DESIGN AND FABRICATION OF ATMOSPHERIC WATER GENERATOR FOR DRINKING

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Abstract: In many rural places in Bengaluru, the availability of water for drinking and other purpose is very less especially in regions where there is little safe drinking water. This problem of water unavailability in arid regions can be solved by condensing the water vapour present in air and water can be obtained. Here, this project presents the method to develop a water condensation system based on refrigeration cycle. The system consists of cooling elements, heat exchange unit and air circulation unit. Atmospheric Water Generator is a device that can convert atmospheric moisture directly into usable and even drinkable water. It is such a device which uses the principle of latent heat to convert molecules of water vapour into water droplets. It has been introduced a bit before, though it is not very common in India. It has a great application standing on such age of technology where we all are running behind renewable sources.
Our prime works aims at designing and fabricating an atmospheric water generator which is capable of collecting water by condensing the water vapour present in atmospheric air.

Index terms – evaporator, humidity, water generator, temperature, vapour.

I. INTRODUCTION

Our earth atmosphere is surrounded by water vapour and is estimated to contain a overall total of $12.9*10^{12}$ m^3 of drinkable water. The amount which is present in the atmosphere is greater than the all of the available water present on earth that includes rivers, wet lands and marsh places around the world. The water vapour present in the atmosphere can be extracted by cooling the moist air to a air temperature which is lower than the dew point. The process of extracting water from atmosphere can be done in many ways i.e dehumidification by refrigeration cycle, liquid desiccation method and by using thermo electric cooling. Several scientists have been developing air wells so that to collect moisture from air passively. Our device uses the basic principle of latent heat to convert the water vapour present in the atmosphere to water droplets. Our project uses traditional refrigeration cycle to dehumidify the air to get water droplets from the atmospheric humidity. This process circulates the humid air over a evaporator or cooling coils which is connected to a refrigeration cycle to bring the humid air below the saturation point so that water droplets can be formed. Latent heat is defined as the change of the state from one phase to another like solid to liquid or gas to liquid. The atmospheric temperature below which the water droplets start to condense is called as dew point. The whole vapour compression refrigeration cycle where the refrigerant enters the compressor as saturated vapour where the refrigerant is compressed at a constant entropy and comes out of the compressor as a superheated vapour. The superheated vapour goes through the condenser where the removal of the heat by cooling the vapour. The refrigerant comes out of the condenser as a saturated liquid this process is always at constant pressure. Then the saturated liquid is passed through an expansion value to decrease the pressure. This process is imputable to adiabatic flash evaporation and auto refrigeration for some of liquid and is thought as Joule Thomson effect. This adiabatic flash evaporation always occurs at a constant enthalpy. The refrigerant which is cold and has low pressure and with partial vaporized state is passed through the evaporator which completes the vaporization of cold refrigerant by the outside air which is present inside the evaporator box. The evaporator works at constant pressure and vaporizes all of the refrigerant and thereby superheating the refrigerant. This superheated refrigerant flows back to the inlet of the compressor thereby completing one full thermodynamic cycle. Hence this is the simple idea which represents a perfect vapour compression refrigeration cycle. The main purpose of this study is to build an experimental model of the atmospheric water generator device for drinking.

II. LITERATURE SURVEY

2.1 Mr. Swapnil B. Patond, Miss. Priti G. Bhadake (2015):

In this research a thermoelectric module is designed to analysis the heating and cooling system by using solar energy and which is based on peltier effect. To minimize these effects, focus is shifted towards the utilization of renewable energy sources. Abundant source of renewable energy on the earth's surface is solar energy. The new alternative method to produce cooling effect is to design and develop a thermoelectric device powered by solar energy.[1]

2.2 Prof. Pushkarny B.H. (2016):

This project is a demonstration of an eco-friendly methodology for the implementation of solar powered thermoelectric refrigeration system. Solar energy is the most abundant and renewable source of energy in environment, and hence it is used in their project.[2]

2.3 Matthieu Cosnier et.al (2008):

Presented an experimental & numerical study of thermoelectric air-cooling & air-heating system. The studies on TE cooling include the heat transfer to the air connected with ventilation systems, like an investigation of a thermoelectric air-cooling and air-heating system is presented.[3]

2.4 Niewenhuis et.al (2012):

They have tried to incorporate Liquid Desiccant method to extract humidity from air and convert it into drinking water. Wet desiccation is a process where a brine solution is exposed to humid air in order to absorb water vapour from that air. The solution is then sent into a regenerator where the water vapour is extracted from the solution. This method has grown in popularity because of its efficiency and the ease with which it can be adapted to renewable energy, particularly solar.[4]

2.5 Kabeela et.al (2014):

In his paper "Solar-based atmospheric water generator utilization of a fresh water recovery: A numerical study" has done thermodynamic analysis for a Peltier device which is used to develop a device that uses the principle of latent heat to convert molecules of water vapour into water droplets called the Atmospheric Water Generator. It has been introduced a bit before, though it is not very common in India and some other countries. It has a great application standing on such age of technology where we all are running behind renewable sources. Here, the goal is to obtain that specific temperature, called the dew point temperature, practically or experimentally to condense water from atmospheric humid air with the help of thermoelectric Peltier (TEC) couple.[5]

