# "DESIGN AND ANALYSIS OF HYDRAULIC RAM PUMPING SYSTEM"

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***Abstract:*** This paper give information about the design of hydraulic ram pump for maximum efficiency, theoretical calculation for calculating efficiency, the study gives information about effect of individual head losses influencing the efficiency of hydraulic ram pump by step by step systematic study.it gives information about effect of all parameters on efficiency of hydram. And graph showing relation between heads of supply pipe and drive pipes for a given diameter. This paper gives the hydram design to get maximum efficiency up with min losses. And a model is using CAD (Computer -Aided Design) software . this project covers the calculations of the efficiencies for a design fix dimeter of supply and drive pipes for different heads of supply and delivery pipe. And a comparative study of the relationships between head and discharge of water.

***Index Terms* - . Hydraulic Ram Pump, hydram, Efficiency, Factors and Parameters affecting Efficiency, Supply pipe, Drive pipe, Design specification.**

## I. INTRODUCTION

Hydraulic ram pump us used over hundreds of years to supply the water from source to desired height, it uses the energy of falling water to lift a lesser amount of water to a higher elevation than the source. Hydraulic rams are economical in a comparison with other water lifting devices and it is easy to install, when it installs with proper planning it gives many years of trouble-free service with no pumping costs. For this reason, the hydraulic ram pump is a attractive solution where the large gravity flow is available, Hydraulic ram pumps are time tested technology that use the energy of the large amount of water falling from a small height to lift the small of the water to desired limited height.in this way , water from spring or stream in a valley can be pumped to a village irrigation scheme on hillside. Depending on the difference in height between the inlet piped and outlet pipe, this water pumps will lifts 1-20 of water that flow into it. I general a hydram can lift up to one tenth of received water therefore the loss of water is very high. Since ram pumps can only be used in situations where falling water is available, their use is restricted to three main applications:1) Lifting drinking water from springs to settlements on higher ground.2) Pumping drinking water from streams that have significant slope.3) Lifting irrigation water from streams or raised irrigation channels. A hydram has a tew moving pars are waste valve and delivery (check) valve. the unit is also consisting of air chamber and air valve the operation of the hydram continuous intermittent due to cyclic opening and closing of waste and delivery valve. The closing of the waste valve increase the pressure rise in the drive pipe. An air chamber is required to transfer the high intermittent pumped water flow to the desired height through drive pipes. The air valve allows the air in the ram pump to replace the air absorbed by the water due to high pressure and mixing in the air chamber.so it is a alternative all other devices with relatively simple technology that uses renewable energy, and is durable and it has only two moving parts so it can easy to maintain.

### 1.1 OBJECTIVES

1. To design hydram for maximum efficiency.
2. To lift small portion of minimum water loss.
3. To study performance of hydraulic ram pump with different operating conditions.
4. To find out the efficiency of hydraulic ram pump.
5. To design model using solid works software.
6. To find relation between parameters of hydram.

### 1.2SCOPE OF THE PROJECT WORK:

1. By the use of hydram we can save electrical energy.
2. By providing hydram we can supply water 24x7 to rural as well as urban areas.
3. To pump a small proportion of available flow with a little environmental impact.
4. Simplicity and reliability give a low maintenance requirement.
5. There is a good potential for local manufacture in rural areas.
6. Design of maximum efficiency can be used for installation manufacturing of hydram.

## II. LITURATURE SURVEY

**[1] Er, Indu Bhushan Bhagat (01) (2018)**- in this paper he said that the normal operation range of this pump is 0.5 to10 liters/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.

**[2] Mr. Arude Harshal (2) (2018)-** he said that most in India where villages are situated far away from the water source it is not possible to the people living there to go miles away carrying away the buckets of water. Especially at those places this pump has a much utility because it is cheap, without electricity and easy to maintain. As it requires no external energy other than kinetic energy of flowing water it can be considered as a pump which uses Renewable energy. Though the pump is in use since long time, it is not seen in common forms for lots of its performance limitations. This type of pump is truly a blessing to the rural areas, farmers and middle class for its zero-running cost. The paper after study the literature available, aims to present generalized design methodology for hydraulic ram pump (HYDRAM) covering design parameters, design procedure along with the mathematical relationship used for the design work.

