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Design and Development of RO System with Pedal Operation

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Abstract - Pure water is very much essential to survive but now a days this water is getting contaminated due to Industrialization which leads to many water-related diseases. Our project Pedal Powered Water Purification by RO method meets the needs of people without requiring any electrical energy. RO is a physical process that uses the osmosis phenomenon, that is, the osmotic pressure difference between the salt water and the pure water to remove the salts from water. RO is a pressure-driven membrane process where a feed stream flows under pressure through a semi permeable membrane, separating two aqueous streams, one rich in salt and other poor in salt. Water will pass through the membrane, when the applied pressure is higher than the osmotic pressure, while salt is retained. As a result, a low salt concentration permeate stream is obtained and a concentrated brine remains at the feed side. A typical RO system consists of four major subsystems: pre-treatment system, high-pressure pump, membrane module, and post treatment system. Using a high-pressure pump, the pre-treated feed water is forced to flow across the membrane surface. In operation by pedalling the cycle, man power is converted into mechanical energy which is further converted into hydraulic energy in RO pump. RO pump is attached to rear wheel of bicycle which runs due to friction. RO pump pumps the water to SEDIMENT FILTER which removes various foreign bodies such as bits of rust, sand silt and dirt. Then the water passes through CARBON FILTER which removes chlorine and other organic chemicals. The water from pre filters enters into RO membrane, which removes bacteria, pyrogens, pesticides, asbestos etc. The impurities are flown into drain and the pure water is collected. Simple tests are carried out to check purity of water. This technology has advantage of a membrane-based process where concentration and separation are achieved without a change of state and without use of chemicals or thermal energy, thus making the process energy efficient and ideally suited for recovery applications.

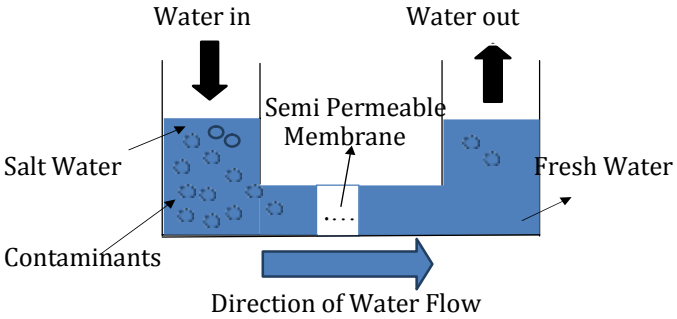
***Key Words*: Reverse Osmosis, Membrane, Filter, Permeate, Osmotic Pressure, Brine, Hydraulic Energy**

1. INTRODUCTION

Pedal Powered Water Pump along with water purification (PPWPWP) is an eco-friendly system. The PPWPWP works only on mechanical energy without electricity. PPWPWP provides drinking water and irrigation in remote areas where electricity is still a major problem. Along with providing eco-friendly environment it also helps to regulate a good health while pedaling PPWP is not only free from pollution but also provide healthy exercise. PPWPW Produces the rising energy costs. PPWPWP was designed as a portable one which can be used for irrigation in various places. PPWPWP consists of a centrifugal pump operated by pedal power. The centrifugal pump is positioned on its stand in such a way that driven shaft of the centrifugal pump has butted to the bicycle wheel. By pedaling the bicycle, the bicycle wheel rotates, thereby rotating the centrifugal pump which in turn discharges water from the sump and transmitted to pre filter which purify the water simultaneously.

1.1 REVERSE OSMOSIS

Reverse osmosis (RO) is a water purification technology that uses a semi permeable membrane to remove larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property, that is driven by chemical potential, a thermodynamic parameter. Reverse osmosis can remove many types of molecules and ions from solutions, including bacteria, and is used in both industrial processes and the production of potable water**.** The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other effluent materials from the water molecules. The availability of fresh and good quality drinking water to all Indians remains a concern.



1.2 OBJECTIVE

As such we decided to design an apparatus that could produce clean and safe drinking water at low cost and effectively and also without using electricity, since majority

of the remote areas of our country still don't have access to electricity. Pedal Powered Water Pump along with water purification is an eco-friendly system. The unit works only on mechanical energy without electricity. This system provides drinking water and irrigation in remote areas where electricity is still a major problem. Along with providing eco-friendly environment it also helps to regulate a good health while pedaling is not only free from pollution but also provide healthy exercise. The System Produces the rising energy costs.

