Design and Fabrication of Air to Water Convertor using Radiative Cooling

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Abstract— Extraction of water from the natural air around us to help the betterment of human life. Pumping natural air into the earth and using the lower temperature along with radiative cooling to condense the dew drops. One-half of the device is buried inside the earth for around 6 feet or more. The open end of the device which is exposed to the atmosphere consists of a turbine and fan setup which is used to pump humid air into the device continuously. Heat from the air is transferred to the soil around the duct. Once the air temperature falls below its condensation temperature it condenses as water droplet and is stored in the chamber below. Since the temperature of the chamber below is always less than the temperature of the atmospheric air, because of use of superhydrophobic material, we expect nominal water condensation even when the turbine is not actuated by the wind.

Key words: Radiative Cooling, Super Hydrophobic Material, Condensation, Humidity, Turbine

I. INTRODUCTION

Our goal of this project is to meet the increasing water demands worldwide by condensing natural humid air and provide safe clean drinking water. We have planned to do it eco-friendly without the use of electricity and chemicals.

II. PROBLEM STATEMENT

Our planet has an abundance of water but most of that water is undrinkable. 97.5% water available is undrinkable, 1.75% water is frozen and only 0.75% water is good for drinking.

- 1 in 3 people worldwide, more than 2.3 billion don't have clean & safe drinking water.
- 1 in 5 people around the world, more than 1.2 billion live in areas of water scarcity.
- Every day more than 18k people die due to lack of safe drinking water.
- Poor woman & children walk for hours together in order to collect safe drinking water in urban areas.

III. EXPERIMENTAL SETUP

Our device consists of a 12-inch pipe of length 0.7m, closed at one end and connected to a 350*160mm reducer at the other end. The reducer is now in turn connected to a 6inch pipe of length 3m. Now a 1&1/2 inch pipe of 3.5m is held inside to the 6inch pipe in such a way that they form concentric circles when viewed from the top view. This 1&1/2 inch pipe is used as a return path pipe for the air which entered the system to come out.

Apart from the above-illustrated setup, there is a turbine and fan setup at the open end which helps to draw air into the system. Turbine being a vertical axis open sourcing wind turbine gets rotated even with a week windy action. Since the turbine is coupled with a fan, it enables the fan to rotate and pump air into the system.

IV. WORKING PRINCIPLE

In order to understand the working principle, it is very important to understand the below mentioned basic concepts.

A. Reflectance

It is the property of a material to reflect away the visible light emitted by the SUN. If we do so correspondingly the temperature of the material is going to be considerably low. Materials like titanium oxide (TiO_2) and barium sulfate ($BaSO_4$) have high reflectance. Titanium oxide has emittance in the wavelength region of 8to 13 micrometers. And barium sulfate stands for to reflect visible light. Thus this titanium oxide barium sulfate coating acts as a superhydrophobic coating which means supercooled.

B. Radiative Cooling

It is the property of a material to lose its temperature (heat) by emitting thermal radiation. In the earth- atmospheric system, it refers to the process by which long wavelength (infrared radiations) is emitted and short wavelength (visible radiations) energy from the sun is absorbed. This obeys newton's law for each and every action there is an equivalent reaction. Studies showed that polyethylene has good radiative properties. Now as we have discussed above all radiative materials emit longer wavelength radiations and absorb shorter wavelength radiations. Since we are planning to coat polyethylene with superhydrophobic coating it enables it to reflect shorter wavelength radiations lying in the radiation spectrum of (8-13micro meter).

C. Black Body Phenomenon

If the above two properties are combined then it results in the formation of a thermal black body (i.e) all thermal radiations entering the system is equal to the radiations exiting the system and without causing any changes to the system.

D. Relative Humidity

Since the process involves the conversion of atmospheric air to water relative humidity of the air plays a major role. It is the measure of water vapor present in the air relative to the temperature of the surrounding.

E. Absolute Humidity

It is the measure of water content irrespective of the air temperature.

F. Dew Point Temperature

It is the temperature at which water vapor can no longer exist and gets converted into dew drops. So achieving the dew point temperature by natural means is the prime goal of our project. Now if the above- explained properties are clear, then

it is time to take a look at the design and understand the working.

