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Wind Based Rope Water Pump


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Abstract:

In this era of great technological growth, there are still people that do not have a readily available supply of one of the most basic of needs, water. The main goal development of an Efficient Rope Pump that will provide access to potable water in rural areas, the rope pump is the ideal method to tap the obtainable resource of fresh groundwater. When compared to other existing methods it is the more reliable, sanitary, and cost effective option. To provide sustainability, once the pump is constructed no outside sources are required for any purpose. Rope pump pulley is connected to a vertical axis wind mill by means of a gear which rotates the pulley of the system, gear of wind mill and pulley can be engaged and disengaged when required. On the rope, round disks or knots matching the diameter of the pipe are attached which pull the water to the surface.

I. INTRODUCTION:

A Wind Based Rope Pump is a simple device constructed of basic materials that pushes water from the bottom of a well using rope with seals attached to it. A Wind Based Rope Pump works by creating a seal inside the riser pipe and pushing the water upward. The type of seal (knots tied by hand or seals that were cut out) will determine the efficiency of the pump. As the vertical wind mill rotates by the force of wind which turns a horizontal shaft with a drive pulley attached to it by which knots rotate. Once inside the well the seal travels the length of the well down to the guide box.

The purpose of the guide box is to redirect the rope going down into the well back upward into the riser pipe. A guide box can be made in many different ways and with various materials. After the seals travel through the guide box they enter the riser pipe. As the seals enter the riser pipe there is a water level between the bottom of the riser pipe and the surface water level which becomes trapped and forced upward. Water is pushed the up entire length of the well by these seals until it reaches the top where an out spout is attached.
This sudden opening allows the contained water to flow out into an awaiting bucket. Also the continued

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and enlarged riser pipe above the out spout allows air flow which drains the water through the out spout quicker. The wind based rope water pump was generally invented in the late 12th century, where there was a problem in excavating the water from the wells for larger purposes such as farming and cultivation of crops and general uses. Although there were many mechanisms but it took much time and energy to conceive it. Before the wind based rope water pump there were simpler rope water pumps which were generally powered by man or a animal to draw out water. This consisted of simple pipes and washers which were tied to a rope which was intern tied to a pulley or a round clog or wood. This was powered by generally by a man or a animal such as bulls or horses or cows. The earliest generations which were capable of harnessing this technology were the Chinese of song dynasty. This technology was popular instantly and got used to this. And this was used by many farmers for farming purposes.

A rope pump works by creating a seal inside the riser pipe and pushing the water upward. The type of seal (knots tied by hand or seals that were cut out) will determine the efficiency of the pump. When the drive wheel is turned friction will allow the rope and seals to travel up from the riser pipe and down into the well.
Once inside the well the seal travels the length of the well down to the guide box. The purpose of the guide box is to redirect the rope going down into the well back upward into the riser pipe. A guide box can be made in many different ways and with various materials. After the seals travel through the guide box they enter the riser pipe. As the seals enter the riser pipe there is a water level between the bottom of the riser pipe and the surface water level which becomes trapped and forced upward. Water is pushed the up entire length of the well by these seals until it reaches the top where an out spout is attached. This sudden opening allows the contained water to flow out into an awaiting bucket. Also the continued and enlarged riser pipe above the out spout allows air flow which drains the water through the out spout quicker.
Seals continue out of the top of the riser pipe and are grabbed by the wheel again due to friction. Then the whole process repeats.

II. PARTS OF THE WIND BASED ROPE WATER PUMP

- Rope
- Pvc pipes
- Drive wheel
- Pvc guide box
- Wheel guide box
- Shaft
- Bearings
- Rotor
- Gears
- washer

Rope

Rope comes in many sizes, materials, colors and with many different properties. The important thing about rope for a pump application is its water absorption and its elasticity. Strength is not an issue because it is extremely rare for a pump rope to handle more than 10 pounds. Elasticity is important because a rope that will stretch when under a working load or when wet will decrease the tension, therefore limiting the necessary friction with the drive wheel.

Fig 1: Rope

Pipes:

The piping is used as the cylinder in the piston cylinder concept of the rope pump design. As the rope (with some sort of seals) passes upward through the pipe, the trapped water is forced to ground level and exits via the out spout. The pipes which we used in our project are the PVC pipes which stand for poly vinyl chloride pipes. They were used because they were easy to work on and they would avoid friction between the seals and the tube, and they are light in weight and are easy to work upon them.