• Provide a low-cost machine.

• Easy replacement of the filter membrane.

• The mechanism is Pedaling, Processing and filtering

- A small-scale water filtration system could be brought into remote areas and emergency conditions like flood, famine, earthquakes, and tsunami to provide the means of purifying contaminated water.
- In other hand there are no proper water facilities and electricity in villages and these people are drinking hard water which is dangerous to health.
- Filtering local sources of water would eliminate the need to import large quantities from elsewhere, saving relief funds for alternate uses.
- To make the system portable and user friendly.
- The purpose of this project is to design a small-scale water purification kit which requires minimal maintenance and is cost efficient.

1.3 TYPES OF WATER PURIFIER

Types of water purifiers:

A.) Reverse Osmosis (RO) Water

Purifiers

B.) Ultraviolet (UV) Water Purifiers

Reverse Osmosis (RO) Water Purifiers

Reverse osmosis, also known as hyper filtration, is the finest filtration available today. It is the most common treatment technology used by premium bottled water companies. It is effective in eliminating a very wide variety of contaminants from contaminated water. The pores in a reverse osmosis membrane are only approximately 0.0005 micron in size. Reverse osmosis systems vary in membrane quality, output capacity, and storage capacity.

Ultraviolet (UV) Water Purifiers

Ultraviolet water purification lamps produce ultraviolet radiation of much greater intensity than sunlight. Most ultraviolet purification systems are combined with various forms of filtration, as UV light is only capable of killing microorganisms such as bacteria, viruses, molds, algae, yeast.

2. MAJOR EQUIPMENT

Pedestal Bearing: A pillow block usually refers to a housing with an included anti-friction bearing. A pillow block refers to any mounted bearing wherein the mounted shaft is in a parallel plane to the mounting surface, and perpendicular to the center line of the mounting holes, as contrasted with various types of flange blocks or flange units. A pillow block may contain a bearing with one of several types of rolling elements, including ball, cylindrical roller, spherical roller, tapered roller, or metallic or synthetic bushing. The type of rolling element defines the type of pillow block. These differ from "Plummer blocks" which are bearing housings supplied without any bearings and are usually meant for higher load ratings and a separately installed bearing.

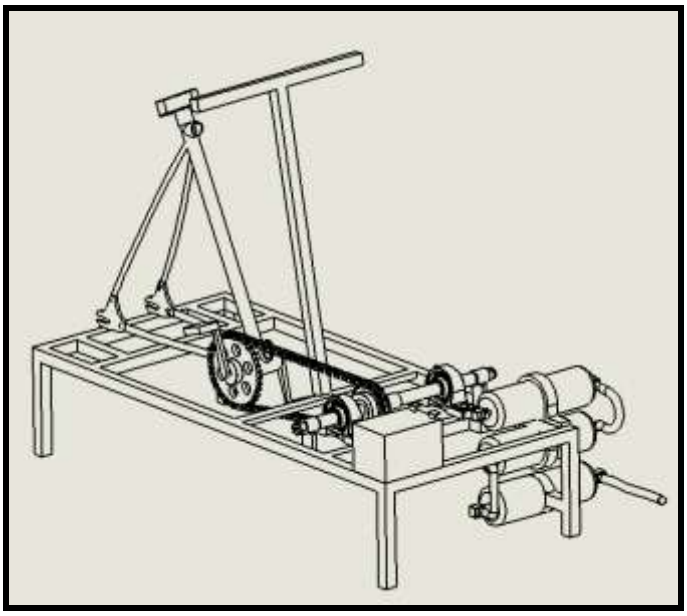
Small DC Motor: A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

Filters: Activated carbon filter: It uses the phenomena of adsorption. The water flowing through it contains impurities which are harmful for us. The impurities in the low-pressure water are adsorbed on the surface of the activated carbon. The large surface area provided by each particle Activated carbon also removes smells in water and makes cloudy water clear by removing color causing compounds in the water. While going through the activated carbon filter, each water molecule gets sufficient space for adsorption. Pedal powered water filtration system lowers down the turbidity & the TDS value under the acceptable range. Sedimentation filter: It is used to reduce the turbidity of the water. Is consists of suspended solids, such as silts, sand or clay. All the insoluble impurities get separated by this filter.

