

DESIGN AND MATHEMATICAL MODELLING OF PENDULUM BASED PUMP

Submitted in partial fulfillment of the requirements
Of the degree of

**BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING**

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CERTIFICATE

This is to certify that the Research work titled DESIGN AND MATHEMATICAL MODELLING OF PENDULUM BASED PUMP that is being submitted by Mohsin Alam , Shubham Kumar, Satya Prakash Singh and Mohit Kuntal is in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor

Internal Examiner

External Examiner

Approval Sheet

This thesis/dissertation/project report entitled **DESIGN AND MATHEMATICAL MODELLING OF PENDULUM BASED PUMP** by Mohsin Alam, Shubham Kumar, Satya Prakash Singh and Mohit Kuntal is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

Supervisor

Dean

Date: _____

Place: _____

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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(Department of Mechanical engineering)

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.

Index Terms- pendulum, oscillatory motion, pendulum based pump.

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Introduction

1.1 Project background

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.

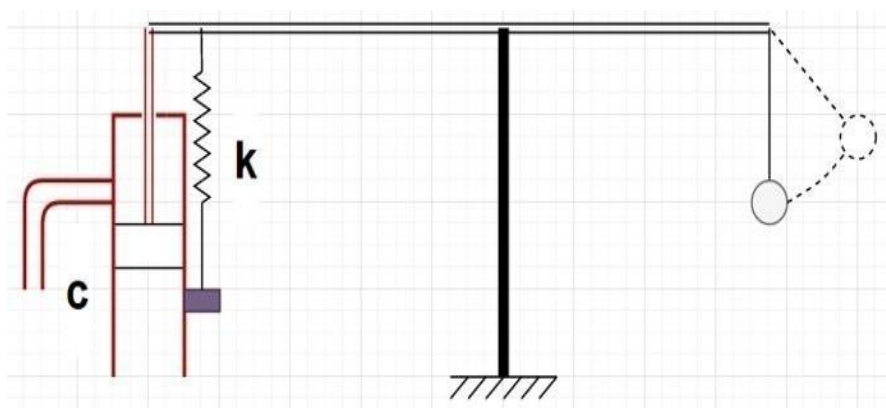


Fig 1.1: Line Diagram Of Pendulum Based Pump

1.2 Research purpose and meaning

Sir Veljko Milkovic in the year 1999 created a mechanism named as two-stage oscillator mechanism. The objective of the mechanism was the amount of energy input provided to be less than the energy output. Various kind of experiments where performed to verify above statement.

Without using Electricity, Hand water pump is the best solution to lift the water. But it requires a large human effort to pump water which is not feasible for long period of time. So, Pendulum based pump is the best solution for pumping water without using the hand pump.

1.3 Objective of study

Objective of our study is to -

1. Design and fabricate water pump using pendulum principle
2. Mathematical modelling of Pendulum Based Pump
3. Achieve continuous discharge of water through pump.
4. Ensure a safe operation of pump.
5. Study various parameters effecting pendulum based pump.

2

Literature review

3

2.1 Reviews

Dr S.M Mowade in his paper titled ENERGY GENERATION FROM PENDULUM: A REVIEW has reviewed various researcher 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 in his paper ENERGY CONVERSION IN IMPLEMENTATION OF WATER LIFTING BY USING 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.