**[3] Dr. CC Handa, AP Ninawe (3)IJESR (2013)-** The availability and cost of electric power is a great concern to common 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 convention energy. Water pump is a more utility item. Today, pumps are the second most commonly used kind of industrial equipment after the electric motors (Working, 1996). 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. The paper after study the literature available aim to present generalized design methodology for hydraulic ram pump (HYDRAM) covering design parameters, design procedure along with the mathematical relationship used for the design work. In this paper contain, introduction, history of ram pump, Review, A generalized design procedure based on the review of different papers is try to summarize here.

**[4] Padekar .A.U.,Gaikawad .A.U, (4) (2015)-** this paper gives information about the designing a recycled hydroelectric power plant by using hydraulic ram pump to transfer the tail race water from turbine to water source which is situated at a higher height this pump uses the kinetic energy for flowing water for its flowing it does not require external energy source. This paper gives an very good example of the use of water wasted after electricity generated water can be lifted again after for reuse it.

**[5] Alireza keramat, Reza fatahi-babak, (5) (2019)-** In this article it they are study about the energy and power changes of hydraulic ram pump were evaluated using using the combination of analytical mode and experimental results. they have also study the dimensional analysis and sensitivity analysis show that length to diameter ratio (L/D) energy ratio of pumping energy to maximum energy due to due to water hammer and sensitivity study is carried out.

**[6] N S M Hussein, S A Gamil, N A M Amin, M J A Safar. (6) (2017)-** This paper they said that the current pumping system (DC water pump) for agriculture is powered by household electricity, therefore, the cost of electricity will be increased due to the higher electricity consumption. In addition, the water needs to be supplied at different height of trees and different places that are far from the water source. The existing DC water pump can pump the water to 1.5 m height but it cost money for electrical source. The hydraulic ram is a mechanical water pump that suitable used for agriculture purpose. It can be a good substitute for DC water pump in agriculture use. The hydraulic ram water pumping system has ability to pump water using gravitational energy or the kinetic energy through flowing source of water. This project aims to analyse and develop the water ram pump in order to meet the desired delivery head up to 3-meter height with less operation cost. The hydraulic ram is designed using CATIA software. Simulation work has been done using ANSYS CFX software to validate the working concept. There are three designs were tested in the experiment study. The best design reached target head of 3 m with 15% efficiency and flow rate of 11.82$l/min$. The results from this study show that the less diameter of pressure chamber and higher supply head will create higher pressure.

## III. RESEARCH METHODOLOGY

**Steps to follow for design and analysis of hydraulic ram pumping system**

**STEP 1:** Consideration of parameters in hydraulic ram pumping design.

1. Area suitability (head and flow rate)
2. Flow rate and head requirement
3. Consideration of design specifications.

**STEP 2: Analytical calculations of design of hydram by individual head losses of hydram with related search..**

1. Calculation of discharge from supply pipe and drive pipe.
2. Calculations of velocity of fluid flow in pipes.
3. Calculation of various losses.
4. Calculation of power required.
5. Calculations of efficiency for given diameter of supply and drive pipe.at different operating conditions for obtaining maximum efficiency of hydram.

**STEP 3: preparation of table of calculations of efficiency obtained along with design parameters.**

**STEP 4: Preparation of graph which shows the relation between the heads of supply and delivery pipe with efficiency.**

In this the we plot a graph between supply heads and delivery head for given design and efficiency for a design diameter of supply and delivery pipes. And check the relation between design parameters.

**STEP 5: design of model using the CAD Software name SOLID WORKS for the parameters of the design of maximum efficiency obtained from calculations.**

## IV. DESIGN SPECIFICATIONS

Table no 1

| Sr No. | Parameters | Design 1<br>Hs= 1.2m<br>Hd = 3m | Design 2<br>Hs= 3.2 m<br>Hd = 6M | Design 3<br>Hs = 5m<br>Hd = 9m |
|---|---|---|---|---|
| 1. | Día Of Supply Pipes (MM) | 25 | 50 | 75 |
| 2. | Día of Delivery pipe (MM) | 12.5 | 25 | 37.5 |
| 3. | Length of Supply Pipe (M) | 0.075 | 0.075 | 0.075 |
| 4. | Speed of Revolution (beats/min) | 96 | 96 | 96 |
| 5. | Kinematic Viscosity (m2/sec) | $1x10^{-6}$ | $1x10^{-6}$ | $1x10^{-6}$ |
| 6. | Density of Water (kg/m3) | 1000 | 1000 | 1000 |
| 7. | Gravitational Constant | 9.81 | 9.81 | 9.81 |