Chain Sprocket: A chain and sprocket drive is a type of power transmission in which a roller chain engages with two or more toothed wheels or sprockets, used in engines as a drive from crankshaft to camshaft.

3. WORKING PRINCIPLE

As shown in the figure, the project involves fabrication of pedal operated water pumping and purification unit. The energy obtained by pedaling the pedaling system is transferred to the drive train using the chain and sprocket drive. The chain and sprocket drive used is of required speed ratio so as the pedaling action of human being makes the required energy as well as speed to drive the pump. The pump is connected to the impure water tank. As the user pedals the impure water from the tank is pumped to the purification unit. The purification unit purifies the impure water and gives to the outlet. Thus, this project can serve as a means to pump the water from the tank using pedal power as well as purify the water from the tank. In addition to this the part of the drive is used to generate electricity. The project consists of a small Generator which is attached to the pedaling unit using a speed reduction drive. As the pedaling action takes place, the generator also rotates, thereby generating electricity. The generated electricity is stored in a battery which can be used in case of power cutoffs.



Wire Frame Design

4. DESIGN AND MODELLING

For final product, we have done 3D design in Solid works software. We have made design of different component and assembled into one final model.

For manufacturing of pneumatic cutting machine, firstly we require individual parts with dimensions of whole machine and then we need to assemble every individual part with each other to make final design.

Here, Different View of parts with dimensions are shown:

Sr. No.	Part Name
1	Bicycle Frame
2	Motor
3	Chain Sprocket
4	Filter
5	Pedestal Bearing
6	Battery
7	Final Assembly