Fig 2.1: Fabricated Model

D. Apparao 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.

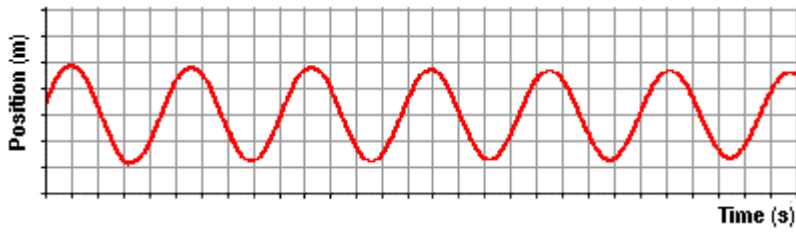


Fig 2.2: Position time graph of pendulum

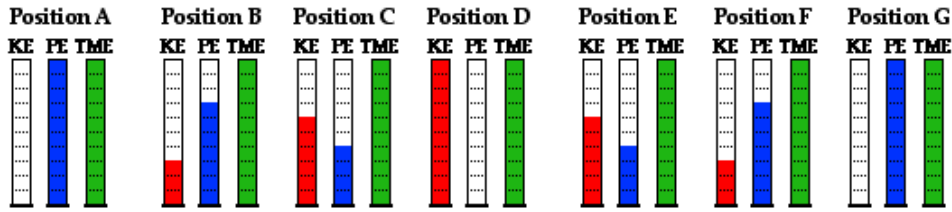


Fig 2.3: Bar Graph b/w KE, PE and Time of Pendulum on different position

Anurag Anand 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. And designed a 3D model for his project



Fig 2.4: 3D CAD model Pendulum Pump

Prof D.P Patil 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.

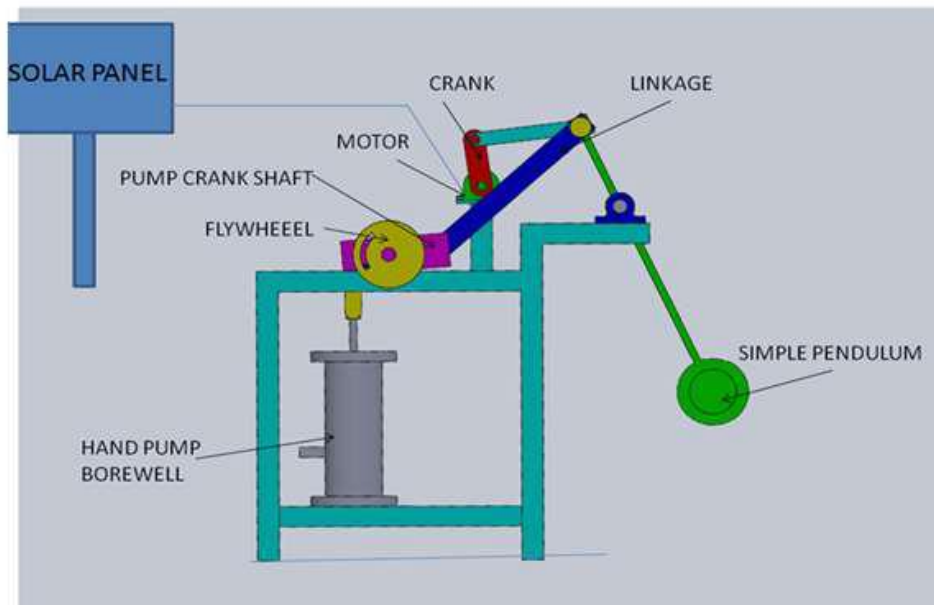


Fig 2.5: Proposed simple pendulum borewell

Rajesh Kumar Sahu 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.