III. EXPERIMENTAL PROCEDURE

Atmospheric water generator is based on vapour compression refrigeration cycle. Condensation of water in air happens only if the temperature of moisture present in air reaches to its saturation value i.e. Dew Point Temperature. In evaporator box, sufficient cooling surface is provided by the use of Aluminum fins over the evaporator tube & temperature below dew point temperature is maintained. Vaporized refrigerant is collected in accumulator & flows towards compressor. The reciprocating compressor compresses vapour refrigerant into very high pressure & high temperature. Then pressurized refrigerant goes into condenser where it losses heat by convention, conduction & radiation. An axial fan is used which blows ambient air over the condensing tubes so refrigerant losses heat mostly by forced convection. For the better condensing, Aluminum fins are provided over the copper condensing tubes. Condensed refrigerant is subjected to pass through an air drier. Silica gel which is a good absorbent absorbs any water particle present in refrigerant & avoids chocking of capillary tubes. Refrigerant is subjected to expansion process in capillary tube which is throttling process. Here pressure & temperature of refrigerant are reduced to desired value. Temperature inside the evaporator box is achieved below Dew Point Temperature. Evaporator box which houses the evaporator is provided with channels for the inflow of ambient air by the help of an axial air blowing fan. When ambient air is flown into the evaporator box, it is passed over the fin & tube type evaporator. As the fin of evaporator is maintained below dew point temperature so condensation of moisture present in air occurs. Droplets of water formed over cooling surface is accumulated at the bottom of evaporator box and collected in water collecting chamber.

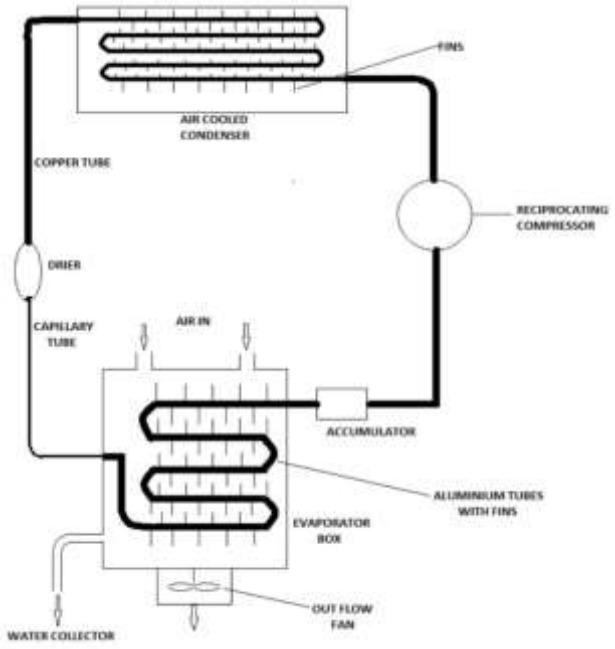

Figure 1 Flow diagram of atmospheric water generator

IV. WAYS TO EXTRACT WATER FROM ATMOSPHERE (CONCEPT DESIGN)

There are many ways where we can extract the water from atmospheric air. Some of the different ways are mentioned below:

4.1 Fog catchers:

A fog catcher uses large pieces of vertical mesh net to make the fog droplets flow down towards a trough below the mesh. The water condenses on to the surface of the wires in the form of water droplets and collects at the bottom of the net and then to the trough.

4.2 Heat recovery ventilation:

Here the cold from the atmosphere enters the duct and then to the heat exchanger where it gets heated up so that warm fresh air can be sent inside the house to maintain optimum temperature. The moist air present inside the house exits through the duct and enters the heat exchanger where it pre heats the cold the air from outside. The water vapors present in the moist air starts to condense because of the cold air from outside and thus water droplets are formed and clod exits the duct o the atmosphere.

4.3 Thermoelectric refrigeration:

Here it works according to the peltier effect. This effect creates a temperature difference by transferring heat between the two electrical junctions. A voltage is applied across the two joined conductors to create an electrical current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. The atmospheric air is sent on the cooling side of the plate and water vapour present in air starts to condense and water drop lets are formed.

4.4 Vapor compression refrigeration:

This method circulates air over cooling fins connected in a refrigeration cycle to bring the water within the air below its saturation point. In evaporator box, sufficient cooling surface is provided by the use of Aluminum fins over the evaporator tube, so condensation of moisture present in air, which forms water droplets over the cooling surface.

