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'Pedal Operated Water Purifier'

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ABSTRACT

Pure, clean drinking water is a need of every household as humans can't live without it. Electricity at rural and remote areas is extremely erratic, thus making conventional water purifiers almost redundant for use. Thus, this project is specifically aimed at such areas and conditions of the world where water supply is erratic or non-existent and access to clean drinking water is sometimes at long distances. A pedal operated water filtration system is a water filtering apparatus which can filter water by using human muscle power via a pedal operated mechanism. This apparatus is preferably mounted on a supporting frame for increased portability. It will be specifically designed to perform three important functions: storing water, filtering it and transporting it to the final destination. the aim of this project is to solve purifying drinking water by creating a durable apparatus which is cheap to manufacture and to buy, which can last for a long time in rural conditions and which can be detachable so that it can be mounted on any frame. The system works on the sprocket chain system with power generator dynamo along with supporting frame interfaced with filters, container with integrated heating element and supporting circuit to achieve this system development. The overall apparatus is designed to be as lightweight and as cheap as possible so as to make it easily accessible to a very wide range of people. The apparatus is also designed to be made detachable so that it can be easily shifted from one place to another with minimal modifications.

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I. INTRODUCTION

Problem Statement:

Developing countries around the world face debilitating challenges accessing safe and clean drinking water. Alarming statistics led us to the idea that we would use a simple mechanism of transportation that is common in these areas, such as bicycle, to help aid their water and sanitation struggles. Our goal are to remove unwanted constituents in the water and to make it safe to drink or fit for a special purpose in industry or medical applications. Widely varied techniques are available to remove contaminants like fine solids, micro-organisms and some dissolved inorganic and organic materials or environmental persistent pharmaceutical pollutants.

Purifying water may reduce the concentration of particulate matter including suspended particles, parasites, bacteria, algae, viruses, fungi, as well as reducing the concentration of a range of dissolved and particulate matter. The standards for drinking water quality are typically set by governments or by internationalstandards. These standards usually include minimum and maximum concentrations of contaminants, depending on the intended purpose of water use.

Visual inspection cannot determine if water is of appropriate quality. Simple procedures such as boiling or the use of a household activated carbon filter are not sufficient for treating all the possible contaminants that may be present in water from an unknown source. Even natural spring water – considered safe for all practical purposes in the 19th century – must now be tested before determining what kind of treatment, if any, is needed. Chemical and microbiological analysis, while expensive, are the only way to obtain the information necessary for deciding on the appropriate method of purification.The objective of providing pure drinking water throughout the world is one that has been an ongoing process for the past decades. Although we fully support the work done by charities such as The Water Project and Water.org, we believe that it will be a very long time until water can be provided as a clean source located locally throughtout all developing countries. Therefore, our motivation was stemmed from the idea of quickly aiding those less fortunate areas, as well as providing a backup should those regions run into contamination problems within their local wells. In addition our solution will exponentially reduce the time taken to retrieve the water, and allow time for more benefical tasks to be accomplished in their native area. With our model we will be able to provide a working solution that mends the problem until a permanent clean water well can be produced within that community.

II. METHODOLOGY

The design and fabrication of pedal powered water purifier includes sprocket chain system with power generator dynamo along with supporting frame, filters, container with integrated heating element and supporting circuit to achieve this system development. The system uses a pedal fixed sprocket with chain attached to supply circular force to the dynamo to be driven. The power generated by dynamo is then used to store in batteries. The water before getting pressurized is passed through filters to remove large particles and basic filtering. The container on the other end is used to draw pure water from it using a tap. Thus, we achieve a pedal powered water purification system as a renewable water purifier.

Working Principle

Working principle, the system uses a pedal fixed sprocket with chain attached to supply circular force to the dynamo to driven. The power generated by the dynamo is stored in the battery. Then the power is supplied to filter which are used to purifies the water. Thus, we achieve a pedal powered water purification system as a renewable water purifier.

Parts required

CHAIN, PULLEY, FREE WHEEL, PEDAL

These components are used for the cycling process. Pedals are connected to the main free wheel. There to chain is attached to the small free wheel. When cycling speed is increased on main free wheel then the chain rotates in heavy motion. Automatically smaller free wheel get rotates because of chain attachment.

Water Filters

A water filter removes impurities by lowering contamination of water using 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.

Tanks

Two water tanks are required for the collection of Impure and Pure water i.e., the water before purification and after purification. These tanks will be mounted on the bicycle for water collection.

Dynamo

The electric dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current through Faraday's law of induction. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. Due to Faraday's law of induction the motion of the wire within the magnetic field creates an electromotive force which pushes on the electrons in the metal, creating an electric current in the wire. On small machines the constant magnetic field may be provided by one or more permanent magnets; larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils.

Tubes

Tubes are required for the flow of water. Water will travel through tubes to all parts of the purification system. Primary function of tube is just to maintain the flow of water.