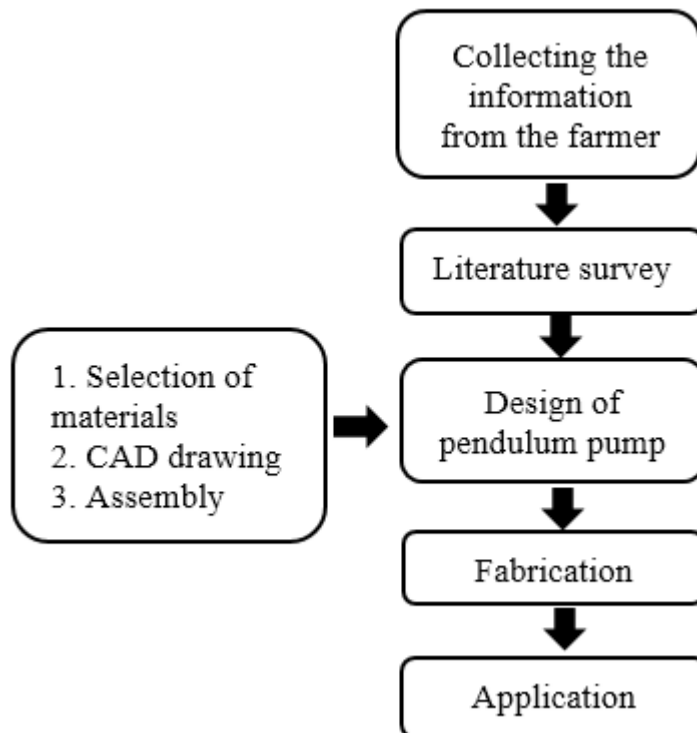


Fig 2.6: Fabricated Model

Kali Charan Rath 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 used for the model.

Manoj C in his paper DESIGN AND FABICATION 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.

And methodology used by him was,



Sermaraj .M 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.

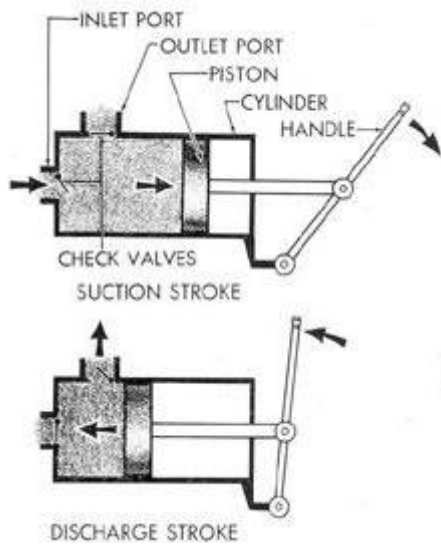


Fig 2.7: Line Diagram of Pump Working

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 has presented the torque analysis in the swing cradle which can be used to run the dynamo to generate electricity.

Problem description

3.1 Problem description

The concept behind this project is to lift the water with the help of pendulum, which is attached to the lever.

The Pump converts the oscillatory motion into the reciprocating motion, and hence lifts up the water up to the desired level.

