Design and fabrication of water extraction system from humid air

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ABSTRACT

Fresh water scarcity and climate change are few of the global issues which was identified by the United Nations. Because of the climate change, a lot of areas have started experiencing drought. Marathwada is such a place in India. But, due to the presence of sea, this area also experiences a lot of humidity especially in the month of June to September. This project provides a novel approach to trap the water molecules from that humid air which can be helpful in reducing the effects of drought. An atmospheric water extraction device (AWED) is a device that extracts water from humid atmospheric air. This is done by cooling the air to the dew point temperature. In the highly humid area place like desert and sea, due to lack of rainfall water can be obtained by condensing the water which is present in the air.

1. INTRODUCTION

An atmospheric water extraction device (AWED) is a device that extracts water from wet atmospheric air. This can be done by reducing the temperature of air to a very low temperature called as dew point temperature. The highly humid place like deserts and the places near to the seas, can be an ideal location for the installation of such kind of devices. Due to the requirement of significant amount of energy, the extracted water cannot be considered as cheap but its cost would be much lesser than the cost of conventional desalination system. Some traditional atmospheric water extraction methods completely relying on the natural temperature differences, and requires no external energy source[1]. Water extraction device is sustainable. It is a very simple device which does not require any person to operate and mere installation would be enough. Due to that simplicity and scale, device can be used by an uneducated people too so if the person is not much educated.

A lot of research has been performed in this field. Ahmed et.al. [1] has performed a review on the extraction of water from wet atmospheric air. Gandhidasan et.al. [2] has modelled a dew collection system by using a radiatively cooled pigmented polyethylene foils. Ahmed Abdel [3] has used non-conventional system for the extraction of water from atmosphere. Some research has also been performed by considering the atmosphere of a particular place also, e.g. Adel Khalil [4] has done research on the feasibility of dehumidification in UAE whereas Beysens, et.al. [5] has performed research on dew equipment for water project in Croatia. This shows that a lot of research has been done in this field but a lot is still left.

Moisture extracting system uses fundamentals from different branches of science and combines them in a way to get feasible result. From atmospheric sciences to the refrigeration and air conditioning system,

the system uses all different branches of sciences. On an average, India has an average precipitation (including snowfall) of about 4000 km^3per annum [7].

It is estimated that out of the 4000 km^3, 1869 $km^3$of water is available in rivers. Out of the total available water resource, only 1123 km^3can be used for drinking purpose (690 $km^3$of water from surface and 433 km^3 from ground). With the growth of economy and population of the country, the demand of water would increase exponentially in the coming decades. The water demand in the year 2000 was 634 km^3 and it is likely to be increased to 1093 km^3 by the year 2025 [8].

2. DESIGN CONSIDERATIONS

As this is the project of extraction of water from atmospheric moisture, so following psychometric parameters are very important:

- Relative Humidity: The average annual relative humidity of Marathwada district is 59.3 % and during the month of June to September it ranges around 70-80 %. This shows the availability of huge amount of water molecules in the atmosphere.
- Dew Point: During the month of June to September, dew point value is around 21^oC.
- Amount of water: The system was designed in such a way that the average value of extracted water should be 2 liters per day.

3. EQUIPMENT PROTOTYPE

The prototype was manufactured by using items like water pump, Heat Exchanger, Galvanised iron pipe, Hopper, flow circulation tube, etc.

