

In the fabrication of the above shown model lathe machine, drilling machine, EDM, and CNC machines are used. For fabrication of the window of waste valve a special type of EDM machine is used for having its advantage of fine cutting operation.

Fig. 1: Parts used

Fig. 2: Assembly of Hydraulic Ram Pump

II. SAMPLE CALCULATIONS

Nomenclature- Qs=supply rate, A= area of pipe, Vs=supply velocity, Vd= velocity through deliver pipe, Ad= area of drive pipe, Dwv= dia. Of waste valve, At=area of T-section, Awv=area of waste valve, Hd=delivery head, Hs= supply head, Qw= rate of water through waste valve.

A. The volumetric discharge from the drive pipe is given by

$$Qs = (nL\pi r^2) \div 60$$
$$= (49 \times 6 \times \pi \times 0.05^2$$
$$= 9.62 \times 10^{-3}\ m^3/s$$

B. The Velocity of Fluid Flow in the Supply Pipe is given by

$$Vs = Cv \times \sqrt{2gHs}$$
$$= 0.96 \times \sqrt{2 \times 9.81 \times 1.4}$$
$$= 5.03\ m/s$$

C. The velocity of fluid flow in the delivery pipe is given by

$$Vd = Cv \times \sqrt{2gHd}$$
$$= 0.96 \times \sqrt{2 \times 9.81 \times 2.5}$$
$$= 6.72\ m/s$$

D. Discharge through delivery pipe is given by

$$Qd = Ad \times Vd$$
$$= \frac{\pi}{4} \times 0.025^2 \times 6.72$$
$$= 3.92 \times 10^{-3}\ m^3/s$$

E. Discharge through waste valve is given by

$$Qw = Qs - Qd$$
$$= (9.62 - 3.29) \times 10^{-3}$$
$$= 6.33 \times 10^{-3}\ m^3/s$$

F. Velocity of fluid flow in T-junction is given by

$$Vt = \frac{Qw}{At}$$
$$= \frac{6.33 \times 10^{-3}}{\frac{\pi}{4} \times 0.09^2}$$
$$= 1\ m/s$$

G. Losses

1) Head Loss Due to Sudden Enlargement

$$H1 = \frac{(Vs - Vt)^2}{2g}$$
$$= \frac{(5.03 - 1)^2}{2 \times 9.81}$$
$$= 0.821\ m$$

2) Head loss due to sudden contraction

$$H2 = K \times \frac{Vt^2}{2g}$$
$$= 0.5 \times \frac{1^2}{2 \times 9.81}$$
$$= 0.025\ m$$

3) Head loss at inlet

$$H3 = K \times \frac{Vs^2}{2g}$$
$$= 0.5 \times \frac{5.03^2}{2 \times 9.81}$$
$$= 0.644\ m$$

4) Head loss at outlet

$$H4 = \frac{Vd^2}{2g}$$
$$= \frac{6.72^2}{2 \times 9.81}$$
$$= 0.644\ m$$

5) Head loss due to pipe fittings

$$H5 = Kt \times \frac{Vt^2}{2g}$$
$$= 1.18 \times \frac{1^2}{2 \times 9.81}$$

6) Coefficient of friction is given by

$$f = \frac{0.079}{Re^{1/4}}$$
$$= \frac{0.079}{(2.51 \times 10^5)^{1/4}}$$
$$= 0.0035$$

7) Re (Reynolds number) can be determined by

$$\mathrm{Re} = \frac{\mathrm{Vs} \times \mathrm{Vd}}{10^{-6}}$$
$$= \frac{5.03 \times 0.05}{10^{-6}}$$
$$= 2.51 \times 10^{5}$$

8) Water acceleration in the driven pipe, this acceleration is given by

$$\mathrm{H} - \mathrm{f}\frac{\mathrm{L}}{\mathrm{Ds}} \times \frac{\mathrm{Vs}^2}{2\mathrm{g}} - \sum \mathrm{Headloss} = \frac{\mathrm{L}}{\mathrm{Ds}} \times \frac{\mathrm{dv}}{\mathrm{dt}} 1.4 - 0.54 - (0.82 + 0.02 + 0.64 + 2.3 + 0.06) = \frac{6}{0.05}\frac{\mathrm{dv}}{\mathrm{dt}}\frac{\mathrm{dv}}{\mathrm{dt}}$$
$$= 0.02\,\mathrm{m}^2/\mathrm{s} \quad (-\mathrm{ve})$$

9) Drag force given by equation

$$\mathrm{Fd} = \mathrm{Cd} \times \mathrm{At} \times \rho \times \frac{\mathrm{Vt}}{2\mathrm{g}} \quad = 1.12 \times \frac{\pi}{4} \times 0.09^2 \times 1000 \times \frac{1}{2 \times 9.81} \quad = 0.36\ \mathrm{N}$$