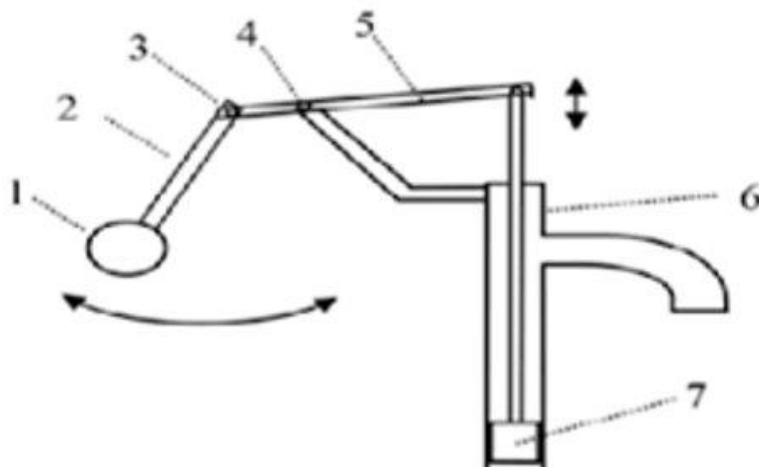
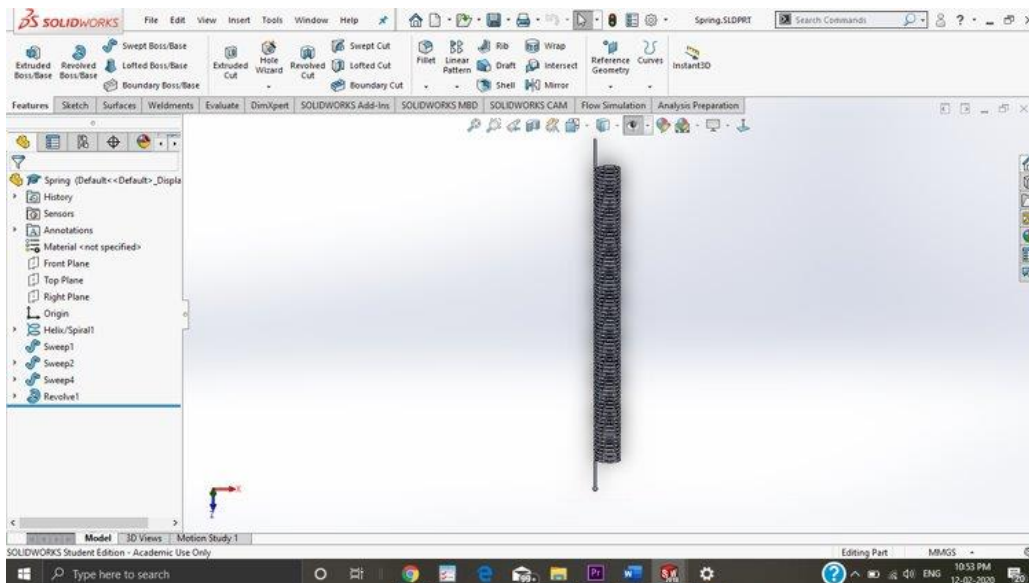
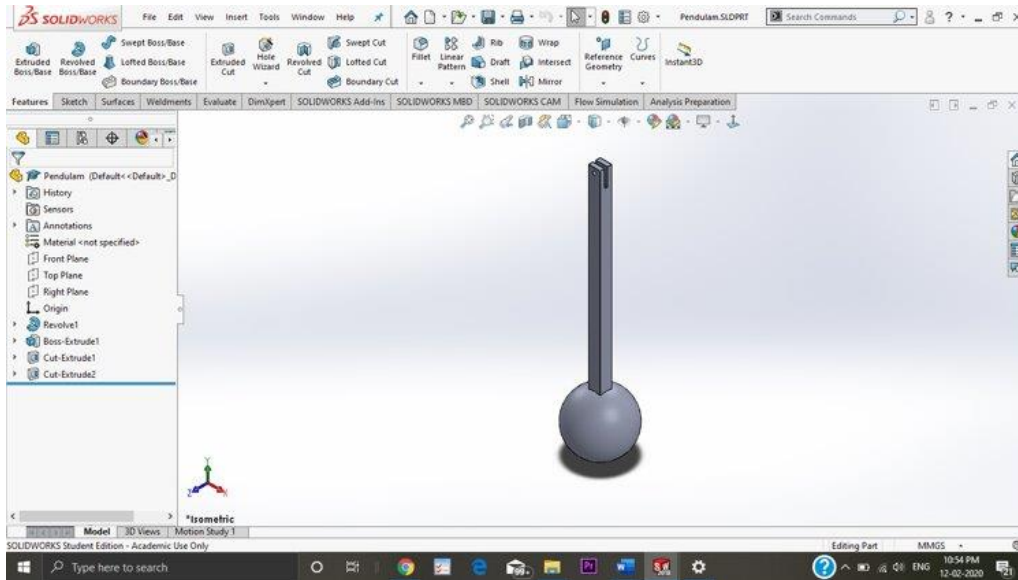