Here, q= Discharge of Delivery Pipe

Q= Discharge for Supply Pipe

Hs =Supply Head

Hd= Delivery Head

## V. CALCULATIONS FOR DESIGN

**Design no 1**

**STEP 1 CALCULATION OF DISCHARGES**

1) Volumetric Discharge from Drive Pipes –

Qs = π r² L×n/60

Qs = 5.89 × 10^-5 m3/sec

2) Velocity of Fluid flowing supply pipe –

Vs = Cv $\sqrt{2gHs}$

$Vs = 0.589 \times \sqrt{2} \times 9.81 \times 1.2$

$Vs = 2.86$ m/sec

3) Velocity of fluid in Delivery Pipe-

$Vd = Cv \times \sqrt{2} \times g \times Hd$

$Vd = 0.589 \times \sqrt{2} \times 9.81 \times 3$

$Vd = 4.51$ m/sec

4) Discharge Through Delivery pipe is given by –

$Qd = Ad \times Vd$

$Qd = \pi/4 \times 0.0125^2 \times 4.51$

Qd = 5.53 × 10^-4 m3/sec

5) Discharge through waste valve is given by –

$Qw = Qs - Qd$

Qw = 5.337 × 10-5 m3/sec

6) Velocity of Fluid Flow in T- Junction –

$Vt = Qw/At$

$Vt = 5.33 \times 10^{-5} / \pi/4 (0.029)^2$

Vt = 0.08 m/sec

**STEP 2 CALCULATION OF LOSSES: -**

1) Head loss due to sudden enlargement $H_1 = (Vs-Vt)^2/2g$

$H_1 = (2.86-0.08)^2/2x9.81$

$H_1 = 0.39$ m

2) Head loss due to sudden contraction $H_2 = K \times Vt^2/2g$

$H_2 = 0.5 \times 1^2/2 \times 9.81$

$H_2 = 0.025$ m

3) Head loss at Inlet $H_3 = K \times Vt^2/2g$

$H_3 = 0.5 \times 2.86^2 /2 \times 9.81$

$H_3 = 0.20$ m

4) Head loss at outlet $H_4 = Vd^2/2g$

$H_4 = 4.52^2 /2 \times 9.81$

$H_4 = 1.03$ m

5) Head loss due to fittings of pipe $H_5 = K_L \times Vt^2/ 2g$

$H_5 = 1.18 \times 0.08^2/2 \times 9.81$

$H_5 = 0.00038$ m

6) Coefficient of friction $f = 0.316/R_e^{0.25} = 0.036$

$R_e = Vd \times Vs / 1 \times 10^{-6} = 1.29x10^5$

7) Water acceleration in the driven pipe

$H- F \times L/Ds \times Vs^2/2g - \in \text{Headloss} = L/ Ds \times dv/dt$

$4.2- (0.036 \times 0.075/0.025 \times 2.86^2/2 \times 9.81) – (0.39 + 0.025 +0.20+1.03+0.00038)$

$dv/dt = 0.162 m^2/sec$ (-ve)

8) Pressure at waste valve

$P_3$ =F/ At = 0.59÷ $\pi$/4 x 0.029

= 25.90 N/$m^2$

Here, Fd = cd x As x $\delta$ x Vt/2g

= 1.12 x $\pi$/4 x $0.029^2$ x 1000 x 0.08/ 2 x 9.81

= 0.31N

F = m x a = $\delta$ x g x h x Qs

= 1000 x $\pi$/4 x $0.025^2$ x 0.075 x 0.162

= 0.59 (-ve)

