Single Acting Piston Pump Using Oscillating Motion

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Abstract
We initialized our project with an objective to reduce the human effort. The purpose of sucking the water from the ground, they were installing the piston pumps on every village. The reason behind the choice of piston pump is due to its less maintenance and less installation cost. Hence according to us, people were spending large effort on this in the way of giving continuous reciprocating motion to suck the water from the ground. Not only the continuous motion but also lot of time to be spent until the required amount of water is being sucked. In this type of pump the continuous reciprocating motion should be given only by the people, no other motion can replace that until now. But we were planned to replace that reciprocating motion with an oscillating motion. This method may be an already existing one, but the way of application is quite different in our project. A one who knew the concept of oscillating motion will know about the reciprocating motion present in it. Hence we can obtain two reciprocating motion from one single oscillation obtained due to oscillating a certain weight (a bob). Hence according to us by slight modification of an existing piston pump for adapting to the oscillating motioned piston pump, we can obtain the required amount of water with a minimum effort and with a low cost.

Keywords
Pump, Single acting piston, Oscillating motion

List of Symbols

N	Newton
Pa	Pascal
Hs	Suction Head
Hd	Delivery Head
Q	Discharge
V	Velocity
g	Acceleration due to gravity
ID	Inner Diameter
OD	Outer Diameter
TDC	Top Dead Center
BDC	Bottom Dead Center

I. Introduction

Basically in villages and also in some town side areas, we could able to see the piston pumps which have been installed to suck the water from the ground, and this source of water from the ground is known as ground water. In pump the reciprocating motion is to be given by the people who access it. And by using that reciprocating motion, the suction is created and as a result water comes out from the ground. Hence no other method can easily replace it, due to its less maintenance, and easy accessibility. Hence it has been in the peak for several years. But we do not have the idea to replace those pumps. But we have the idea to reduce the human effort which is being given in these types of pumps. By saying particularly that, the reciprocating motion that is being given in the piston pump can be replaced by the oscillating motion obtained due to the oscillation of certain mass. New and technically original idea - hand water pump with a pendulum - provides alleviation of work, because it is enough to move the pendulum occasionally with a little finger to pump the water, instead of large swings. Using the minimum of human strength in comparison to present classic hand water pumps enables efficient application in irrigation of smaller lots, for water-wells and extinguishing fires even by old people and children. Hand water pump with a pendulum is a realization of a new, original, and even unbelievable, by very simple solution for pumping water. Work is alleviated because easier, long-lasting and effortless use of the hand water pump has been enabled. Input energy for starting the process of pumping, in form of occasional pushing of the pendulum, is much less than with typical hand pumps. To get the water running out of the pump, the pendulum needs to be out of balance. After that, based on gravitational potential, the piston starts oscillating and the continuous stream of water is coming out of the output pipe. The pendulum should be occasionally pushed, to maintain the amplitude. The pump works well with all sizes of the pendulum, but mainly with the amplitude of 90°.

II. Literature Review

Joseph et al (Nov 2005) This is a sobering reality check for a project such as the current Mahadaga Pump Project. Almost all of the data is somewhat dated, as most of the hand pump work was done in the 1980's, but because hand pumps are a low technology product, there is reason to believe that the findings presented below are still valid.

Milkovic et al (Sep 2003) He said some information about the pendulum pump which is as follows. Hand water pump with a pendulum is a realization of a new, original, and even unbelievable, by very simple solution for pumping water. Work is alleviated because easier, long-lasting and effortless use of the hand water pump has been enabled. Input energy for starting the process of pumping, in form of occasional pushing of the pendulum, is much less than with typical hand pumps.

Matos et al (Jan 2010) He said about the pendulum pump is as follows The milkovic's pendulum –lever system does work only in one direction, when the working of lever side goes up. To return it to the initial point he needs to use a spring or a weight in the lever to push it down. This is the method used to pulse the lever. When the pendulum is in its lower position is when maximum work is achieved. Some energy is used in the spring or to lift the weight. In his proposal the pendulum works in the same direction of the load, and the amplitude is independent of work done or load applied.

III. Summary

By introducing this pendulum motion (Oscillating motion) to suck the water, it will be quite innovative and will be very useful to the people living in rural areas, and also for some industries. By implementing this motion in the pump, we can be able to suck the water from the ground with the minimum effort.