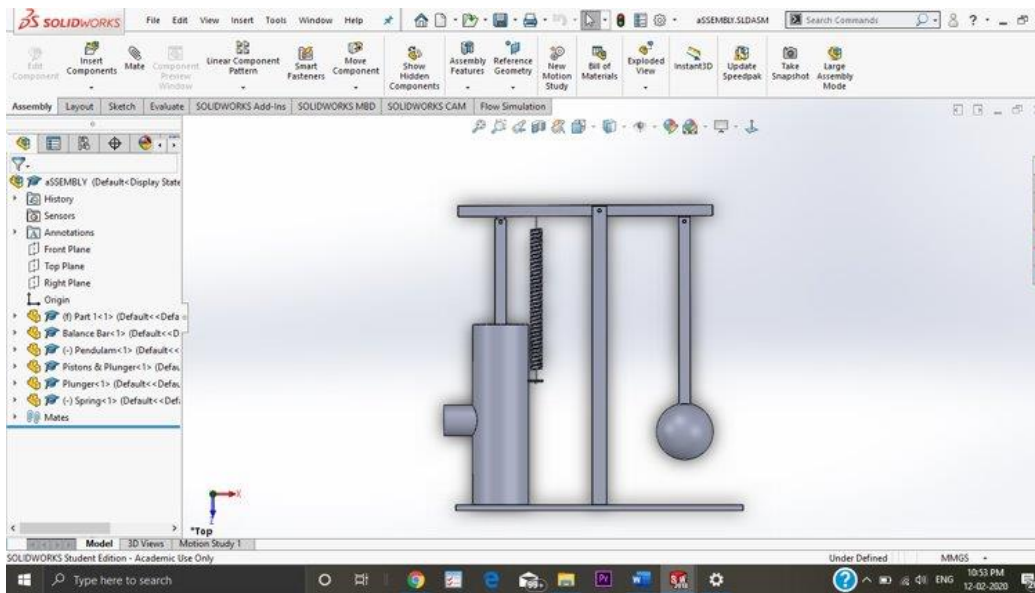
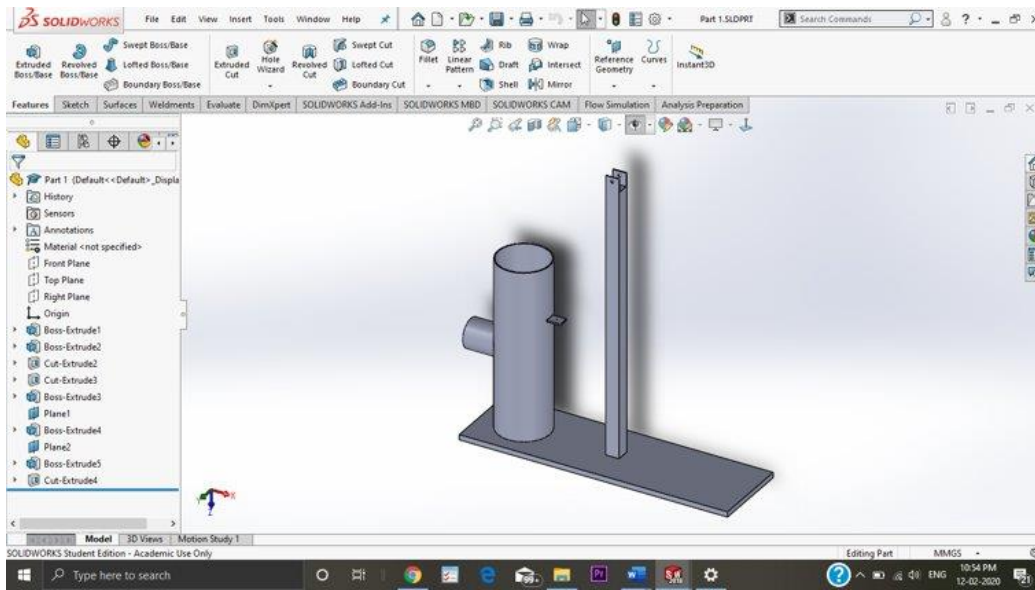