V. THEORETICAL CALCULATION

Table 1 : Calculation For Different Temperature

Sl.no	T_f	T_{df}	T_c	T_{dc}	P_v	P_{vsat}	φ	ω	ρ
1.	78.8	64.4	26	18	2.065	3.362	61.42	14.95	14.948
2.	75.2	55.4	24	13	1.498	2.984	50.20	10.92	10.917
3.	79	41	26.1	5	0.8725	3.38	25.81	6.31	6.314
4.	82	43	27.7	6.1	0.9418	3.715	25.35	6.7851	6.779
5.	90	45	32.2	7.22	1.016	4.810	21.12	7.21	7.205
6.	88	41	31.1	5	0.872	4.519	19.29	6.21	6.206

T_f = Temperature in degree Fahrenheit
T_c= Temperature in degree Celsius
T_{df} = Temperature in degree Fahrenheit
T_{dc} = Temperature in degree Celsius
P_v = Actual vapour pressure in kPa
P_{vsat} = Saturated vapour pressure in kPa
φ = Relative humidity in percentage
ω = Absolute humidity in grams/m^3
ρ = Density in grams/m

VI. 3D MODELLING

This figure shows the views of the evaporator which is used in the atmospheric water generator which dehumidifies the air to get water droplets; this is made with aluminum with fins attached to the tube. The length of the evaporator is 380mm, the width is 170mm and the diameter of the tube is 6.4mm. The fins are placed 5mm apart from each other with a thickness of 0.5mm

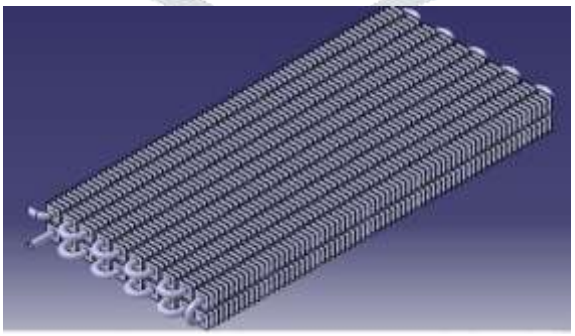

Figure 2: Isometric view of the evaporator

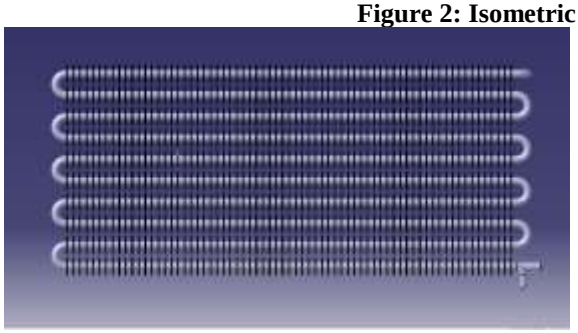

Figure 3: Top view

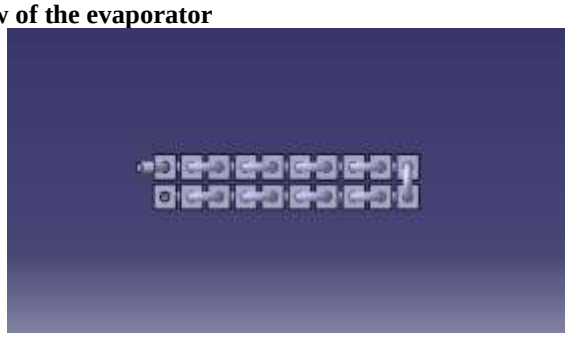

Figure 4: Side view

VII. COMPONENTS

Table 2: List Of Components

Sl.No	Components	Quantity/Size
1	Reciprocating Compressor	1
2	Condenser	1
3	Capillary Tube	3m
4	Evaporator Fabricated	1
5	Axial Fan/Blower	2
6	Filter Drier	1
7	Accumulator	1
8	Wire	3m
9	Electric Switch	1
10	Evaporator Box	1
11	Brazing	-
12	Copper Tube	2m
13	Refrigerant	-
14	Welding	-
15	Frame/Body	1

VIII. FABRICATION

8.1 Evaporator-Fabrication:

Figure 5 Fabricated Evaporator

An evaporator is a device used to turn the liquid form of a refrigerant into its gaseous form. The liquid is evaporated, or vaporized, into a gas. An evaporator is used in an air-conditioning system to allow a compressed cooling chemical, such as R-134a to evaporate from liquid to gas while absorbing heat in the process. The Evaporator was made using hollow aluminum tubes with a diameter of 6.4 mm, the tubes were bent in U-shape according to a traditional evaporator. The whole length of the aluminum tube is 7.62m. The fins attached to the aluminum tubes are made with aluminum sheet metal with a thickness of 0.5mm. The evaporator temperature Ranges from -18 °C to 15 °C.

IX. FINAL PRODUCT

Figure 6: Top view of assembled model

Figure 7: Side View of assembled model

Figure 8 Front view of assembled model

As shown in the above figures all the components have been assembled according to the refrigeration cycle, And there are two axial fans where one of it is attached to the side of the evaporator box and the other one is placed between the condenser and the compressor.

X. CONCLUSION

- After testing it was found that water collected from atmospheric water generator depends upon the Dry bulb temperature, Relative humidity of the air, Velocity of air passed over the evaporator and surface temperature of the evaporator.
- By increasing the efficiency of the compressor and velocity of air we can more amount of water in the same hour of operation.
- Atmospheric water generator acts as a dehumidifier and subsequently helps in reducing indoor humidity.

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