Self Operated Switching Mechanism for Water Pump

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***Abstract*— A collective effort has been put towards understanding and designing of a Self-Operated Switching Mechanism and analysis of various forces acting on the system. Water level control is highly important in household and also in industrial applications. In this work a simple water level controlling device based on mechanical forces is proposed. This device does not require any external electrical power or manpower but works completely on mechanical forces which are exerted to the system by the water due to buoyancy and gravity.**

Keywords-self operated; household; industrial; buoyancy; gravity

I. INTRODUCTION

Water is the most important Nature's gift to the mankind. Without water there is no life. Now man understood its importance, especially where water is not easily available. The people who live in cities or towns do not give much thought to how the water they use each day gets to their house. All they need to know is how to open the tap at the sink. Moving a few miles out of town the picture changes. Each home has its own well from which water is drawn. More than that, each home has its own electromechanical system for getting the water from the well to the house. At the heart of each system is a pump, and the most common types are jet pumps and submersible pumps. In many areas of the country, finding potable water is as easy as getting out a shovel and digging a hole in the ground. In such a shallow-well situation, lifting the water up to the house is going to be a little easier, if only because the distance one has to move it is modest. But if the area does not have a high water table, or if it lacks a stable supply of potable water near the surface, one must dig deeper to achieve the same result. And because a deep well means that the water has to be lifted farther, the strategies for moving it change. Hence the use of water pump becomes an utmost necessity. Generally we switch ON the pump when our taps go dry and switch OFF the pump when the overhead tank starts overflowing. This results in the unnecessary wastage and sometimes non availability of water in case of emergency. Here a device is designed which can make this system automatic, i.e. it switches ON the pump when the water level in the overhead tank goes low and switches it OFF as soon as the water level reaches a pre-determined level. Hence this self-operated device is one of the cheapest and simplest devices which prevent wastage of both electricity and water.

II. DESIGN

In Fig.1, the AutoCAD design of the system is shown. Supports on both sides of the water tank have been provided so that the latter is mechanically more stable. The starter used here is a push button starter. We have used this starter as it is easily available in the market and due to its swift working. A pulley arrangement is made. One end of a string is fixed to the bob and the other end is fixed to a dead weight which is used to balance the bob.

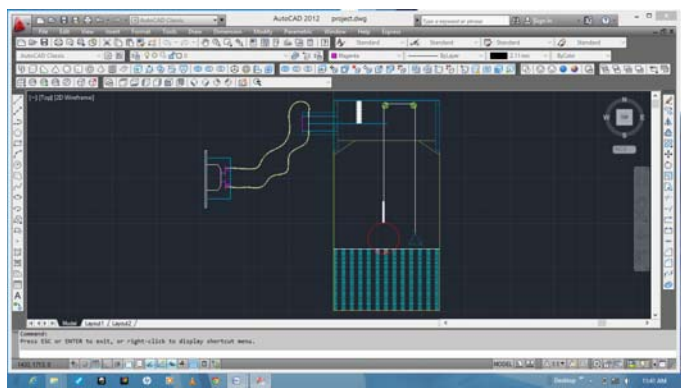

Fig.1: A complete view of the project designed in AutoCAD

The wire is passed through a hole at one end of the operator link and the other end of the link is connected to the starter through two clutch wires.

III. THEORY OF OPERATION

The main theory behind the mechanism is the theory of buoyancy force and the gravity force itself. The right side of the link is long enough comparing to the left side of the link to increase the force ratio. But the total weight of the link in both the side will be the same. The link is free to move about the pivot point. A bob fixed in a tight string (metallic) is inserted in the water tank and the other end of the string is passed through o hole at the right end of the link and then it is passed over a pulley and connected with a dead weight. The mass of the bob is 'm' and hence its weight will be 'mg'. One end of the clutch wire is fixed to the link (say link 1) which is pivoted to the support. This link would be pushed up and down by the rigid bar which is fixed to the bob. A link mechanism is set around the starter switch. The other ends of the clutch wire are fixed to the link (say link 2) which is attached to the starter. As the water level rises, the bob pushes the "link 1" upward as a result of which the upper clutch wire is pulled and the "link 2" pushes the red button of the starter, switching OFF the pump. As the water level falls, the stop which is fixed to the string of the bob, pushes the "link 1" downward which results in pulling of the lower clutch wire and hence the "link 2" pushes the green button of the starter, switching ON the pump.