**STEP 3 CALCULATION FOR POWER REQUIRED**

P = $\delta$ x g x h x Qs

P = 1000 x 9.81 x (3-1.2) x 5.89 x $10^{-5}$

P= 104.0 kw

**STEP 4 CALCULATION FOR EFFICIENCY,**

E = Qd x h/ (Qd+Q)xHs x 100

= 14% by Rankine's formula

= Qd x h / Qs x H

= 26.62% by Aubrisson's Formula

When Hs = 3.2 m

Hd = 6 m

E = 19.97 ≅ 20%

Hs = 5m

Hd = 9m

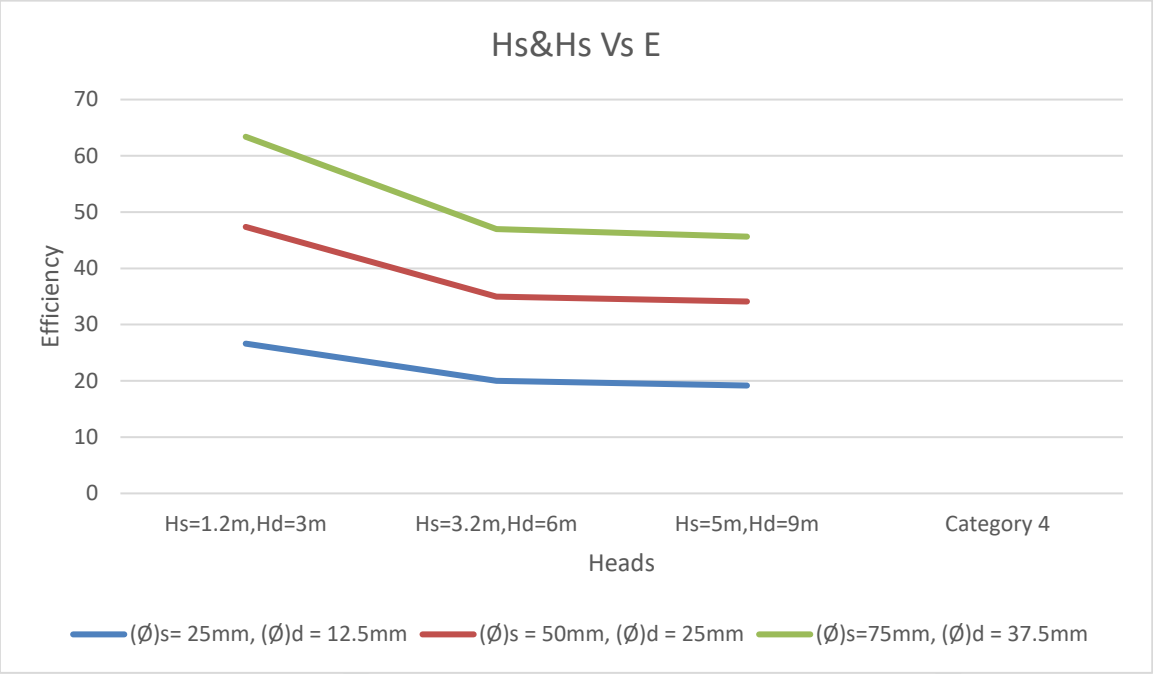
E = 19.17%

This are the calculations to be perform to calculate efficiency of hydram and power required by hydram by using this step of calculation we have also calculate for Design no 2 and Design no 3. result table is formed

**VI. RESULT TABLE :**

| | Design 1 | Design 2 | Design 3 | Design Specification |
|---|---|---|---|---|
| | Hs = 1.2m Hd = 3m | Hs = 3.2m Hd = 6m | Hs = 5m Hd = 9m | |
| Efficiency | 26.62% | 20% | 19.17% | (Ø)s= 25, (Ø)d = 12.5 |
| | 47.37% | 35% | 34.11% | (Ø)s = 50, (Ø)d = 25 |
| | 63.39% | 47% | 45.64% | (Ø)s=75, (Ø)d = 37.5 |

**VI. GRAPH:**




Graph no 1. Heads of supply and delivery VS Efficiency

This is the graphical representation for the Heads of supply and delivery pipe VS Efficiency obtained by design calculations for 3 different design diameter sets.