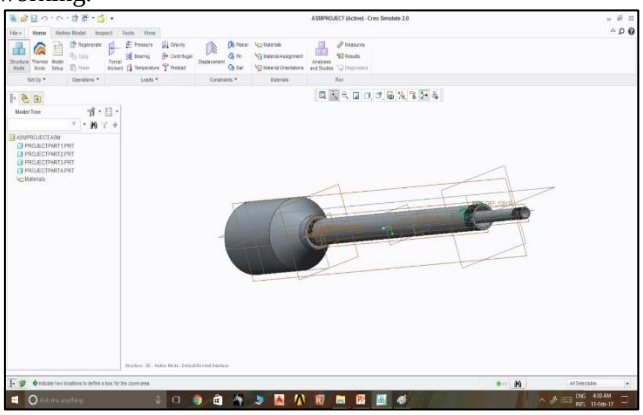

Fig. 1: Final assembly

Above-shown image is the detailed design of our project. Air which enters the system through the gap between the larger and smaller pipe and reaches the bottom. Since the other half of the device around 2 meters in buried vertically in the earth, it is normally at a lower temperature than the earth above and we have enhanced the properties of the material with the superhydrophobic coating. Thus air which reaches the bottom of the system experiences dew point temperature and gets condensed and dew drops formed along the walls of the storage chamber. Now the air after depositing the water droplet moves out of the system through the small pipe (1&1/2 inch) and escapes into the atmosphere. As the turbine revolves continuously by the action of wind there will be continuous circulation of fresh air into the system.

Now since the temperature of the system is always at a lower temperature than the outside atmosphere it is seen that dew is formed even under optimum (i.e) conditions even when the turbine and fan are not rotating.

Now the water which is collected at the bottom can be pumped up with the help of a hose and pump setup and can be used for drinking purpose. Since this process involves the condensation of natural air without the use of electricity and chemicals it is the purest form of water ever available on earth.

V. CONSTRUCTION (KEY PARTS OF THE PROJECT)

The following are some of the major parts of the setup.

A. Storage Tank

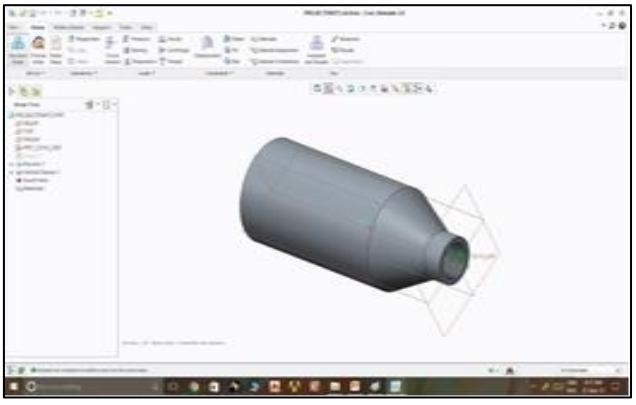

Fig. 2: Storage tank

350mm outer diameter, 330 mm inner diameter and 0.7m height. This is a 30-liter capacity tank closed at one end with an end cap and connected to a 160mm pipe through a 350*160mm reducer.

B. Air Inlet

160mm outer diameter, 150mm inner diameter, and 3m height. This is the only part of the system through which air enters into the system and reaches the bottom. One of this pipe is fitted to the bottom chamber and the other has a fan coupled with a turbine.

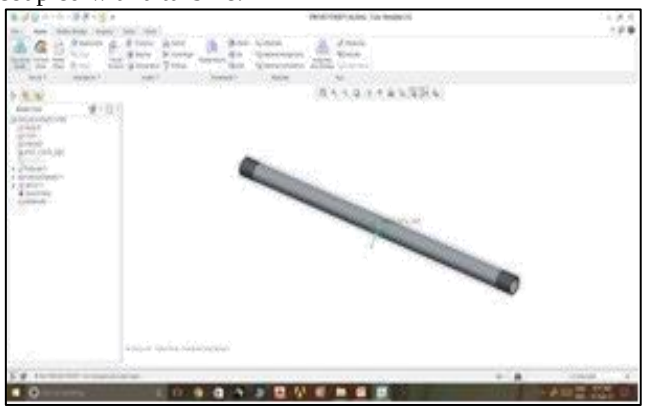

Fig. 3: Air outlet

C. Air Outlet

40mm outer diameter, 35mm inner diameter, and 4m height. This the part of the system through which the air which entered the system leaves after getting a part of it condensed as dew.