IV. Working Principle

The basic principle behind the working of the oscillating piston pump is the pendulum motion (motion of the bob pivoted at a point). Hence in simple harmonic motion obtained by the oscillation of the weight, we can obtain two reciprocating motion which means for one oscillation of the weight in the pump, the piston reciprocates twice. But as much as the oscillation of the weight continuous the piston reciprocation also continuous.

V. Construction

The lever shown is the basic concept that is been used nowadays. And we were implementing our concept in terms of weighted pendulum. Hence by oscillating this weight horizontally, it is possible to obtain two reciprocating motion with one oscillation, which will be used to pump the water from the underground.
The 3D model of the oscillating piston pump is shown in the figure and in that the blue color shows you the cylinder and the yellow color shows you the NR (Non Return) Valve.

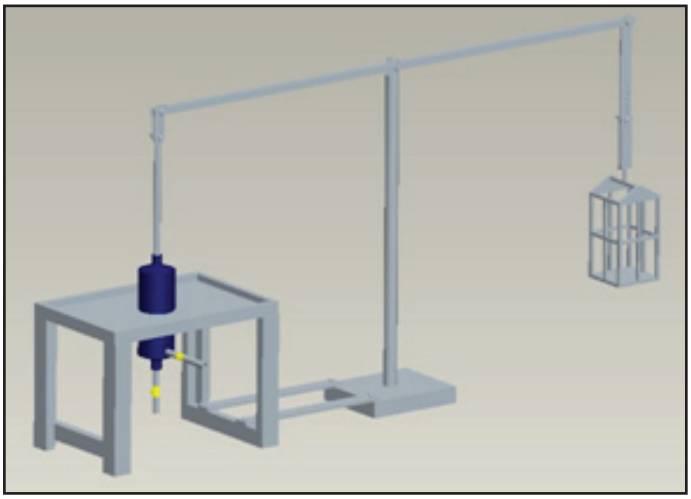


Fig. 1: 3D Model of a Simple Oscillating Piston Pump

VI. Components and Model

We have used several components for our project which is listed in the table 1 given below.

A. List of Components

1.	Piston
2.	Cylinder
3.	Pendulum
4.	One way valve (NR Valve)

VII. Working

During the oscillation of the weight which is hanged at one end. It oscillates like a bob in the simple pendulum. Hence during the upward motion of the weight, the pivoted end moves upward hence the other end moves downward. Hence the downward motion results in delivery of the fluid. And during the downward motion of the weight, the pivoted end moves downward and hence the other end moves upward, which results in suction of the water. Hence for one oscillation we get two suction and two delivery stroke. And also two NR valve is used for the operation. During suction, the NR valve in the delivery side will be closed and during the delivery stroke, the NR valve in the suction side will be closed. Hence this avoids the backflow of the water in their respective strokes.

VIII. Design and Calculation

We have made a certain design calculations for our project for the selection of the suction pressure and selection of the diameter of the pipe and also to find out the discharge. Hence this calculation will be useful to find out the flow rate of the water for the power given on the piston and also the suction pressure plays a vital role in the amount of water pumped and it determines the efficiency of the pump.

A. During Suction Motion

Total Force Acting Downwards

Total force acting downward

$= (mg - T)$

Where, $W = mg$

$= 10 * 9.81$

$= 98.1$ N

The tension (T) on the string will be equal to 20N

Total load = 80 N

Friction Force Calculation

$F = \mu N$

Where, $\mu = 0.045$ for PVC materials.

$N = RA / \mu$ (RA = 10N)

$N = 220$ N

$F = 10$ N

Total Force During Suction

$P = F/A$

Where, F = (Total load) – (friction)

$F = 80 - 10$

$F = 70$ N

$A = \pi * D^2 / 4$

$A = 7850$ mm^2.

$P = 8.91$ KPa.