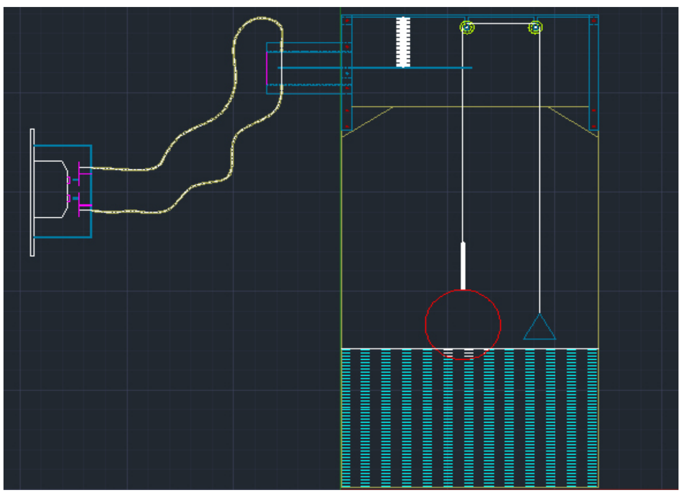

Fig.2: Enlarged view of the AutoCAD design

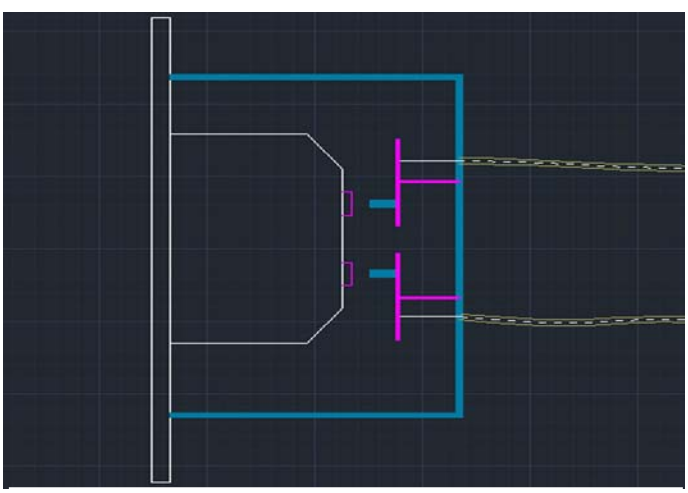

Fig.3: AutoCAD design of the starter mechanism

IV. Force Analysis

The force analysis is done to calculate the various forces acting on the various links of the mechanism. This enables to utilize the available forces in a resourceful manner. A proper force analysis reduces the losses that may take place in a system.

A. *The Possible Positions of the Main Link*

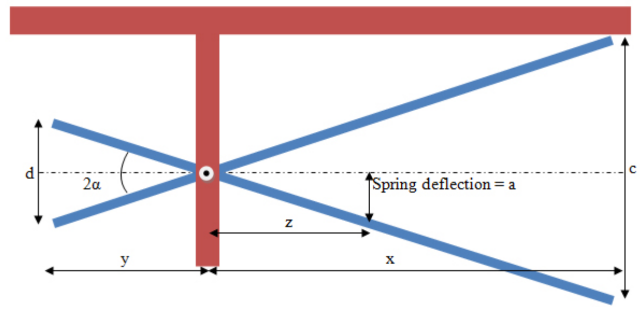

Fig.4: The possible positions of the main link

Let,

The length of the link on the right side	= x
The length of the link on the left side	= y
Spring position from the pivot point	= z
Total link deflection on right side	= c
Total link deflection we need on left side of the link	= d
Total deflection angle	= 2α
Spring stiffness	= k

Now,

$$\tan \alpha = \frac{d/2}{y} = \alpha \quad \text{(for small angles)}$$

So, Spring deflection, a $= z \times \alpha$

$$= z \times \frac{d/2}{y}$$

$$= \frac{zd}{2y} \qquad (1)$$

Force due to the spring $= ka$

$$= k\frac{zd}{2y} \qquad (2)$$

The link material taken is very strong material i.e. mild steel and due to the external forces of the bob weight we take all the stresses on the link as negligible.

