

Design and Mathematical Modeling of Pendulum based Hand Pump

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Abstract— Pendulum based pump is a very simple method for pumping water from ground wells in rural area and villages across the country. It requires very less effort to oscillate the pendulum to pump the water. The objective of this project is to decrease human effort to pump water and save electricity. With the help of link mechanism and spring force we can able to convert oscillatory motion to linear motion. So, the energy consumption of this system will be lowest. Use of pendulum based pump can reduce human effort, increase efficiency and save time. Its eco-friendly and maintenance and production cost is also less.

Keywords: pendulum, oscillatory motion, pendulum based pump

I. INTRODUCTION

Electricity is an essential resource for our ongoing life. Electricity is generated using coal or natural gas. Natural resources are non-renewable so we must conserve electricity so that we can conserve these resources. Household electricity are generally the major source of electricity consumption. Large amount of electricity is wasted on pumping water. So, hand pump is used for pumping water without use of electricity, but it requires a lot of effort to pump even small amount of water form ground but if a pump is linked with pendulum, its combine mechanism can help us deal with both the human effort and conserves electrical energy.

In rural areas mostly Hand pump are installed to pump water from ground. In these pumps the input is the reciprocating motion which is provided by people which requires lots of effort and by this reciprocating motion the suction of water from ground takes place. But if we replace this reciprocating motion with oscillation motion by suspending certain mass, we can pump the water through pump even with very less human effort. So, it can be very beneficial and easy for use for Children and old people also. So, pendulum based pump is the best solution for pumping water. It can used for a long continuous period of time because of less work requirement and can save a large amount of electricity.

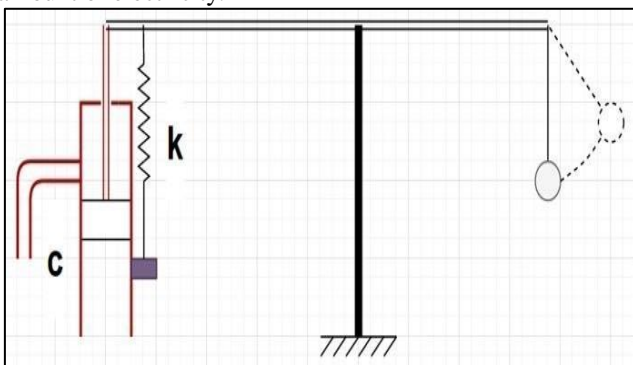


Fig. 1: Line Diagram of Pendulum Based Pump

II. LITERATURE REVIEW

Dr S.M Mowade[1] in his paper titled ENERGY GENERATION FROM PENDULUM:A REVIEW has reviewed various research articles suggesting use of pendulum for energy generation. The author has reviewed some of the very effective ways in which pendulum can be used to generate energy. The methods reviewed by the author are ,use of magnet and pendulum to generate energy with the help of blowing wind, use of pendulum to produce voltage peaks and use of pendulum to replace conventional hand pump.

Prof. Bhane Ajeet Bhagwat [2] in his paper ENERGY CONVERSION IN IMPLEMENTATION OF WATER LIFTING BY USIN PENDULUM EFFECT has discussed working of reciprocating pump which is operated by a pendulum. His paper encourages the use of pendulum based reciprocating pump for gardening, transport of water within small distance via pipe in rural and hilly areas where electricity supply is inadequate. He has also proposed a prototype of the pump.

D. Apparao[3] in his paper DESIGN AND DEVELOPMENT OF HAND PUMP WITH A PENDULUM has discussed forces acting on the various components of the pendulum based pump, the nature of pendulum motion ,energy analysis of the pendulum. He has clearly mentioned that existence of free energy defined by his method is not in accordance with conservation of energy principle, but according to him it can be verified by experiment.

Anurag Anand[4] in his paper FABRICATION OF PENDULUM PUMP has discussed various components required to make a pendulum based pump .The main components mentioned in his paper are frame, reciprocating pump, spring, weight hanger. The paper also discusses comparison of length of pendulum to discharge and mass of pendulum to discharge.