Fig 3.1 Schematic Setup

1. Load of the pendulum
2. Handle of the pendulum
3. Axis of the pendulum
4. Axis of the lever
5. lever
6. Water Pump
7. Piston of the Pump

Cad Design





Force Analysis on Pendulum:

Mainly two types of forces act upon a pendulum bob at all times during the period of its motion. There is a tension force acting upward and towards the pivot point of the pendulum and there is gravitational force acting downwards upon the bob of the pendulum. Other minor forces like Air resistance, which opposes the motion of the swing of the bob.

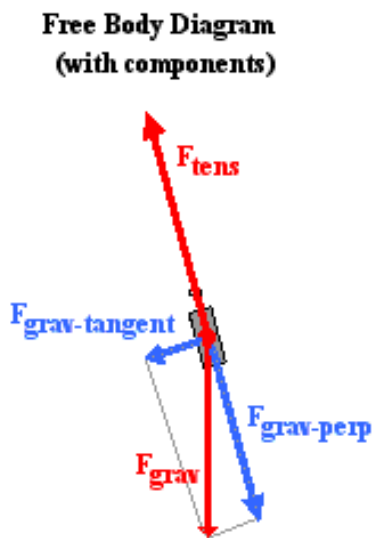
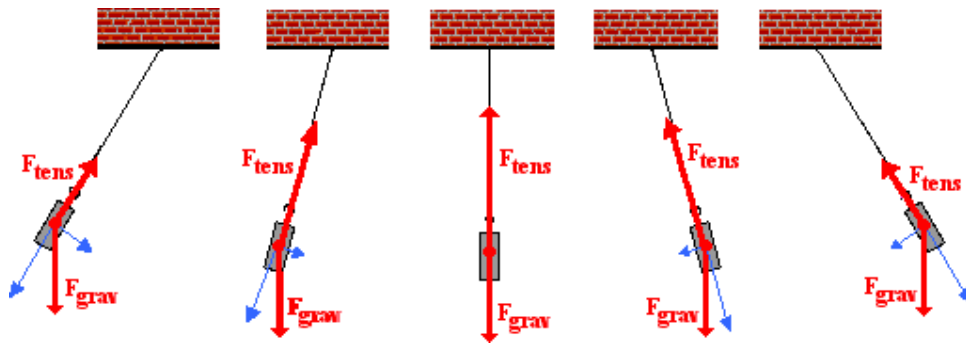


Fig 3.2 FBD of force analysis on pendulum

The gravitational force always acts in the same direction i.e. downward direction and always of same magnitude ($Mass \cdot 9.8 \text{ N}$)

But in tension force both its direction and its magnitude change as the bob swings in to and fro motion. The direction of the tension force is always upwards and towards pivot point of the pendulum , as can be seen in the below diagram.



Fig

3.3 Forces at different positions over the course of the pendulum's path.

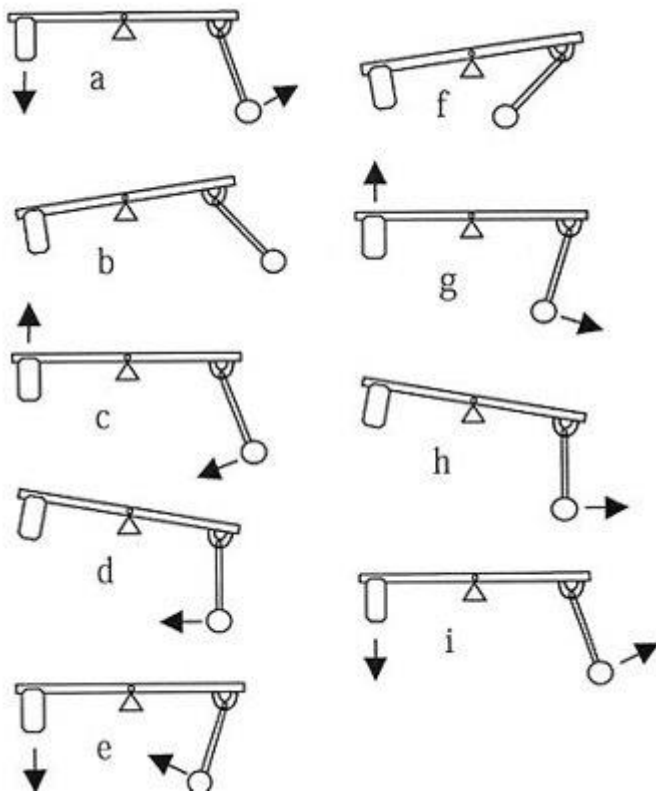


Fig 3.4 Relative position of pendulum and piston

Energy analysis:

The kinetic energy is the energy possessed due to motion. It is a quantity which depends both on mass and speed. The equation for kinetic energy (KE) in terms of mass and velocity is,

$$KE = \frac{1}{2}mv^2$$

Two types of potential energy acts in this system - gravitational potential energy and elastic potential energy. The gravitational potential energy is dependent upon the mass (m) of the object and the height (h) of the object. Elastic potential energy is only present when a spring is compressed or stretched. The equation of gravitational potential energy (PE) is,

$$PE = mgh$$

PRINCIPAL COMPONENTS

Frame

Frame is a base part which holds another part like pump, lever, ball bearing etc. It is the main component and made of steel.

Reciprocating Pump

This is a positive displacement pump. Consist of a plunger or piston which moves forward and backward and suction of water or liquid takes place.

Springs

The spring is an elastic object which is used to store mechanical energy. Here in the pendulum based pump generally compression springs are used. It is the function of these springs to stretch and compress according to the load applied. And plays a vital role in obtaining optimizing results.

Lever

It is also the main component of the pendulum based pump system and is made up of steel. One half of the lever is the oscillating motion of the pendulum and on other side the reciprocating motion of the piston.

Pendulum

The weight which is suspended from the pivot point and it is the oscillating part of the system and thus it acts like a pendulum.

Mathematical Analysis

For analysis first we divide this system in two parts -

1. Pendulum system
2. Lever Piston System

Pendulum System:

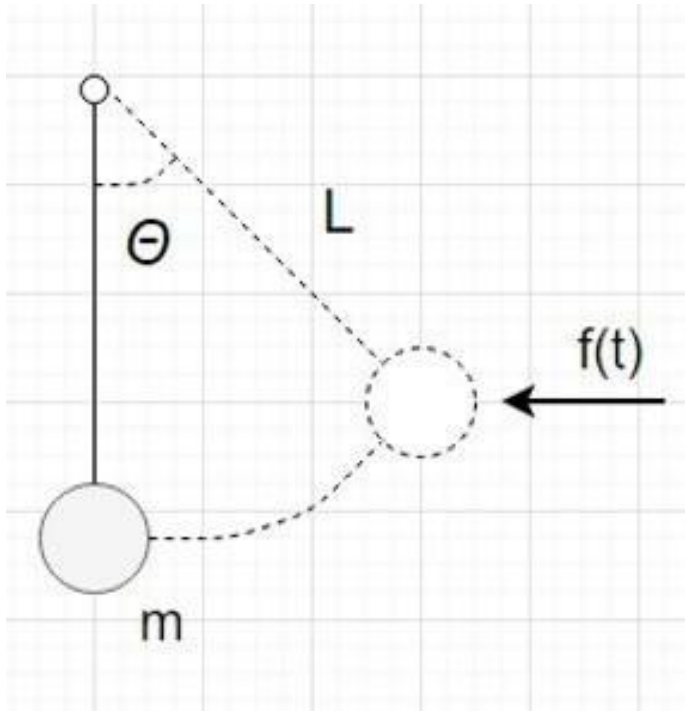


Fig 3.5: Line diagram of pendulum

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

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

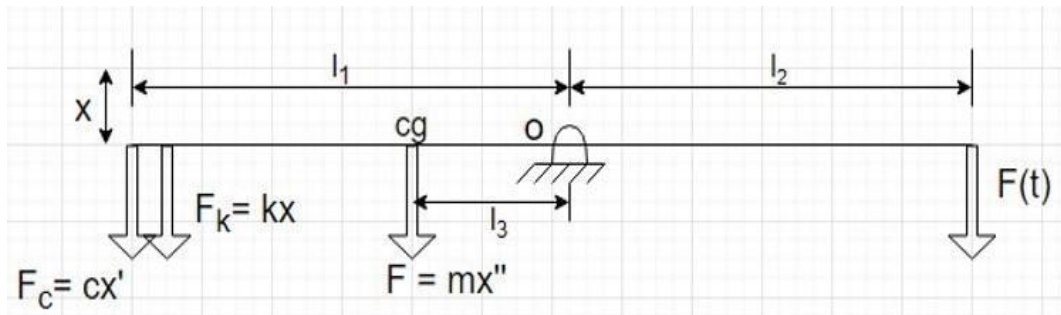


Fig.

3.6: Free Body Diagram of Pendulum Based Pump

Taking moment about point o

$$mx''l_3 + cx'l_1 + kxl_1 = F(t)l_2$$

(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)).

Calculation of Spring Constant -

Formula for Spring constant for compression spring:

$$k = Gd^4 / 8D^3n_a$$

Material Used - Mild Steel

Shear Modulus (G) = 80 GPa (MILD STEEL)

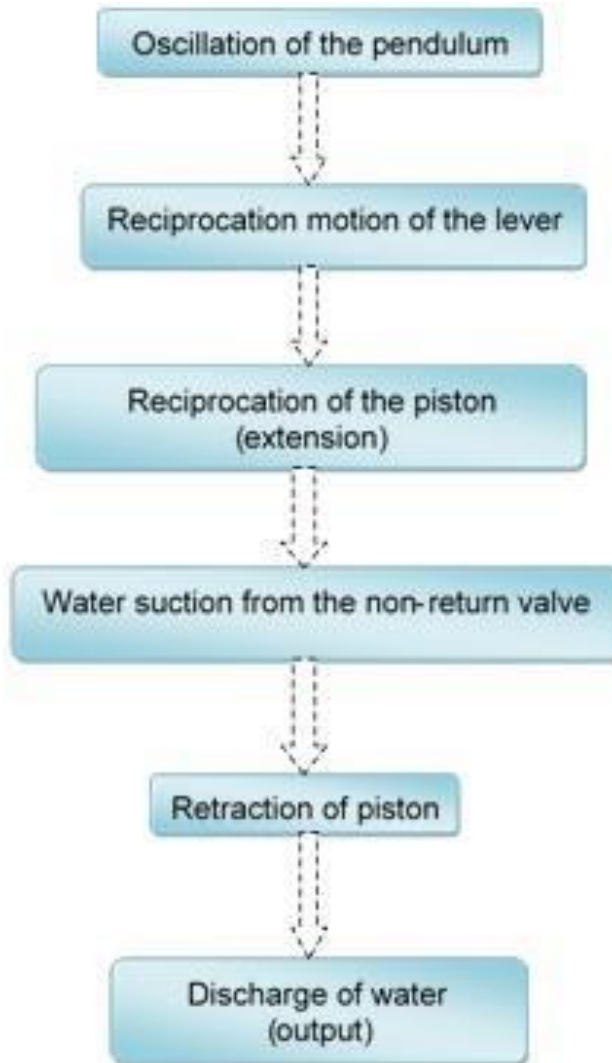
Where,

Mean Diameter (D)

Wire diameter (d)

No. of active coils (n_a)

WORKING FLOWCHART OF PENDULUM BASED PUMP



3.2 Applications

- Domestic: For drinking water.
- Drainage: Control the level of water in a protected area.
- Irrigation: Used to make dry lands agriculturally productive.
- Chemical Industry: Used to transport fluids to and from various sites of chemical plant.

- For spraying pesticides
- Gardening purposes.

3.3 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.

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