B. *Calculation of Forces When the Link is Pulled Down Due to the Bob Weight*

Let the mass of the bob = m

Now taking moment about the pivot point O,

$$F_1x - F_3z = F_2y$$

⇨ $mgx - kaz = F_2y$

⇨ $F_2 = (mgx - kaz) / y$

⇨ $F_2 = (mgx - k\frac{zd}{2y}Z) / y \qquad (3)$

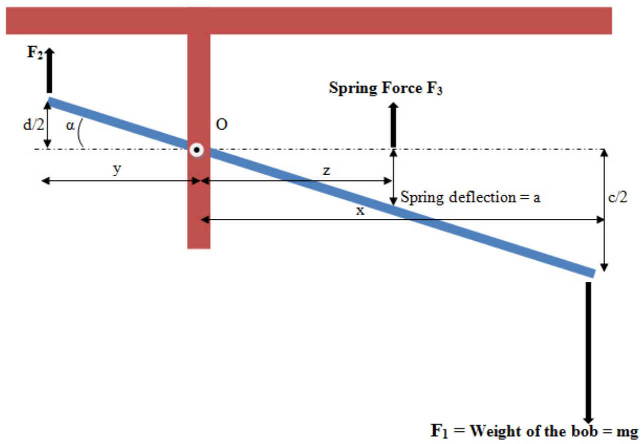

Fig.5: Force analysis, when the link is pulled downward

C. *Calculation of Forces When the Link is Pushed Upward Due to Net Upward Force*

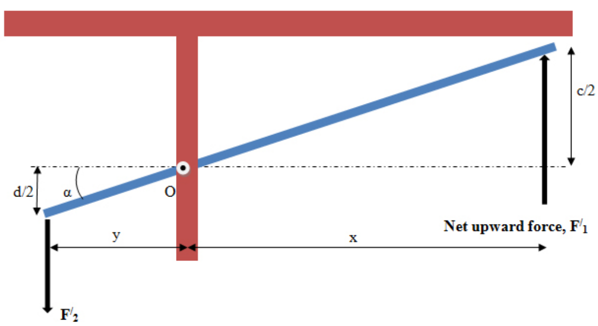

Fig.6: Force analysis on the link, when the link is pushed

Net upward force = Buoyancy force – Weight of the bob

Weight of the bob = mg (4)

Buoyancy force = Vρg (5)

Where, V = Volume of the bob = $\frac{4}{3}\times\pi\times r^3$ (6)

(r = radius of the bob)

ρ = Density of water = 1000 kg/m^3

g = gravitational constant

So, Net upward force $F'_1 = V\rho g - mg$

$= (\frac{4}{3}\times\pi\times r^3\times\rho g) - mg$

$F'_1 = (\frac{4}{3}\times\pi\times r^3\times\rho - m)g$ (7)

Taking moment about point O,

$F'_1 x = F'_2 y$

⇨ $(\frac{4}{3}\times\pi\times r^3\times\rho - m)gx = F'_2 y$

⇨ $F'_2 = (\frac{4}{3}\times\pi\times r^3\times\rho - m)gx/y$ (8)

V. OBSERVATIONS

- Force required to switching the starter ON, F = 0.65kgf.

Fig.7: Use of force gauge to calculate the force required to switch ON the starter

- Force required to OFF the starter switch, F$'$ = 0.48kgf.

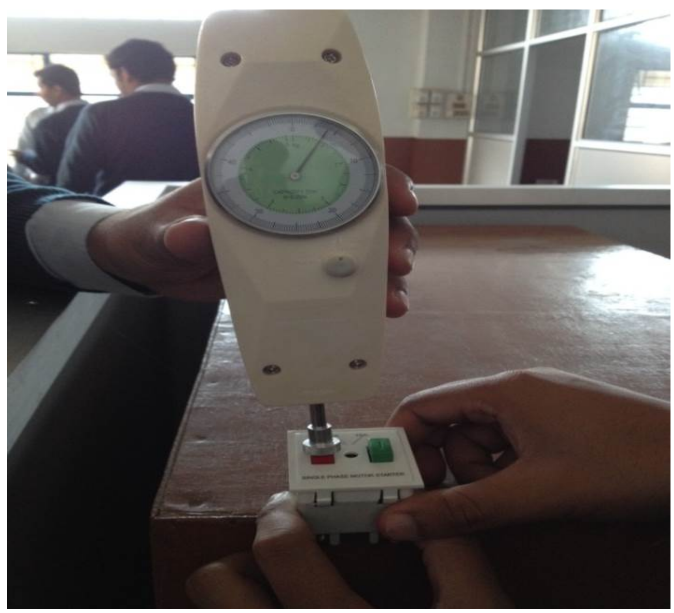

Fig.8: Use of force gauge to calculate the force required to switch OFF the starter