Peristaltic Pump

A water pump is an essential device used to move the fluid by a mechanical system. There are various types of pumps utilized on a wide range of applications such as pumping waters from wells, water-cooling in a car, aquarium filtration systems. A reciprocating or rotary type of mechanism is usually found in a water pump.

The specialty of this pump is the applied rolling force, or restitution, on the tube creates a compression that seals and acts as suction;therefore,dischargethefluidforward.

Calculations

Power Supplied

It is a function of moment arm (R) and RPM (N).

$P_{supplied} = P(R, N)$

Power Required

It is the sum of power developed due to friction between the rollers and the tube and the power developed by the system.

$P_{required} = P_{friction} + P_{system =} P(L,D,d,N)$

Q=Q(D,d,N)

Theoretical Flow Rate Calculations

The theoretical flow rate is calculated as follows.

Assuming inner diameter of tube (d) = 0.009m

Casing diameter (D) = 0.017m

The volume of water displaced per roller is given as:

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

$= (\pi \times 0.25 \times d^2) \times (\pi \times 0.017)$

$= 3.3976 \times 10^{-4} m^3$

Total volume displaced ()Vtotal for 5 rollers used: = (Volume displaced per roller)

$= 3.3976 \times 10^{-4}\ m^3$

Discharge per occlusion (Q):

Assuming average pedalling speed of human = 35RPM … $(30 \leq N \leq 40)$

$Q = V_{total}$ x (rotational speed per minute)

$=3.3976 \times 10^{-4} \times (2 \times \pi \times N/60)$

$=3.3976 \times 10^{-4} \times (2 \times \pi \times 35/60)$

$=1.2453 \times 10^{-4} m^3/sec$

Frictional Head Loss

Let the diameter of both the suction and delivery tube be equal. For the purpose of this design, the tube is considered to be smooth. Therefore, velocity of flow in the tube is

Velocity =[(discharge)÷(area)]

$=(1.2453 \times 10^{-3}) / (\pi \times 0.25 \times 0.081)$

= 1.957 m/s

To decide whether the flow of water in the tube is laminar or turbulent we calculate Reynolds's Number (Re).

Re= (density x velocity x Hydraulic diameter) / (dynamic viscosity of fluid)

$= (\rho \times v \times d_h)/(\mu)$

$= (v \times d_h)/\nu$

Where , kinematic viscosity $\upsilon=\mu / \rho$

Kinematic viscosity of water at 20.20C for all practical purposes is considered as $1 mm/s^2 = 10^{-6}\ m^2/s$

Therefore, $\nu = 10^{-6}\ m^2 /s$

$D_h = (4A/P) = (4\pi \times r^2) / (2 \times \pi \times r)$

= 2r

=d (duct diameter)

Where, Re = (v d) / ν

$=(1.957 \times 0.009) / (10^{-6})$

=17613

Since Re> 2000 (flow is turbulent)

Required Power

The power required to drive the pump depends on the frictional forces and the torque on the arm:

$\Sigma F_x = (-\mu N) - \mu N\cos72 + \mu N\cos36 - \mu N\cos72 + \mu N\cos36$

$= 2\mu N$

The force needed by the flexible tube choosing thus TygonTMXL-60 to retract after compression is 200 N therefore that is the force that will act on the rollers, N = 200 N. Further, we assume friction coefficient as 0.3

Applying Bernoulli's Equation

$(P1/\rho g) + (v1^2/2g) + z1 + H_p = (P2/\rho g) + (v2^2/2g) + z2 + \Sigma(\text{losses})$

There will be no velocity heads at points 1 & 2. Therefore, v1 = v2 = 0. Both points 1 and 2 are exposed to [09] atmosphere therefore the pressure head at both points is zero and datum is the centre of sprocket.

Therefore, $z_1 + H_p = z_2 + \Sigma(\text{losses})$

$0.8 + H = 0.85 + [H_L$ +Loss at entry to pipe and filter + Loss at exit through pipe and filter + Loss due to bends + Pressure head lost in filter]

$0.8 + H = 0.85 + [(0.637 + 1.6752 / 2 \times 9.81) + (4 \times 1.5 \times 1.675 / 2 \times 9.81) + (2 \times 1.6752 / 2 \times 9.81) + 24.94]$

$_{Hp} = 26.8671$ m

Power delivered by pump = $\rho \times g \times Q \times H_p$

$= 1000 \times 9.81 \times 1.2453 \times 10^{-4} \times 26.8671$

= 32.82 W

III. RESULT AND CONCLUSION

Through extensive research we found cost effective parts that will meet our goal of building 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. In the coming months a prototype will be constructed which consists of a peristaltic pump, the filter and a sidecar. Each component will be thoroughly tested in order to provide the best product possible at the most reasonable price. In the future we hope to be able to partner with one of the many non-profit organizations dedicated to provide clean water around the globe such as, The Water Project, Water.org and Charity Water and reach the millions of people in need of a product like ours.

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