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HARVESTING OF WATER FROM AIR USING HELICAL COIL

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ABSTRACT

Water scarcity has become a worldwide issue in the current era, this issue is more complicated in the arid areas, where it rains rarely and there is hardly any freshwater source at all. Hence, there is a serious need to find new, sustainable, alternative ways to get drinking water. One of the most interesting methods to get clean water is harvesting humidity from air. Many new initiatives have been taken to develop this old way of getting water, and many technologies have potential to solve the challenge of getting a new, sustainable and renewable source of fresh water in desert areas.

This paper presents a thermal process of cooling and dehumidifying the atmospheric air passing through helical coil and extracting water from it. The main objective of the paper is to design a thermal experimental setup as well as a helical coil capable of enchancing the cooling and dehumidifying process. It is known that the arid areas have a hot temperature, where as the underground soil is actually cooler. Hence, a pumping device that pushes the surrounding air with humidity under the ground to pass through pipes network where the humidity will start condensing on the internal walls of pipes, then, the water drops will leak from the pipes directly to the roots of plants in the field or can be used for drinking purpose.

KEYWORDS:Arid(dry area),Psychrometer, Thermocouple.

INTRODUCTION

The effects of climate change in India are accelerating at an alarming rate. In Maharashtra state many regions (Alert India, 2013) were experiencing severe drought in a century, which lasted for many years and resulted in irreversible damage to ecosystems, widespread wildlife decline and catastrophic bushfire conditions. Agriculture is detoriating due to severe drought. An alarming figure of one farmer a week were taking their own life, as years of drought resulted in failed crops, mounting debt and slowly decaying towns. Although the year 2013 has brought much needed rainfall to the area, other parts of India are continuing to suffer drought. The southwest corner of the country has experienced its driest year to date. Scientific projections indicate as temperatures continue to increase so too will the severity, frequency and duration of droughts worldwide. Extensive research into droughts revealed an increase in soil evaporation and trans-evaporation (plant and soil) due to the increasing temperatures. However, though the future seems to suffer from water scarcity, but the humanity will not give up and wait for that to happen. This paper concentrates on alternative way of getting water which can be considered as a new source of renewable water which can be used for irrigation or drinking purpose.

The amount of water that can be harvested from thin air is reliable in most of the conditions even if it depends on the temperature and humidity at the place. Although the relative humidity in a certain place might be relatively low, it is still possible to get some fresh water out of it by using the right humidity harvesting method. The method of harvesting water from thin air can cover people basic needs of drinking water in the dry areas, and especially is the coastal areas where there is a high humidity, but during summer season people experience scarcity of water. This way can support the traditional fresh water sources in the targeted areas, and in the future it might even be able to replace certain methods of getting fresh water such as desalination of seawater if it is well developed. There are various atmospheric water harvesting technologies that exist today, but most are high-tech and expensive methods not ideal for the rural farmer market.

In this project nontraditional water harvesting method is use to extract water from atmospheric air. The

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prototype of a scaled down unit produced close to a half liter of water out of the air in a day. Further testing with different setup conditions is necessary to confirm the quantity of water collected.

COMPONENTS AND METHODS

1 To establish experimental setup
1.1 To identify the equipment component
The project setup consists of following components:
1) Helical coil of copper material.
2) Inlet pipe (White colour).
3) Outlet pipe (Black colour).
4) Air pump of 8 LPS capacity.
5) Water manometer.
6) Large drum filled with soil.
7) Thermocouple with temperature indicator.
8) Psychrometer.
9) Water collecting vessel.
10) Base plate for supporting the structure.