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Fig 2: Pipes

Drive Wheel

The drive wheel is an essential part of a rope pump. This is the mechanism that rotates the continuous loop of rope through the system. By utilizing friction on the wheel the rope circulates down through the well, in and out of the guide box and up through the riser pipe, which pushes the water towards the earth's surface. A drive wheel can be made of anything. Our team found it very feasible to utilize an old bike rim due to its availability and ease of adaptability. The drive wheel which we used was of an old recycled cycle tyre rim.

Fig 3: drive wheel

PVC Guide Box

Traditional Wheel Guide Box it is very common for a traditional rope pump to utilize a similar wheel as the drive wheel as the guide box down in the bottom of the well. A wheel is great because the rope can rotate the wheel and turn 180 degrees to be entered into the riser pipe with little or no friction. The down side is the extreme difficulty of installation, requiring someone to be underwater in a well to secure the wheel. PVC Guide Box belowis pictures of our team's innovative PVC guide box. There have been some similar ideas, and we have combined all the great ideas into one guide box.

This is made of only PVC piping and pipe cement (disregard the metal strap which was installed for model scale purposes only).

Fig 4: PVC Guide Box

Shaft

The shaft used was a galvanized iron pipes as they are strong and easy to work on. They were inserted between the drum plates and were attached to one of the gears for providing the required rotation.

Bearings

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Many bearings also facilitate the desired motion as much as possible, such as by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

Fig 5: A simple Ball Bearing model

Gears

The gear used in this project is bevel gears.Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well.The pitch surface of bevel gears is a cone.Independently from the operating angle, the gear axes must intersect (at the point O)

Fig 6: Gear

Two important concepts in gearing are pitch surface and pitch angle. The pitch surface of a gear is the imaginary toothless surface that you would have by averaging out the peaks and valleys of the individual teeth. The pitch surface of an ordinary gear is the shape of a cylinder. The pitch angle of a gear is the angle between the face of the pitch surface and the axis.

Rotor

The rotor was designed as per the requirement by cutting the drum in two. The following is the dimensions of the used drum

The rotor was made by cutting the drum in half and making it aerodynamic. And it was converted into a vertical axis wind turbine. This is called the savonius type wind turbine.

III. BUILD INSTRUCTIONS:

- Take the 12’ steel tubing and cut it into two 5’ parts plus two 6” parts and one 1’ parts.
- Bend the two 5’ parts at a 90 degree angle and smooth off the ends to form the two arches of the pump.
- Cut the angle iron into 4 parts that are 6” in length.
- Weld the angle iron to the arches.
- Measure out and cut two steel plates that are 4” by 3”.
- In one of the plates drill a quarter inch hole in the centre of the plate one inch from the edge. In the other cut out a half circle large enough to fit the pipe.
- Weld the two plates at the centre of the arches so they line up to accept the bike rim and allow it to spin. You may need to set the rim in place for to line everything up.
- Next drill a 1.15” hole in the centre of the aluminium stock using a drill. Cut the stock so it is an inch thick and drill two holes, on either side of the large centre hole, a quarter inch bit.
- Thread these two holes so they accept bolts.
- Take the two 6” cut steel tubes plus the 1’ part and weld them together in an “S-like” Shape similar to the picture shown to create the handle. Attach this to the rim with either a bolt (for easy removal) or through welding (for permanent fixtures) .
- Place the bike rim in between the plates and bolt down one side. On the other place the aluminium stock on the handle side and bolt it to the other steel plate.
- Attach the handle and tighten everything down. This will form the pump assembly.
- If needed take additional piping and brace the two arches to each other.
- Bolt the above assembly to an existing frame to bring the pump to shoulder level.
- Start pumping water

NOTE: Any/all dimensions are subject to change depending on the application and location of rope pump. Also, any methods, tools, or procedures followed may be changed to accommodate the circumstances.