Table – 1 Design Parts

Fig – 1 Bicycle Frame

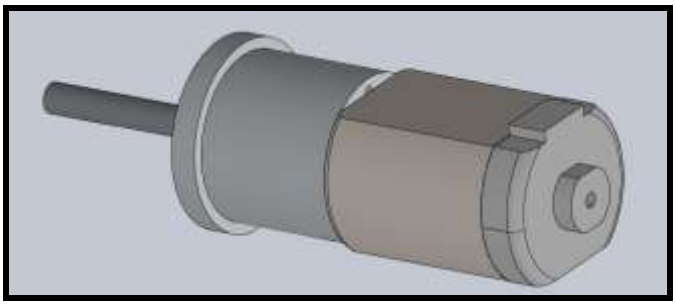


Fig – 2 Motor

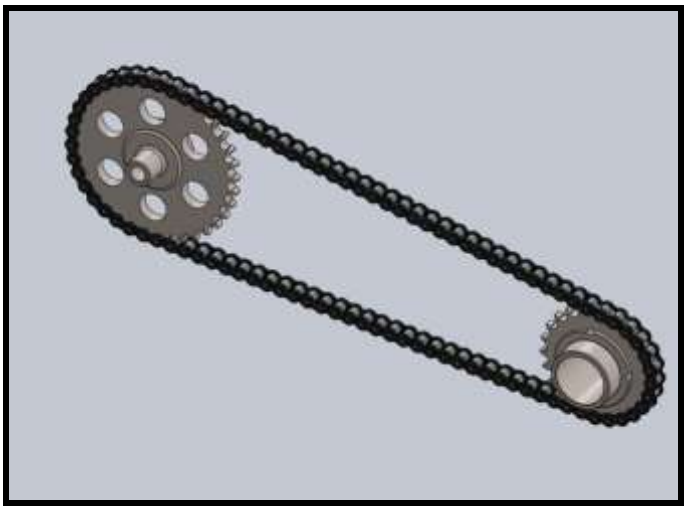


Fig – 3 Chain Sprocket

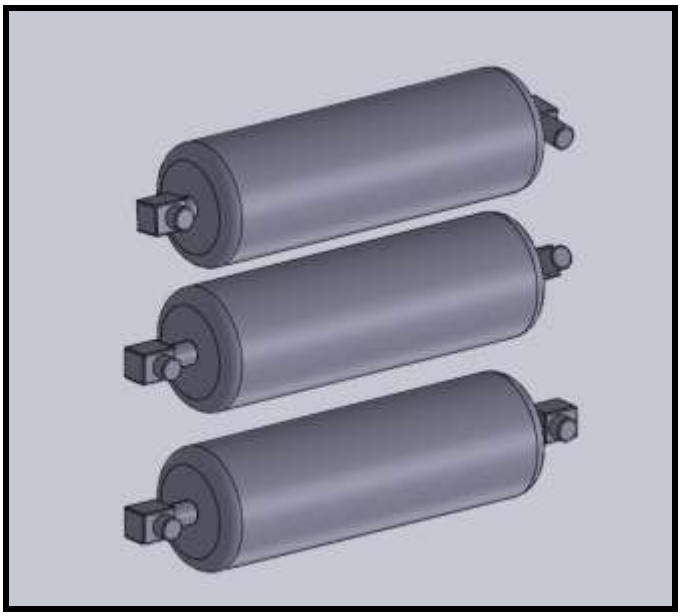


Fig – 4 Filter

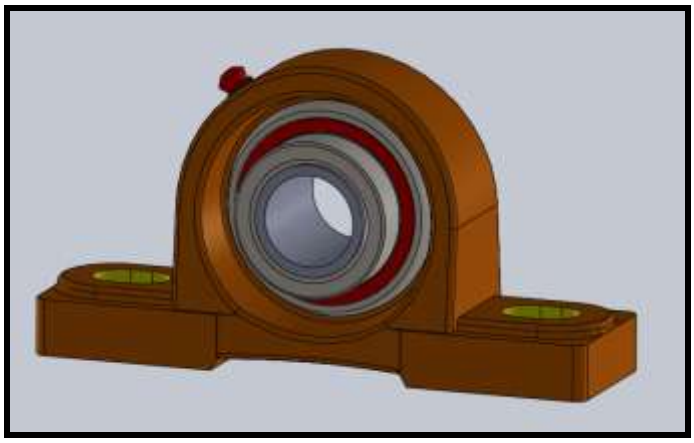


Fig – 5 Pedestal Bearing

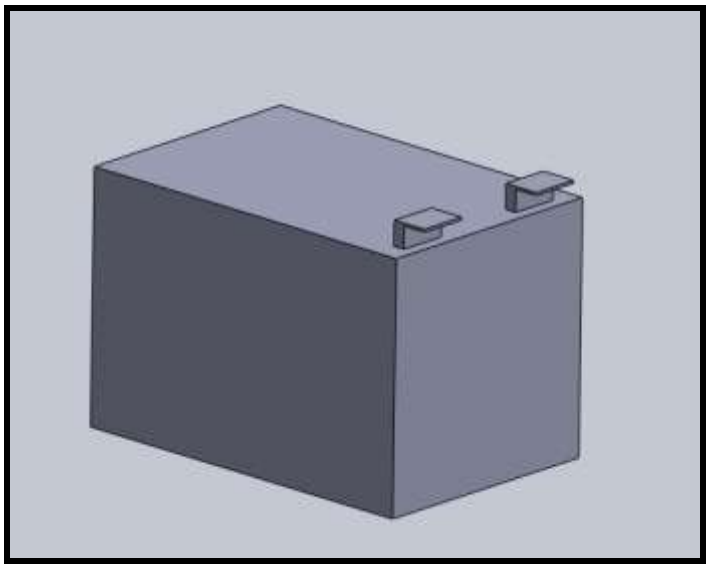


Fig – 6 Battery

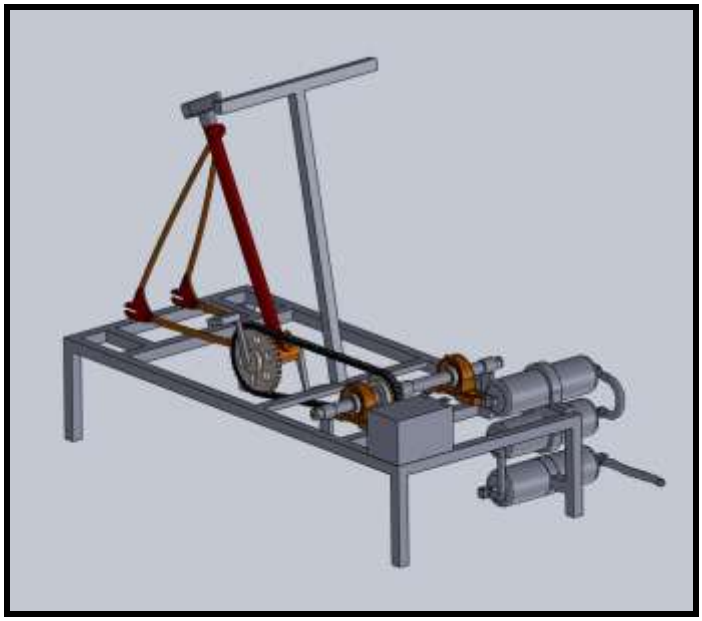


Fig – 7 Final Assembly

5. THEORETICAL EVALUATION

Design Calculation

1. Model calculation

L1 = π(r1 + r2) +2x+(r1 –r2)2 /48

= π (8.2+ 3.2) + 2 * 48 + (8.2-3.2)2/48

L1 = 1.32m

2. Calculation of chain

Pitch of chain

P=AB = 2 AO sin (Θ/2) = 2* (D/2) sin (Θ/2)

D= diameter of the pitch circle

T= No. of teeth on the sprocket

So, P = D sin (360/2T)

P = 16.8 sin (360/2*45)

P = 1.171

3. Pitch circle diameter

D= p cosec (180 /T)

P = D sin (180/T)

D=1.171 cosec (180/45)

D= 16.8cm

4. Length of chain

L = K.P

K= no. of the chain links

P= pitch of chain

The no. of chain links

K = (T1 + T2 /2) + (2x /P) + {T2 – T1 / 2π} 2 (P/x)

= (45 + 18 /2) + (2*48 /1.17) + {18 – 45/2π}2 (1.171/48)

K = 1.13m

Therefore,

L= K*P

= 113*1.171

L = 1.32 m

The theoretical flow rate is calculated as follows.

Assuming inner diameter of tube (d) = 0.0095m, casing diameter (D) = 0.23m.

The volume of water displaced per roller is given as:

Volume displaced per roller = Area of the tube (cross-sectional) * (circumference of the casing)

= $(\pi x 0.25 x d^2)(\pi x 0.23)$

= 5.1217x 10^{-5} m^3

Total volume displaced for 5 rollers used

= Volume Displaced per roller = 5.1217x 10^{-5} m^3

Discharge per occlusion (Q):

Assuming average pedaling speed of human = 35RPM (30≤N≤40)

Q = V (total) x (rotational speed per minute)

= 5.1217x 10^{-5} x (2 πN/60)

= 1.18772 x 10^{-4} m^3/s

6. Design Alternatives

Design Alternate 1:

The first design consisted of an all incumbent tricycle or quad cycle with the built-in filtering system. The picture displayed below is the initial prototype created by and independent company called the Aqua duct. Our goal was to be inspired by this design and improve upon it in

Figure – 8 Aquaduct Tricycle Influence Example

