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Design And Development of Pedal Powered Water Purification Using Reverse Osmosis

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Abstract- *Pure water is very much essential to survive, but now a day the water is getting contaminated due to Industrialization which leads to many water-related diseases. Reverse Osmosis (RO) Water Purification by Cycling Action 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. 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 sub-systems: pre-treatment system, high-pressure pump, membrane module and post treatment system. In operation by pedaling the cycle, man power is converted into mechanical energy which is further converted into hydraulic energy in RO pump.*

Keywords*: Reverse Osmosis, Man power, Drinkable water, pneumatic cylinder*

1. Introduction

Pure water is very much essential to survive but nowadays the water is getting contaminated due to industrialization which leads to many water related diseases. In many developing countries, people walk many miles to reach a source of water that is not necessarily potable. Water can contain dirt, minerals, chemicals and other impurities that make it smell and taste bad. Some of these contaminants can endanger health, especially when they include microscopic organisms and bacteria that can cause serious illness. Filtering water can help purify water, removing these impurities and making it safe to drink, while often improving its taste. A study conducted by various sources compared different modern methods of water purification-distillation, ultra-violet light, reverse osmosis, solid block activated carbon, granular activated carbon, water softeners, sediment filters, boiling, bottled water, ozonation, chlorination, ion exchange etc. Among all the above methods mentioned Reverse Osmosis is best suited for issues which were originally designed for mainly two things, they are: desalination of brackish water or sea water and reducing very specific chemical contaminants. Reverse Osmosis is needed to remove Fluoride, sodium, total dissolved salts, or chemicals like arsenic, radium and nitrates. In response to such a need, Reverse Osmosis Water Purification by Cycling Action is proposed to produce clean drinking water which uses human power to get pure form of water for drinking. The term water purification refers to a process, which selectively extracts pure water from an impure solution, leaving all kinds of impurities behind, regardless of their source or their nature.

This is quite different than water treatment described above. There are only three scientifically recognized methods of water purification. These are: Distillation, freeze-thawing, and reverse osmosis (RO). Of these, reverse osmosis offers the most practical and economical approach to water purification. The equipment is compact, easy to operate, and it is highly energy-efficient, in comparison with distillation and freeze-thawing equipment. RO is an effective method of reducing the concentration of total dissolved solids and many impurities found in water.

1.1 Objectives

- The water filtration project is intended to provide clean drinking water to anyone in need.
- The lack of clean water supplies could save countless lives every year. A small scale water filtration system could be brought into remote areas and provide the means of purifying previously contaminated water.
- Filtering local sources of water would eliminate the need to import large quantities from elsewhere, saving relief funds for alternate uses. The purpose of this project is to design and manufacture a small scale water purification system which requires minimal maintenance and is cost efficient.
- This report describes the process and materials necessary to create a small scale water purification system.

2. Literature Survey

There are many water filtration products in existence today. However, none of these products fully satisfy the needs of families in rural areas with a lack of clean drinking water. All of the following products require either large sums of money or extensive maintenance, and some products don't even come with a guarantee of potable water.

There are many filters that claim to clean water (carbon filters, Brita filters). One type of filter that is in existence is the Brita water filter. This widespread at-home filtration system is very small and can quickly produce enough water for a household. However, the Brita water filter is only applicable to affluent countries because it can only filter aluminum (placed there by existing water treatment facilities during the chlorination process), and reduces the concentration of calcium, chlorine, magnesium, bad tastes, and odors. All of these operations are mere luxuries that affect only the taste and smell of water, but do not actually filter out bacteria or make the water safer to drink. In general, the Brita type water filters count on desalination systems and/or industrial reverse osmosis plants to decontaminate the water.

Reverse Osmosis is a common filtration system used by households and cities around the U.S. This process reverses diffusion by applying pressure on the highly concentrated side of a membrane causing all clean water to end up on the side of the membrane with low concentration of contaminants. These systems come in all sizes ranging from in-home, to city-wide. Reverse Osmosis (RO) is more useful to developing countries than the Brita system because even an at-home kit can eliminate up to 99.99% of microorganisms and up to 98% of dissolved solids, metals, and harmful chemicals from tap water. Both the in-home and city-wide osmosis systems require immense amount of pressure and are thus very expensive. The in-home RO kits cost between $200 and $500 per household. The total cost of a city-wide RO plant is around six million dollars (including control systems, bulk chemical storage, and laboratory facilities). This high cost is one of the major drawbacks of the city wide reverse osmosis plants. Both the at-home and city-wide systems require expensive maintenance and upkeep.