Actual Discharge

$Q = C_d * \text{Area of orifice} * (2gh)^{0.5}$

Where, D = 20 mm

$C_d = 0.3$

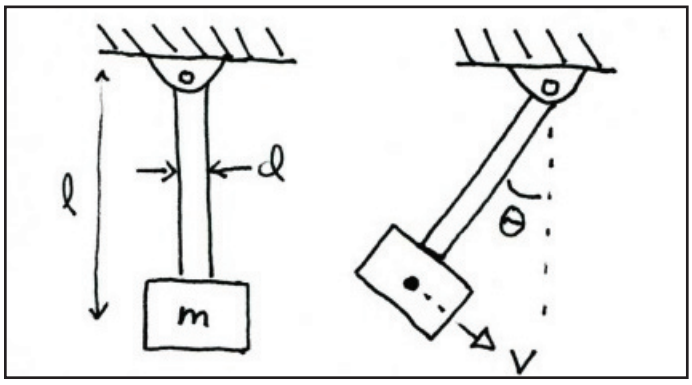
$g = 9.81$

$h = 0.6$

$Q = 1 * 10^{-3}$ m^3/s

- Atmospheric pressure = 1.0132 bar
- Suction pressure = 0.08 bar

B. During Delivery Motion



Total load = (mg – T)

Where, mg = 100 N

N = 20 N

$T = N \cos \Theta$

$= 20 * \cos 30^o$

$= 17$ N

Total load = 100 – 17

T = 83 N

Friction Force Calculation

$F = \mu N$

Where, $\mu = 0.045$ for PVC materials.

$N = RA / \mu$ (RA = 10N)

$N = 220$ N

$F = 10$ N

Actual Discharge

We are used the same pipe with same distance

$Q = 1 * 10^{-3}$ m³/ s

C. Volume of the Cylinder

$V = (3.14 * D2) * L$

Where, D = 0.1 m

L = 0.15 m

(distance between TDC to BDC)

$V = 0.020$ m³.

The volume of the water is 0.02 m². Also the delivery will be equal to 0.0^2 m². Hence for one oscillation, there will be two reciprocating motion. Hence the suction and delivery will be twice.

D. Volume of the Water Delivered For One Oscillation

$V = 0.02 * 2 = 0.04$ m³

E. Actual Outlet of Water

= 0.024 m³

F. Efficiency of the Pump

η_v = (THEORITICAL – ACTUAL) / (THEORITICAL)

= (0.04 – 0.024)/ 0.04

$\eta_v = 40\%$

IX. Flow Rate Obtained

S.No	Diameter	Weight	Discharge
1	50	10Kg	0.002
2	80	12Kg	0.004
3	100	10Kg	0.001
4	150	18Kg	0.07

X. Results

A. Low Cost

There is no need of any additional cost. The cost is as equal to that of the ordinary piston pump. It is more than enough to spend 20$ to install this mechanism in an existing pump. But if we install as a whole set up, we need around 500$.

B. Weight

Actual working model will be around 150 to 200 Kg. But it will be compact because the 70% of the total component will be inside the earth. Hence only 30% of the component will be visible to the human beings. The actual weight of the pump which is being used until now will have the weight of around 120 to 130 Kg. the amount of weight used will vary and it depends on the amount of discharge we required.

C. Safety

It needs just oscillation and not the continuous reciprocating motion that we have been giving so far now. Though we were giving only the light load for the operation hence there is no danger due to the load. And also in terms of flow conditions it will be quite equal to the flow that occurs in piston pumps so far now, so there is no much difference between the pumps at now and our concept. The only difference is that there is no need of large efforts.

D. Operational Efficiency

Let us compare our oscillating piston pump with the reciprocating hand pump. There is no need of giving more human efforts and also we will acquire have good performance, in addition to that we can get high amount of flow rate of water. Finally while comparing with all other pumps for sucking the ground water. Our oscillating piston pump will have be better performance than the hand pumps. The efficiency of the pump will be around 40 to 60%. The efficiency of the hand pump will be around 50 to 60%. This is due to the motion that we give continuously without interaction.

E. Comfort

The oscillating piston pump was very comfort for humans. Because by using this pump we can pump more amount of water with less human efforts. So it is more reliable while comparing to the hand pump. By pushing or pulling the weight (which is attached with the beam of the pump), we can easily pump the water from the ground. So we assure that, this pump will be very comfortable to the humans.

XI. Conclusion

Hence by implementing this oscillating piston pump instead of normal hand pump, we can reduce the effort that is being spent by the people. And also by just giving slight oscillation we can get the continuous flow of water sucked from the ground until the amplitude of the oscillation reduces than the certain height. Hence we can install this in our villages and also we can implement this mechanism in an existing hand pump mechanism. This will be more reliable and effort given is less when compared to electric pump or other pumps.

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