10) The force that accelerates the fluid is given by

$$\mathrm{F} = \mathrm{m} \times \mathrm{a} = \rho \times \mathrm{As} \times \mathrm{L} \times \frac{\mathrm{dv}}{\mathrm{dt}}$$
$$= 1000 \times \frac{\pi}{4} \times 0.05^2 \times 6 \times 0.02$$
$$= 0.23\ \mathrm{N}\ (-\mathrm{ve})$$

11) The pressure at waste valve is obtained by

$$\mathrm{P3} = \frac{\mathrm{F}}{\mathrm{At}}$$
$$= \frac{0.23}{\frac{\pi}{4} \times 0.09^2}$$
$$= 36.13\ \mathrm{N/m^2}$$

12) The power required can k calculated using this expression

$$\mathrm{P} = \rho \times \mathrm{g} \times \mathrm{h} \times \mathrm{Qs}$$
$$= 1000 \times 9.81 \times (2.5 - 1.4) \times 9.62 \times 10^{-3}$$
$$= 103.80\ \mathrm{KW}$$

Where, h = Hd-Hs

13) The efficiency of the hydram is given by

$$\mathrm{efficiency} = \frac{\mathrm{Qd} \times \mathrm{h}}{(\mathrm{Qd} + \mathrm{Qw}) \times \mathrm{Hs}} \times 100$$
$$= \frac{3.92 \times 10^{-3} \times 1.1}{(3.29 + 6.33) \times 10^{-3} \times 1.4}$$
$$= 26.87\%$$

Table – 1
Sample Calculations

SR	*L (m)*	*Hs (m)*	*Hd (m)*	*Ds (mm)*	*Dt (mm)*	*Vs (m/s)*	*Vd (m/s)*	*Qs*10^-3 m^3/s*	*Qd*10^-3 m^3/s*	*Qw*10^-3 m^3/s*	*Vt (m/s*	*P3 (kw)*	*P (kw)*	*%*
1	6	2	4	25	70	6.01	8.50	2.45	1.04	1.41	0.36	14.2	48.06	42.44
2	6	2	4	25	75	6.01	8.50	2.45	1.04	1.41	0.31	12.9	48.06	42.44
3	6	8	15	50	75	12.0	16.4	9.81	8.07	1.74	0.39	375	981.06	71.98
4	6	3	7	55	75	7.36	11.2	0.0118	6.68	5.12	1.15	119	463.03	75.48
5	6	2	4	101	127	6.01	8.50	40.05	17.02	23.03	1.81	246	785.78	42.49
6	15	2	4	101	127	6.01	8.50	100.14	17.02	83.12	6.56	416	1964.7	16.99
7	6	2	4	101	90	6.01	8.50	40.05	17.02	23.03	2.33	482	785.78	42.49
8	6	2	4	101	76	6.01	8.50	40.05	17.02	23.03	5.07	879	785.78	42.49
9	15	2	4	101	90	6.01	8.50	40.05	17.02	83.12	13.0	253	1964.7	16.99
10	15	2	4	101	76	6.01	8.50	100.14	17.02	83.12	18.3	688	1964.7	16.99
11	15	2	4	101	177	6.01	8.50	100.14	17.02	83.12	3.37	136	1964.7	16.99
12	15	1.4	2.5	101	127	5.03	6.72	100.14	0.0134	0.0867	6.84	556	1080.6	10.51
13	15	1.4	2.5	101	177	5.03	6.72	100.14	0.0134	0.0867	3.52	93.4	1080.8	10.51
14	15	3	4.5	101	127	7.36	9.02	100.14	0.0180	0.0821	6.48	415	1473.5	8.99
15	15	3	4.5	101	90	7.36	9.02	100.14	0.0180	0.0821	12.9	237	1473.5	8.99
16	15	5	8	101	127	9.50	12.0	100.14	0.0240	0.0761	6.01	559	2947.1	14.37
17	15	5	8	101	90	9.50	12.0	100.14	0.0240	0.0761	11.2	225	2947.1	14.37

III. Graphs

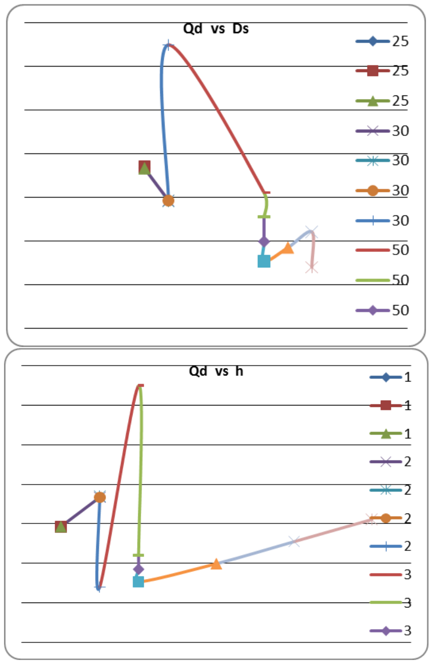

Fig. 1: Graphs

IV. Conclusions

Design of hydram is acceptable for the general uses. Considering individual losses it is seen that performance of hydram flow is drastically affected. It will help to predict losses in complete working system. So that we will try to minimize the losses in curve.

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