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Build Instructions for Seals

- The first step is to make the seals. Place the rubber sheet onto a piece of wood and put the punch onto the rubber.
- One the punch is in place hit the punch with your hammer.
- remove the punched out seal from the punch
- Repeat this until the desired amount of seals has been made.
- After the seals have been punched out, punch out a 5/32” hole in the middle of each rubber seal.
- After creating the holes on the seals you are now ready to put the seals onto the rope.
- ASSEMBLY INSTRUCTIONS FOR ROPE + SEALS
- Begin by tying a knot at the end of the 5/32” Polypropylene rope.
- Slide a 5/32” washer onto the opposite end of the rope where you tied it
- Then slide on a rubber seal that you made previously
- Next slide on another 5/32” washer
- Repeat sequences B-D until the desired amount of seals are on the rope.
- Once the seals and washer are on the rope slide one set (washer-Seal-Washer) down onto the knot you created.
- Tie a second knot after the seal and try to get knot as close as you can to the end of the one set
- Next tie a knot 3.5 ft. or 1 meter away from the last knot and tie another knot.
- Repeat instructions F-H until the desired length of rope is achieved

Assembly Instructions for Connection of Rope + Seals to the Rope Pump

- Tie one end of the old rope to the pump structure.
- The rope needs to be fed around the bottom guide box until the rope comes out and both ends are visible.
- Then feed the rope through the entire pipe that is going to be lowered into the well (it is easier to feed the rope through one section of pipe at a time).
- The rope should then carefully be untied from the pump structure.
- Now the rope can have its free ends tied together with enough tension to stay on the drive wheel.
- To get the desired tension, find where the rope is tight around the wheel and marking those spots on the two ends of rope.
- Then take the two ends of rope off of the wheel and pull the rope slightly tighter.
- Tie the two ends together by creating a double knot with the two ends.
- Once the knot has been made have one person pull on the two ends to make sure the knot is tight and the other person to burn the knot using the lighter for about 4 seconds on each side of the knot (this is to ensure the knot does not come undone.
- Once the two ends have been fused together, place one part of the rope on one side of the wheel and begin to rotate the wheel in order to get the rope around the wheel.

Working:

The working of the wind based rope water pump is based on the simple principle of the rope pump where the pumping of the water takes place with pushing and pulling of the water through the washers which are placed inside the PVC pipes. Firstly the setup is assembled and the required air and position of the system is checked. It works by creating a seal inside the riser pipe and pushing the water upward. The type of seal (knots tied by hand or seals that were cut out) will determine the efficiency of the pump. As the vertical wind mill rotates by the force of wind which turns a horizontal shaft with a drive pulley attached to it by which knots rotate. Once inside the well the seal travels the length of the well down to the guide box. The purpose of the guide box is to redirect the rope going down into the well back upward into the riser pipe. A guide box can be made in many different ways

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IV. DIMENTIONS AND CALCULATIONS OF THE SYSTEM

Height: 230 cm's
Width: 120 cm's
Square channels: ½ inch =1.27 cm's
Shaft: 20 mm
PVC pipes: 1 inch =2.54 cm's
Discharge: Q =AxV
$=1.2^2\times \pi\times 10$
=45.2 liters/ hour (approx)
Propeller height =93 cm's
Gears: $\frac{N_2}{N_1} = \frac{T_1}{T_2}$
T_1= 18 teeths
T^2=10 teeths
Assume $N_1 = 1$
Then , $N_2 = \frac{T_1}{T_2}\times N_1$
$=\frac{18}{10}\times 1$
$N^2 = 1.8$
Gear ratio= 1:1.8

V. EXPERIMENTAL SETUP

Fig 7: Bevel gear assembly

Fig 8: Horizontal bearing and bush assembly

Fig 9: Bearing and bush assembly top

Fig 10: Bearing and bush assembly bottom

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Fig 11: Wind Based Rope Water Pump

VI. CONCLUSION:

This project concluded that a wind turbine of this size could adequately run the hand powered water pump design that was used. However, the flow rate is inadequate compared to the design specifications, with a final maximum flow rate of 1.55 liters per second. It is believed that, due to the prototype nature of the design, there was a significant amount of energy lost to friction and the low efficiency of the machines. In particular, the water pump experienced significant leakage and water loss during operation. However, even with this kind of flow rate, the pump is still effective at providing water.

The goal of this project was to design and build a turbine-pump system that could be constructed in a third world country. This means that the most significant design restrictions were related to the construction methods instead of the efficiency; as such, the design goal was to create a pump that was inexpensive rather than efficient. In that respect, the project was an absolute success. If this project were to be continued past the current stage, the project goalswould likely change to focus more on the effectiveness of the turbine and the pump byimproving efficiency and reducing losses present in the current design.

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