3. Working Principle

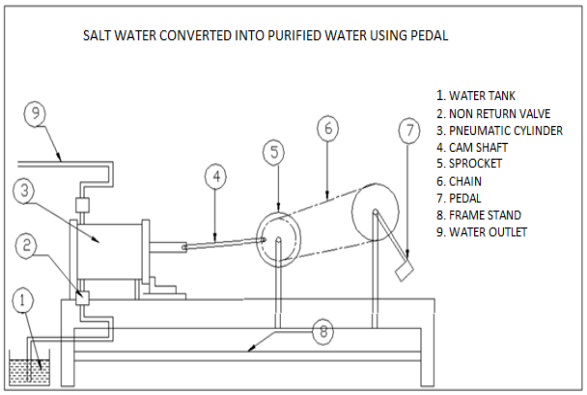

Fig 1: Line diagram of setup

The entire process of the design begins by adding salt water into the tank. All the heavy sediment is immediately removed as the water passes through several layered mesh micro filters. The initial filtering step is crucial because the RO filter would quickly clog if it had to filter heavier sediments. To set the purification system in motion we need to begin peddling the pedal. Since the pump mechanism is geared to minimize the effort needed to operate it, the user feels little to no difference in having to power the pump system compared to pedal a bicycle. The water then enters the two stages of the filters in RO system..


Fig 2: Working Model

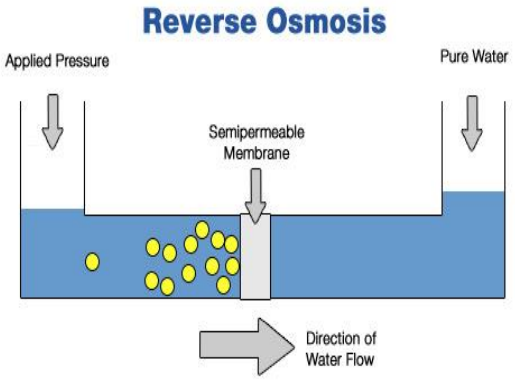

Fig 3: Reverse osmosis principle

The first stage removes any very heavy sediment down to fine microns still left in the water that the first set of filters did not catch. The second

stage removes any unwanted color, taste and odor. These two stages prepare the water for the most crucial step Reverse Osmosis. Without these previous two filters, the RO membrane could easily be destroyed by certain chemicals that may be in the dirty water. The more filtered the water in before passing through the RO membrane, the longer the membrane will last. The third stage is the heart of the system as it removes all particles down to 0.0001 micron in size. The fourth and final stage is a repeat of the second stage, purely to optimize water quality. From here, the water exits the system as potable water and rinse water. The purest water is used for drinking and the rinse water can be used in many ways other than drinking such as irrigation, cleaning etc. so that water can never get wasted.

Main Components

The main components used to fabricate the model are:

- Filters
- Chain Drive with Sprocket
- Pneumatic cylinder

4.1 Filters

Fig 4: Filters

A filter removes impurities from water by means of a fine physical barrier, a chemical process or a biological process. Filters cleanse water to different extents for purposes such as providing agricultural irrigation, accessible drinking water, public and private aquaria, and the safe use of ponds and swimming pools. Filters use sieving, adsorption, ion exchanges, biological metabolite transfer, and other processes to remove unwanted substances from a quantity of water. And unlike a sieve or screen, a filter can potentially remove particles much smaller than the holes through which its water passes.

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4.2 Chain Drive With Sprocket

Chain drive is a way of transmitting mechanical power from one place to another. It is used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. Most often, the power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force into the system.

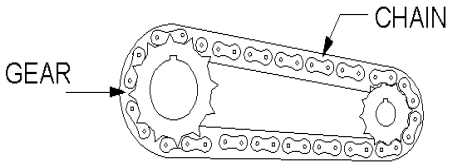

Fig 5: Gear and Chain mechanism


Fig 5(a): Chain


Fig 5(b): Sprocket

A sprocket is a profiled wheel with teeth that meshes with a chain, track or other perforated or indented material. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth. Sprockets are used in bicycles, motorcycles, cars, tracked vehicles, and other machinery to transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion.