- Mass of the bob, m_0 = 0.691kg
- Extra mass provided in the bob, m_e = 1.540
- Mass of the dead weight, m_d = 0.280kg
- Minimum force that have to be applied on the right side of the main link to switch on the starter,
  F_m = 1.05kg
- Minimum force that have to be applied on the right side of the main link to switch off the starter,
  $F^{/}_m$ = 0.65kg
- Length of the main link on the right side, x = 262mm
- Length of the main link on the left side, y = 115mm

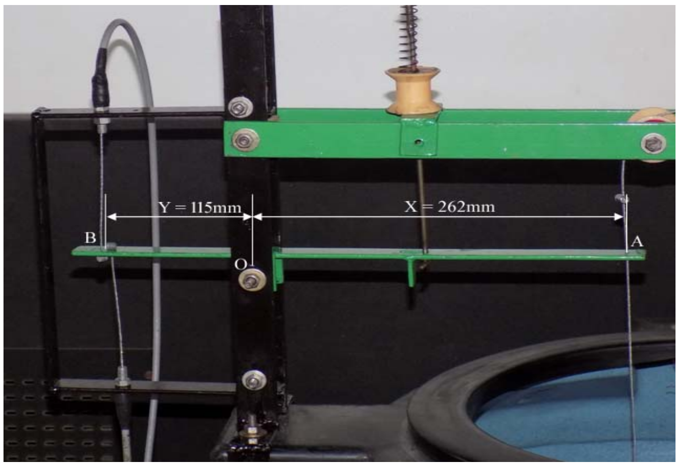

Fig.9: Observation of length of the main link on both side

VI. Calculations

A. Force Analysis Done on the Bob

The bob used here is made of two bowls of same volume and same weight. So analysis is done for the buoyancy force of a single bowl.

Fig.10: Assembled Bob

When the bowl is placed in a water container, it is found to be floating and just a small portion of the bowl is under water. So, the weight of the bowl is itself the buoyancy force which is found to be 0.255kg. After this sand is poured on the bowl to the point at which the bowl is just floating, i.e. to the critical point of buoyancy of the bowl. Then the weight of the sand used is measured, which is found to be 2.710kg.

So, the total buoyancy force on the bob will be

= 2× (2.710 + 0.255)
= 5.930kgf

B. Calculation of the Forces Acting on the Main Link

As the magnitude of the spring force is very small in comparison to the other forces acting on the main link, it is neglected.

Total downward force on the right side of the main link at point A, F_1= (total weight of the bob) – (weight of the dead weight)

= (1.540 + 0.691) – (0.280)
= 2.231 – 0.280
= 1.951kgf

Length of the link on the right side, x = 262mm
Length of the link on the left side, y =115mm

Force developed on the left side of the main link at point B to switch on the starter, F2 = F_1×(x/y)

= 1.951× (262/115)
= 4.445kgf

The total upward force on the right side of the link at point A, $F_1^{/}$ = (buoyancy force + weight of the dead weight) – (total weight of the bob)

= (5.930 + 0.280) – (1.540 + 0.691)
= 3.979kgf

Force developed on the left side of the main link at point B to switch off the starter, $F_2^{/}$ = $F_1^{/}$×(x/y)

= 3.979× (262/115)
= 9.065kgf

Force loss while switching on the starter = F_m×(x/y) – F

= 1.05× (262/115) – 0.65
= 1.74kgf

Force loss while switching off the starter = $F^{/}_m$×(x/y) – $F^{/}$

= 0.65× (262/115) – 0.48
= 1kgf

VII. Conclusions

Water is one of the most important basic needs for all living beings. But unfortunately a huge amount of water is being wasted by uncontrolled use. Some other automated water level monitoring system is also offered so far but most of the method has some shortness in practice. We tried to overcome these problems and implemented an efficient automated water level controlling system. Main intension of this project work is to establish a flexible, economical and easy configurable system which can solve water losing problems.

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