Figure:

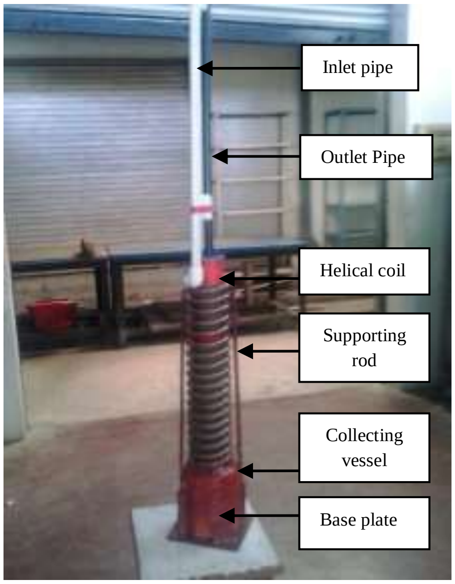

Fig1.Design prototype

1.2 To design experiment component
A helical coil is analytically designed to meet the heat transfer requirement.
1.3 To fabricate experimental setup

Figure:

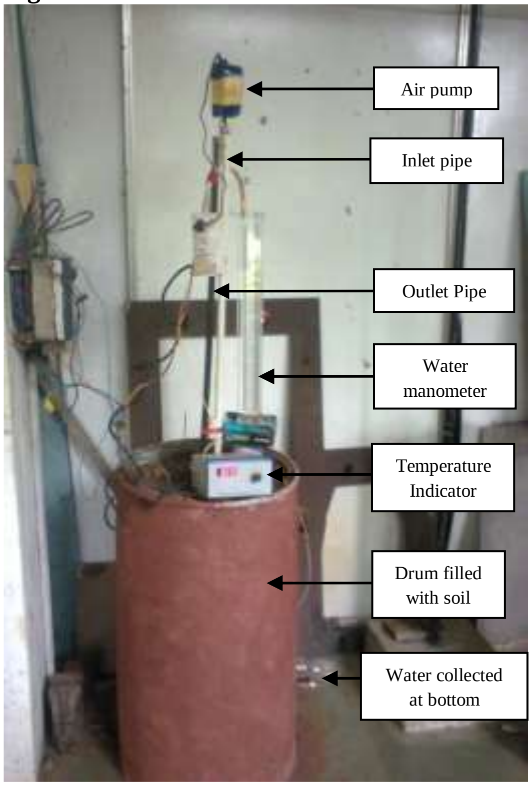

Fig2. Experimental setup

As shown in above picture, Inlet pipe of PVC material having 0.0127 m diameter and 1 m length is connected to one end of helical coil with an elbow attachment and air is made to pass through it.
Outlet pipe of PVC material is directly connected to the collecting vessel at the bottom and extrudes outward as seen in the setup below.
An aquarium air pump of 8 LPS capacity is used for supplying air at the inlet pipe. A pitot tube is attached with water manometer to measure the actual amount of air entering the inlet pipe.
A collecting vessel of 2 liter capacity is used at the bottom to collect water. The vessel is supported by a base plate and two rods are connected with helical coil to support the structure.
Finally the whole set up is placed in a drum of length 0.950 m and 0.585 m diameter, filled with soil.
Thermocouple is attached at inlet, outlet and in soil to measure the temperature.

1.4 To carry out experiment
Experimental Procedure:
1) Fill the manometer with water up to half level.

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2) Start the air pump and let it stabilize for few minutes.
3) Note down the water manometer reading and thermocouple temperature reading at various specified points.
4) Note the Psychrometer reading at inlet and outlet pipe at specified interval.

1.5 To observe the data from the experiment

Table 1. Observations obtained on Day1

Time in hr	Wet bulb Temperature of Air at Inlet, °c	Temperature of Air at Inlet, °c	Temperature of Coil ºC	Wet bulb Temperature of Air at outlet, °c	Temperature of air at Outlet ºC	Flow rate of air @ inlet in LPH
8:30 AM	24.6	26	24	24.1	24.2	1796.52
9:00 AM	24.1	27	23	23.1	23.4	1796.52
10:00 AM	25.1	28	24	24.1	24.4	1796.52
11:00 AM	24.4	28	23	23.1	23.5	1796.52
12:00 PM	24.9	30	23	23.2	23.7	1796.52
1:00 PM	25.9	31	24	24.2	24.7	1796.52
2:00 PM	24.7	29	23	23.2	23.6	1796.52
3:00 PM	24.4	28	23	23.1	23.5	1796.52
4:00 PM	24.4	28	23	23.1	23.5	1796.52
5:00 PM	24.1	27	23	23.1	23.4	1796.52
6:00 PM	24.6	26	24	24.1	24.2	1796.52