4.3 Pneumatic Cylinder

Pneumatic cylinders (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion

Like hydraulic cylinders, something forces a piston to move in the desire direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage.


Fig 6: Pneumatic Cylinder

Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. For example, in the mechanical puppets of the Disney Tiki Room, pneumatics are used to prevent fluid from dripping onto people below the puppets.

The cylinder itself contains a chamber for the compressed air to enter, a path for it to leave, a piston which does most of the work involved, and some type of action system which the piston is a part of. There are several different types of action systems for pneumatic cylinders, and each provides a slightly different kind of force. The first and most simple version is the single-acting cylinder, where a piston-oriented system forces compressed air through a solenoid valve into the back of the piston. This highly-compressed air seeks the easiest way to exit, and exerts a large amount of force on the piston face. The surface area of the piston face, or the bore size, directly affects how easily the air will manage to push the piston. The larger the bore size, the more easily the air will move it--until weight itself becomes a significant factor. As the piston is pushed out, the air exits through escape valves that are carefully position further down the cylinder. The piston falls back naturally in place until another burst of compressed air is fired into the cylinder.

The single-acting cylinder can also be modified with a compressed spring mechanism, inserted between the end of the cylinder and the side of the piston opposite where the compressed air enters. This system works in a similar fashion to the standard, but after the compressed air is released, the piston is forced back down to its original position at the end of the cylinder by the spring. This system is used for repeated, linear motion involving heavy loads, and requires a greater force of compressed air to complete its task.

5. Components Used

5.1 Sprocket

A sprocket or sprocket-wheel is a profiled wheel with teeth, or cogs, that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

It is used to convert rotational motion from chain and sprocket mechanism into linear motion and transmit power to operate the pneumatic cylinder. Sprocket has 41 teeth and is made of cast iron with diameter of 0.165m

Fig 9: Sprocket

5.2 Non Return Valve

Fig 10: Non return valve

A non-return valve allows salt water to flow in only one direction. A non-return valve is fitted to ensure that a salt water flows through a pipe in the right direction, where pressure conditions may otherwise cause reversed flow.

5.3 Bars

Bars are made of cast iron and each bar is 1.5m long and is used as the supportive frame to the entire model

Fig 11: Bars

5.4 Pillow Block

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 "plumber blocks" which are bearing housings supplied without any bearings and are usually meant for higher load ratings and a separately installed bearing.

Pillow block is made of cast iron material, it acts as a antifriction bearing and supports the shaft with an internal diameter of 1 inch.

Fig 12: Pillow Block

7. Advantages and Disadvantages

The advantages, disadvantages, applications and future scope of this project are:

Advantages

The advantages are as follows:

- Its operation and maintenance is very simple
- It is compact and portable.
- It is simple in process.
- Power saved and good exercise for human beings

Disadvantages

The disadvantages are as follows:

- Slow production rate.
- Requires lots of water to produce pure water.

8. Conclusion

The pedal operated water filtration system is a new system that is useful in developing countries like India to have daily access to safe drinking water all by harnessing the energy of pedal power. Reverse osmosis is a relatively new, but very effective application of an established scientific process. Whether it is used to meet the needs of a typical family of four, or the needs of an industrial operation requiring thousands of gallons per day, it can be a cost effective to provide the required quantity of highly treated water. With continual advances in system and membrane design that boost efficiency and reliability, RO can be expected to play a major role in water treatment for years to come. In Reverse Osmosis Water purification by Cycling Action

- Simple in design.
- Portable.
- Economical.
- Effective way for providing potable water.
- Less maintenance

9. Future Scope

- The future scope includes redesigning the structure of the model and the type of pump to get higher pressure.
- The RO filters can be made combinations with UV filters to get high quality of pure water. By increasing the speed of cycling action higher rate of water flow can be created.
- The model can be redesigned in to movable model from stationary model by using bicycle in which pump and filters can be attached using suitable mechanism.
- It can be used as a travelling device from one place to another place and hence pure water can be collected in separate container by the time the person reaches his destination.

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