areas in which it was lacking. The design shown consists of a peristaltic pump that uses the rider's kinetic energy to filter impure water (placed in the rear tank) to the front tank. Our tricycle will be more durable for more rural areas, and will have filters that can be self-cleaned and long lasting. Although this model is very well built, it is extremely expensive and only in the prototype stage. Once analyzing price comparisons, we also came to the conclusion that building a whole tricycle would be far too costly for the budget we are trying to achieve. Therefore, we chose to move to further alternatives.

Design Alternate 2:

Given the problems presented above the group decided to take the discussion into another direction. This included the idea of creating a caboose cart that could be dragged along behind an already existing bicycle. The same idea of filtering the water by the energy presented to the pedals would be used.

Figure – 9 Bicycle Trailer Caboose Influence

But now this attachment along with the pump could be dismantled and attached to any other bicycle at the rear. This seems like an excellent method to consider, where the tanks and pumps could be placed on a rear platform and the seat would be removed. Some concern though does exist in weight distribution, as well as the sloshing of water when moving. Balancing could become an issue and create hauling problems, which would not be ideal for the given conditions.

7. Conclusion

The project carried out by us made an impressing task in the field of water purification method. Through extensive work we found cost effective parts that will meet our goal of designing a portable filtration system that can be retrofitted to any standard bicycle and facilitate the transportation of water for the daily use of families in developing countries. Considering other water purification systems, a human powered reverse osmosis system is not only feasible, but quite an economical and effective means for providing potable water. In the coming days a prototype will be constructed which consists of a pressure pump, the filter and a stand. Each component will be thoroughly tested in order to provide the best product possible at the most reasonable price.

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