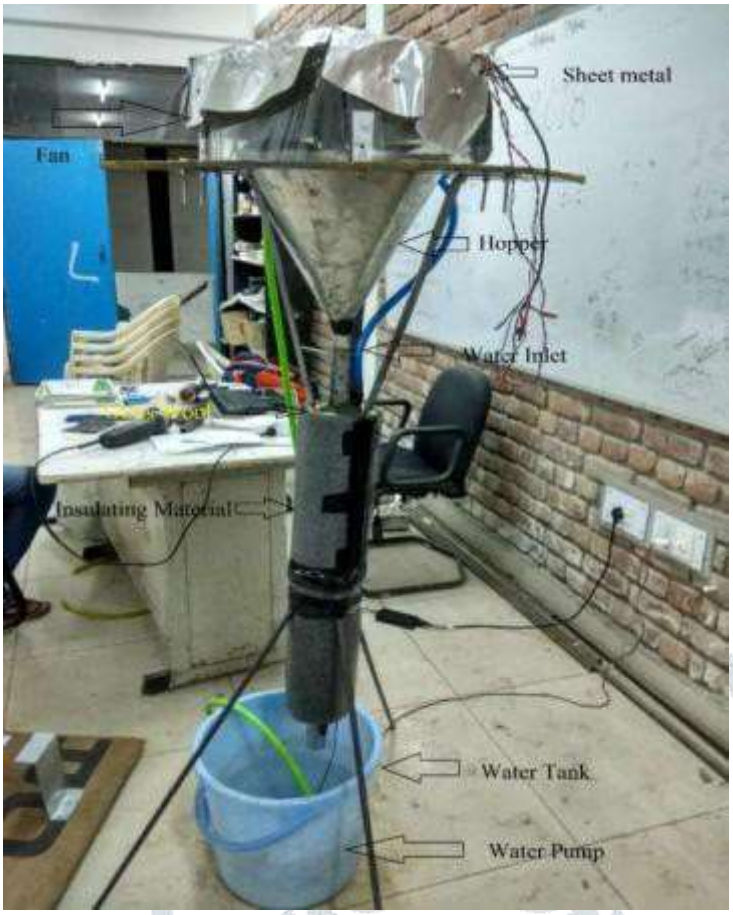

Figure 1 Working prototype

During the designing of the prototype the mass flow rates of the heat exchanger was set by performing the LMTD analysis of the heat exchanger. The temperature of outside air after heat exchanger was reduced to 20.5^{o}C and hence the dew point was achieved. External energy was given in the form of electricity to the water pump which was used to flow the coolant in the heat exchanger.

4. OUTCOMES AND CONCLUSIONS

After the testing of the prototype, it was found that it was working in a proper way and with the RH of 66%, the equipment was able to extract moisture at the rate of 1.5 liter per day. Below of RH of 60%, the prototype was not able to extract any water. This may be because the system was unable to reduce the temperature to the dew point of the air. This system can be used for the water extraction in a humid climate condition, especially near to sea shores.

Single machine cannot extract the substantial amount of water so a number of machines can be installed at a proper site for the extraction.

REFERENCES

[1] Ahmed Hamed, et.al. ―A technical review on the extraction of water from atmospheric air in arid zones‖, *J. of heat and mass transfer, 2010, pp. 213-228.*

[2] Gandhidasan P., Abualhamayel H. I., ―Modeling and testing of a dew collection system‖, *J. Desalination, 2008, pp. 47-51.*

[3] Sultan Ahmed Abdel Rrazik, ―Absorption/regeneration non-conventional system for water extraction from atmosphere‖, *J. Renewable Energy, 2004, pp.1515-1535.*

[4] Khalil Adel, ―Dehumidification of atmospheric air as a potential source of fresh water in the UAE‖, *J. Desalination, 1993, pp. 587-596.*

[5] Beysens Daniel A, et.al. ―Collecting dew as a water source on a small island: The dew equipment for water project in Bisˇevo (Croatia)‖, *J. Energy, 2007, pp. 1032-1037.*

[6] Cattani Lucia, et.al. ―Water Extraction from Air by Refrigeration – Experimental Results from an Integrated System Application‖, *J. Applied Sciences, 2018, pp. 1-21.*

[7] Al-Farayedhi, et.al.―Condensate as a water source from vapor compression systems in hot and humid regions‖, *J. Desalination,2014, pp. 60–67.*

[8] Algarni, S. et.al.―Air-conditioning condensate recovery, and applications—Current developments and challenges ahead‖,*Sustain. Cities Soc. 2018, pp. 263–274.*

[9] Gaspar, P.D. (Ed.) ―Handbook of Research on Advances and Applications in Refrigeration Systems and Technologies‖,*IGI Global: Hershey, PA, USA, 2015*.

[10] Ghassan Abd Al Azeez, ―Fog water collection evaluation in Asir Region-Saudi Arabia‖, *J. Water Resources Management, 2009, pp. 2805-2813.*

[11] Habeebullahbadr, ―Potential use of evaporator coils for water extraction in hot and humid areas‖, *J. Desalination, 2009, pp. 330-345.*

[12] Jacobs A.F.G., et.al. ―Passive dew collection in a grassland area‖, *OAI, 2008.*

[13] Wahlgren Roland Vincent, ―Atmospheric water vapor processor designs for portable water production‖, *J. Water Research, 2001, pp. 1-22.*

[14] Abualhamayel H. I., Gandhidasan P., ―A method of obtaining fresh water from the humid atmosphere‖, *J. Desalination, 1997, pp. 51-63.*

[15] Khalil Adel, ―Dehumidification of atmospheric air as a potential source of fresh water in the UAE‖, *J. Desalination, 1993, pp. 587-596.*