Table 2. Observations obtained on Day2

Time in hr	Wet bulb Temperature of Air at Inlet, °c	Temperature of Air at Inlet, °c	Temperature of Coil ºC	Wet bulb Temperature of Air at outlet, °c	Temperature of air at Outlet ºC	Flow rate of air @ inlet in LPH
8:30 AM	24.6	26	24	24.1	24.2	1796.52
9:00 AM	24.8	27	24	24.1	24.3	1796.52
10:00 AM	25.1	28	24	24.1	24.4	1796.52
11:00 AM	24.7	29	23	23.2	23.6	1796.52
12:00 PM	25.6	30	24	24.2	24.6	1796.52
1:00 PM	25.2	31	23	23.2	23.8	1796.52
2:00 PM	25.4	29	24	24.1	24.5	1796.52
3:00 PM	24.8	29	24	24.1	24.3	1796.52
4:00 PM	24.4	28	23	23.1	23.5	1796.52
5:00 PM	24.8	27	23	24.1	24.3	1796.52
6:00 PM	24.1	27	24	23.1	23.4	1796.52

1.6 To calculate the experimental factors.
1.7 To validate the project observations.

ANALYSIS (CALCULATION AND DISCUSSION)

1.CFD Analysis of helical coil(Ansys 12.0)

As helical coil is most important part of the project setup a CFD analysis is done to validate the design. In this analysis, an attempt has been made to study the fluid flow inside the helical coil heat exchanger. The temperature contours, velocity vectors, total pressure contours, total heat dissipation rate from the wall of the tube were calculated and plotted using ANSYS 12.0. Copper was used as the base metal for the inner and outer pipe and the fluid was taken as hot air (35°c) for inner flow and outer Constant temperature of 24°c of soil.

Results

Following results were obtained from the CFD analysis:

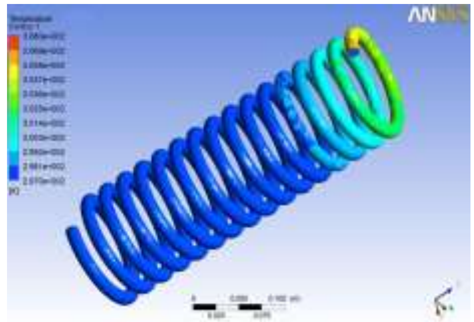

Fig 1 Contour of Temperature

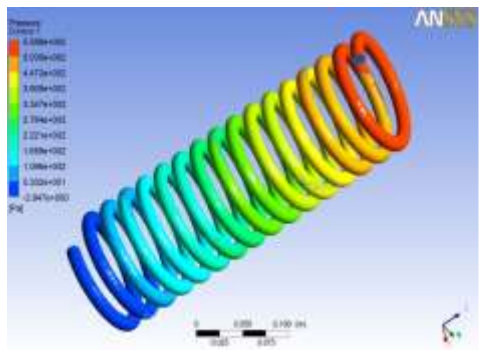

Fig 2 Contour of Pressure

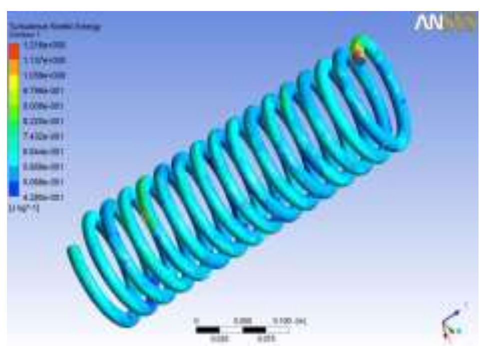

Fig 3 Contour of Turbulence

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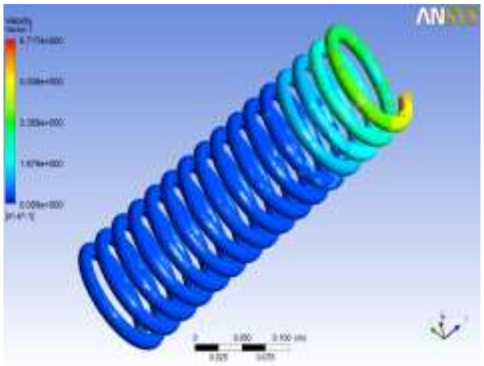

Fig 4 Contour of Velocity

As the results obtained from CFD analysis are well within the limits, the design of helical coil was validated with the analytical design and manufacturing of helical coil was initiated for the project setup.

2.Calculation:

Table 3.Calculation for Day1

Humidity of Air at Inlet,%	Humidity of Air at Outlet,%	Partial Pressure PV in Bar for Inlet air	Partial Pressure PV in Bar for outlet air	Moisture Content W1 (kg/kg of dry air)	Moisture Content W2(kg/kg of dry air)	Mass of water vapour removed in(kg/hr)
89%	95%	0.029	0.028	0.019	0.018	0.0019
79%	94%	0.028	0.026	0.018	0.016	0.0022
79%	94%	0.029	0.028	0.019	0.017	0.0024
74%	93%	0.028	0.027	0.017	0.017	0.0004
66%	92%	0.028	0.027	0.018	0.017	0.0009
66%	92%	0.029	0.029	0.019	0.018	0.0009
70%	93%	0.028	0.027	0.017	0.017	0.0005
74%	93%	0.027	0.027	0.017	0.017	0.0003
74%	93%	0.027	0.027	0.017	0.017	0.0003
79%	94%	0.028	0.026	0.018	0.016	0.0022
89%	95%	0.029	0.028	0.019	0.018	0.0019

Table 4.Calculation for Day2

Humidity of Air at Inlet,%	Humidity of Air at Outlet,%	Partial Pressure PV in Bar for Inlet air	Partial Pressure PV in Bar for outlet air	Moisture Content W1 (kg/kg of dry air)	Moisture Content W2(kg/kg of dry air)	Mass of water vapour removed in(kg/hr)
89%	95%	0.029	0.028	0.019	0.018	0.0019
84%	94%	0.029	0.028	0.019	0.017	0.0024
79%	93%	0.029	0.027	0.019	0.017	0.0028
70%	92%	0.028	0.027	0.017	0.017	0.0009
70%	93%	0.029	0.029	0.019	0.018	0.0005
63%	91%	0.028	0.027	0.018	0.017	0.0013
74%	93%	0.029	0.029	0.019	0.018	0.0004
84%	94%	0.033	0.028	0.021	0.017	0.0074
74%	93%	0.028	0.027	0.017	0.017	0.0004
84%	94%	0.029	0.028	0.019	0.017	0.0024
79%	95%	0.028	0.026	0.018	0.016	0.0022

1. Theoretical water obtained as per the calculation = 0.36 liter / day.
2. Actual water obtained = 0.12 liter / day.

CONCLUSION AND FUTURE SCOPE

By observation and analysis it is concluded that moisture in the air can be condensed successfully using above designed set up though there is some difference between the calculated and actual water obtained, this system is perfect for rural areas and can help eliminate some problems while not created as much of a recurring cost for the user.

- The system even be fitted with an LCD display which monitors the water tank level, solar batteries can be used to run the air pump.
- The design can be improved by making an analysis for change in coil pitch, pitch circle diameter, coil diameter, and coil material using Ansys.

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