Prof D.P Patil[5] in his paper EXPERIMENTAL STUDY ON WATER LIFTING SIMPLE PENDULUM MECHANISM FOR BOREWELL USING SOLAR ENERGY has discussed the use of solar and pendulum to pump water from borewell. The author has discussed the methodology for design & development of the apparatus. The author has discussed the use of Permanent Magnet Direct Current Motor along with pendulum mechanism.

Rajesh Kumar Sahu[6] in his paper DESIGN AND FABRICATION OF HAND PUMP OPERATED BY A PENDULUM has discussed the designing and fabrication procedure of the pendulum based pump. The author has mentioned various factors affecting discharge viz. mass of the pendulum, swing angle and length of pendulum.

Kali Charan Rath[7] in his paper A BRIEF STUDY ON PENDULUM BASED PUMP has discussed design of various parts of pendulum based pump. The author has

proposed an approximate dimension of the parts that can be used for the model.

Manoj C[8] in his paper DESIGN AND FABRICATION OF PENDULUM OPERATED PUMP has discussed the methodology, working principle and principle components of the pendulum based pump. The author has given a detailed 2D drawing of pendulum operated pump. The parts used by the author are frame, reciprocating pump, lever, ball bearing and pendulum.

Sermaraj .M[9] in his paper DESIGN AND FABRICATION OF PEDAL OPERATOR RECIPROCATING WATER PUMP has discussed about the pendulum based pump operated by pedal. The author has discussed about the design aspects and operation of the pump. The author gives a detailed outline of various operation involved.

Sadashiv Bellubbi[10] in his paper WATER PUMPING AND POWER GENERATION BY SWING ACTION has discussed the use of swing cradle to lift water and power generation. The author has suggested the use of double acting reciprocating pump to lift pump. The author has presented the torque analysis in the swing cradle which can be used to run the dynamo to generate electricity.

III. METHODOLOGY

A. Cad Design

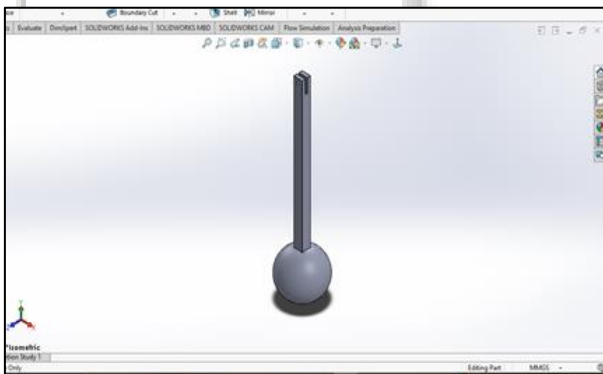


Fig. 2: Pendulum(Solidworks)

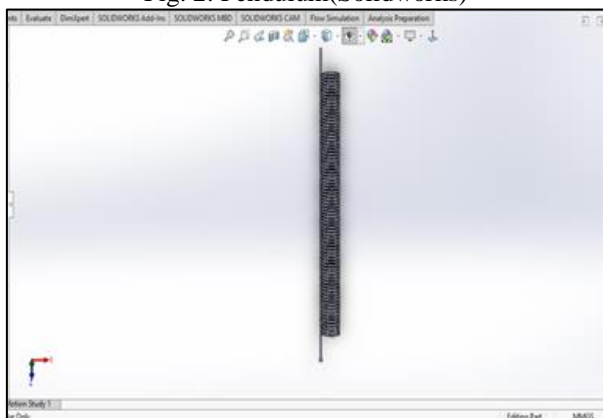


Fig. 3: Spring (Solidworks)

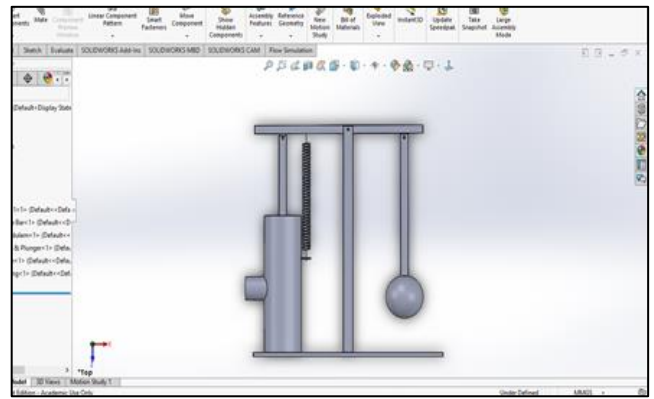


Fig. 4: Pendulum Based Pump (Assembled)