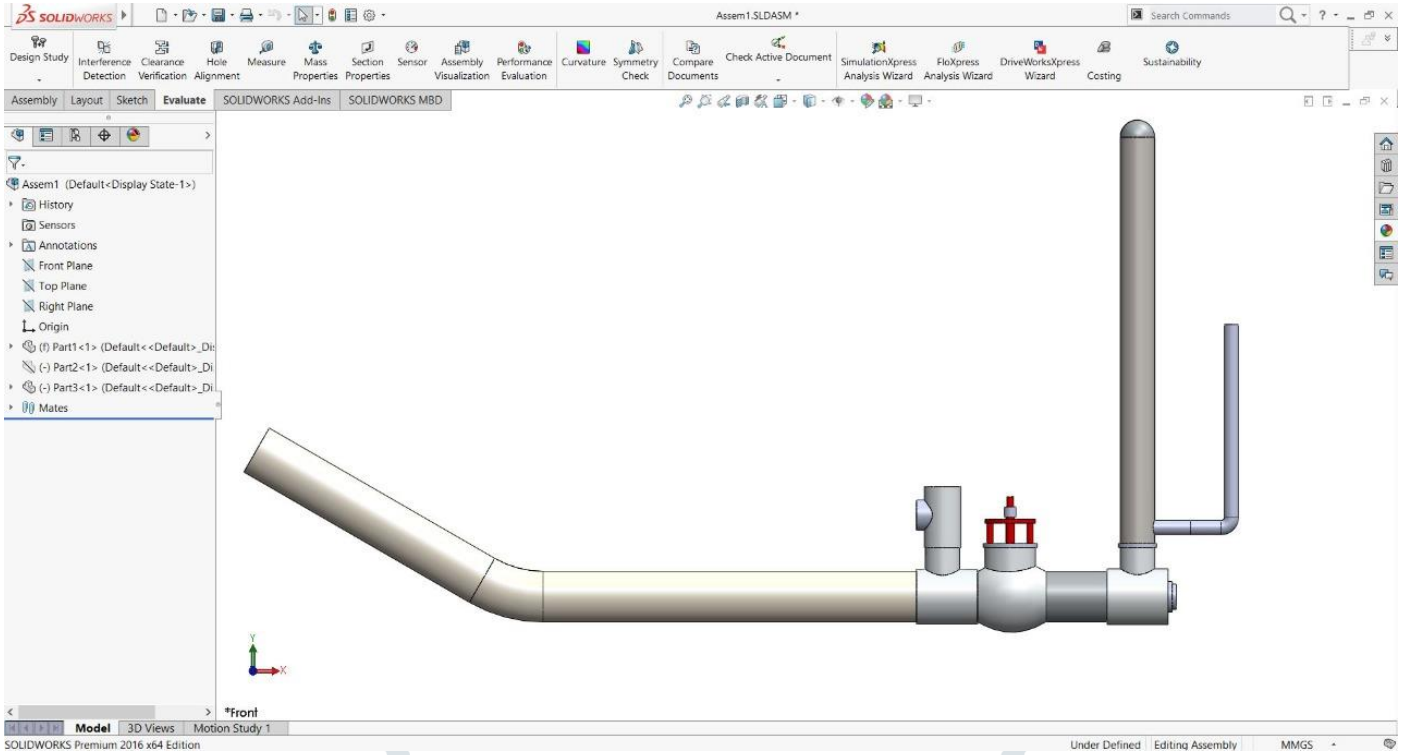
**VII. REPRESENTATION OF MODEL USING CAD SOFTWARE:**

1. Name of software: SOLID WORKS.
2. Version Of Software: Solid works 2020(version no 28)
3. Developer: Dassault systems
4. SOLID WORKS is a worlds engineering and design leading software for product 3D CAD design excellence.
5. It is use to design, simulate, analyze, product data management and manufacture product in the variety of industries including, automotive, consumer goods and industrial machinery.

INPUT PARAMETERS

1. Diameter of supply pipe=75mm
2. Diameter of drive pipe= 37.5mm
3. Supply head Hs=1.2m
4. Delivery head=3m
5. Dimeter of Air vessel=50mm

**PRESENTATION OF MODEL**




**VIII. RESULT:**

By our theoretical design calculation best efficiency (**63 %** , 47% , 45%) obtained at (Ø)s=75mm, (Ø)d = 37.5 mm.

A graph of delivery and supply heads vs Efficiency in% is plotted for given design dimeters of supply and drive pipe.

A model is designed using SOLID WORKS Software.

**IX. CONCLUSION:**

Hydraulic ram pump is easy to operate and it is economical and have very low maintenance cost.

Supply head is important parameter influencing the efficiency of hydram. .

We can obtain maximum efficiency by taking the diameters supply and delivery pipes at a optimum size.

**X. FUTURE SCOPE:**

These calculations can be used for design of hydraulic ram pump to obtained efficiency. Using software model we can analyze the model and use to solve the problems regarding installation of ram pump and find the relationship between different parameters of ram pump design.

By using CAD model we can do the simulation study on model for maximum efficiency and can be used to solve modern problems of designing.

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