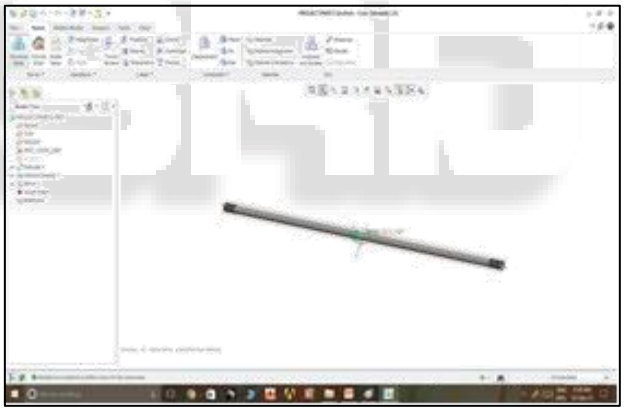

Fig. 4: Air inlet

D. Fan and Turbine

Fan-center is 40mm diameter and a total blade diameter of 320mm diameter. The center of the fan is fitted exactly on the 40mm diameter inner pipe (air outlet) so that the blades revolve in the gap between the smaller pipe and the larger pipe. The bearing used is a deep groove ball bearing 6203-2Z 17mm ID, 40mm OD.

Fig. 5: Bearing

VI. PROPERTY ENHANCEMENT

The following are the salient properties which need to be achieved for best results and we have achieved it as explained above.

- Maximize long wavelength emitting properties of the condensing surface.
- Minimize the short wavelength absorption
- Lower wind speed
- Increase the condensation time

VII. SOURCE OF MOTIVATION

The design concept of this project was an inspiration from "GIRIJA SHARAN". Her project on reducing global warming by using a natural heat exchanger in Kolkata paved way for our project. She buried a 50m pipe horizontally in the earth around 3m deep. One end of the pipe was fitted to a blower and the other end was set free. So air enters the pipe at one end and leaves the pipe at the other end much cooler thus reduces global warming.

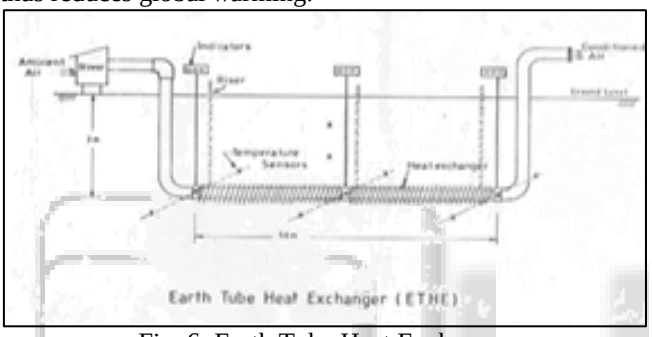

Fig. 6: Earth Tube Heat Exchanger

Thus we decided to cool the air further cooler and condense it to obtain water.

VIII. DEW POINT CALCULATIONS

As explained above dew point temperature is the prime parameter for the formation of dew droplets. We have calculated the dew point temperature using the following formula. The following formula was proposed in a 2005 article by Mark G. Lawrence in the Bulletin of the American Meteorological Society

$$Td = T - ((100 - RH)/5.)$$

Where Td is dew point temperature (in degrees Celsius), T is observed temperature (in degrees Celsius), and RH is relative humidity (in percent). Apparently, this relationship is fairly accurate for relative humidity values above 50%.

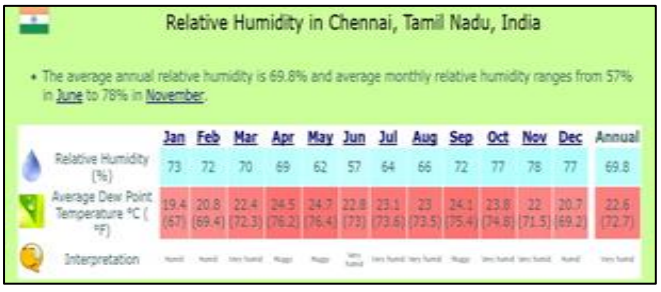

Fig. 7: Relative humidity in Chennai

The above image is an overall calculation for dew point temperature for the year 2016. If the above-mentioned dew point temperatures are reached the nominal amount of water condensation can be achieved.

IX. CONCLUSION

Thus we are looking forward that A2H2O CONVERTER will form a revolution to quench the thirst of the people.

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