B. Mathematical Analysis

For analysis first we divide this system in two parts -

- 1) Pendulum system
- 2) Lever Piston System

1) Pendulum System:

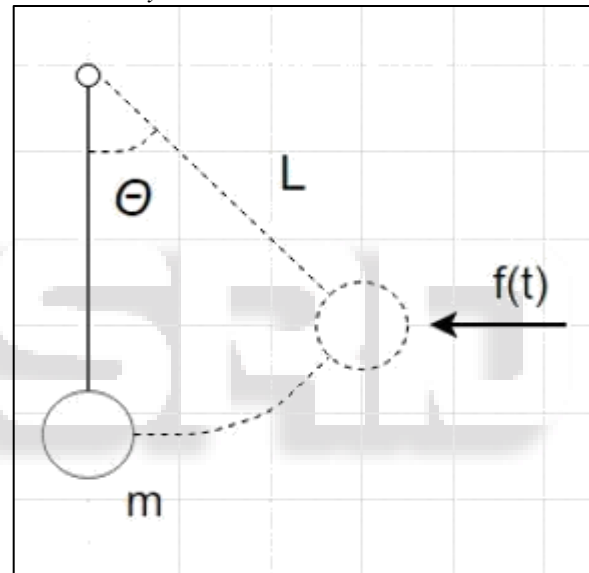


Fig. 5: (Pendulum) Line Diagram

Equation of motion of Pendulum

$$\theta'' + g/L \sin\theta = 0$$

But, here this system depends upon input external force which is time dependent, so

$$\theta'' + g/L \sin\theta = f(t)$$

(Second Order differential Equation)

And

$$\omega = \sqrt{g/L} \text{ (natural frequency)}$$

$$F(t) = F_0 \cos \omega t$$

Where,

θ = Angular Displacement

g = Acc due to gravity

L = Length of pendulum

Lever Piston System:

Linear Vibration

Forced Vibration with a single degree of freedom

$$mx'' + cx' + kx = F(t)$$

Natural Frequency

$$\omega_n = \sqrt{k/m}$$

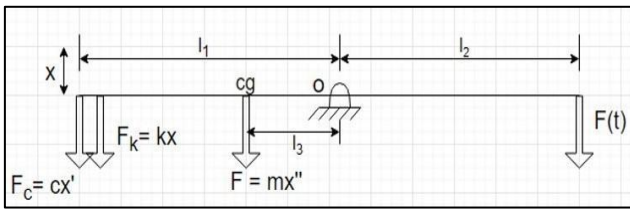


Fig. 6: Free Body Diagram of Pendulum Based Pump

Taking moment about point o

$$mx''l_3 + cx'l_1 + kx l_1 = F(t)l_2$$

(With the help of MATLAB we can solve the equations and simulate a result which can give us the displacement x (Assuming the x displacement of one side of the rod is equal to the displacement of piston inside the pump)).

2) Calculation of Spring Constant

Formula for Spring constant for compression spring:

$$k = \frac{Gd^4}{8D^3n_a}$$

Material Used - Mild Steel

Shear Modulus of Mild Steel (G) = 80 GPa

Where,

Mean Diameter (D)

Wire diameter (d)

No. of active coils (n_a)

IV. ADVANTAGES

- Can be used in areas where there is a shortage of power supply.
- Simple to construct and is also portable.
- Less human strength required
- Maintenance is simple and less costly.
- No operation cost as only manual work required.

V. CONCLUSION

After the analysis Pendulum Based pump, we can conclude that the pump can continuously pump the water but discharge rate is not be constant. There are various factors which affect the discharge rate such as- pendulum (length, weight, amplitude), pump (bore, stroke length) etc.

It will be useful in rural areas as no electric source required and avoids human efforts to pump water by the help of pendulum bob. So, a regular hand pump can be replaced by pendulum based pump

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