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Atmospheric Water Generator

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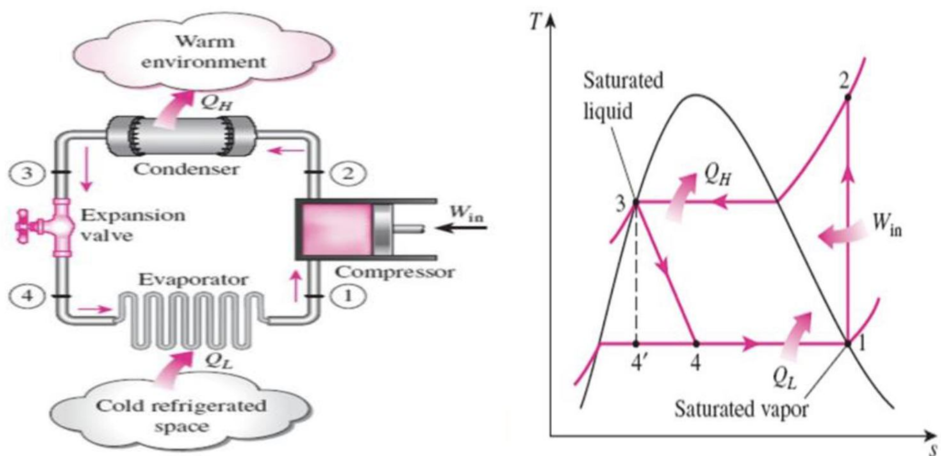
Abstract: An Atmospheric Water Generator is a device which is extracts water vapor from the humid air. By using different dehumidification technique. the water vapor accumulated then water is then filtered and purified through several filters including carbon, and reverse osmosis, and UV sterilization lights. The result is pure drinking water from the air. an Atmospheric Water Generator Works on the same principle as a refrigerators and air conditioners i.e on the principle of vapor compression refrigeration. in atmospheric water generator air passing through evaporator coil which temperature maintain below dew point temperature of water by vapour compression refrigeration method air condenses to to dew point temperature water vapor separate from air then collected water vapor is passed through a filtration system and it is then stored in a tank. The major aim or objective of our project is to provide safe and clean drinking water to those areas which are facing water shortage problems or where water transportation through regular means is expensive (especially rural areas). Our project hopes to reduce this problem by providing an atmospheric water generator that will run via bicycle-gear arrangement or stand-alone renewable source of energy i.e either solar or wind.

I. INTRODUCTION

Water is indispensable for human life and the development of industry and civilization. Water resources however are rapidly declining due to the gradually increasing human population, industrial pollution and inappropriate agricultural policies found that two-thirds of the global population (4.0 billion people) live under conditions of severe water scarcity at least one month per year. Half a billion people in the world face severe water scarcity all year round. Even though in other rich water resource areas it is still difficult for hikers. Because of pure water scarcity in many regions worldwide. Finding alternative methods for pure water generations because At any instant of time the earth's atmosphere contains 37.5 million billion gallon of water vapour if these water is condense enough to cover Entire atmosphere surface with 1 inch of rain.



This is enough to motivate many research to work on related topic AWG (ATMOSPHERIC WATER GENERATOR) one of the promising device to condense the water vapour present in atmosphere for this purpose the project group will initially investigate the suitability of the vapor-compression cycle, where the extraction will be obtained on the evaporator. An AWG is a device that generates clean drinking water by utilizing the natural presence of water vapor in the air. This thesis will hopefully result in information that will be used as a basic data for decision-making. Since most of the evaporators on the market today are designed merely to cool the air passing through them, much effort will be made to design an evaporator that not only lower the temperature but also condensate some of the water vapor included in the air and to collect the condensed water if this technology is assessed to be liable. There can also be other technologies that can be more suitable for this application. The main purpose is to investigate which technology is the most suitable one in order to extract water. Other possible solutions for this problem will be presented, explained and discussed. The purpose is to find and develop a technology applicable for water extraction.

We developed several goals that the design should be able to meet.

They are-

1) Flexibility in Power Source - The design should be able to utilize a variety of power sources, including (but not limited to) solar, wind, and the traditional power grid.
2) Maximize Efficiency - The design should maximize the water produced per unit energy.
3) Minimize Cost - The design should minimize the cost per unit water production for both capital cost and production cost.

II. LITERATURE REVIEW

SR NO	PAPER NAME	ABSTRACT	CONCLUSION
1	Anbarasu and Pavithra, 2011	Use vapour compression refrigeration system in which evaporator coil cool to dew point temperature of water. Air flow over evaporator by fan or natural and air get cooled to dew point temperature and water vapour present convert into water by condensation.	AWG is very promising device which provide considerable amount of water per KW .
2	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.	To test the performance of the device, an experimental prototype was fabricated and a testing platform was built. The best water production rate of 460 mL/h can be achieved when T_{in} = 27, RH_{in} = 92%, Q_a = 600 m^3/h, with the desalination rate above 99.65%, proving itself a feasible solution as a portable desalination device. The main drawback of the device is its low condensation efficiency.
3	Niewenhuis et.al. 2012	In their paper (Niewenhuis et.al. 2012) and others have also described a novel and unique method to extract water from air. They have said that it is possible to compress humid air so much that it will start condensing at the ambient temperature itself. As pressure increases the dew point rises; thus, enough compression will force the dew point above the ambient temperature resulting in spontaneous condensation	Method is very unique but output is very less and its required a Big size of compressor if want to expand this compress dry air we required a expander device like turbine this make high maintenance cost.

4	Kabeela et.al. 2014	In his paper thermoelectric is used (peltier device) 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	Peltier device is very portable and environment friendly. It has simple design and has high endurance capability. So, this type of Atmospheric Water Generator is the device which can be implemented in extreme situations like during floods or in desert and rural areas. It has great advantages as it works like a renewable source of atmosphere water and doesn't need a heavy power source. But it is not applicable industrial purpose and COP is very low.
5	A SUSTAINABLE ATMOSPHERIC WATER GENERATOR SOLUTION FOR COASTAL RURAL HOUSEHOLDS IN KWAZULU-NATAL	This study found that at the mean climate conditions of the case study location the AWG model can produce water at a competitive operational cost for emergency drought relief. The initial capital cost of the model however was found to be excessively high and resulted in the overall solution being uneconomical for rural households. The development of a cooling condensation type AWG system and its analysis forms the focus of this study. Using vapour compression refrigeration system	The findings in this study suggest that there are major design parameters which significantly influence the overall system's performance, namely; the bypass factor of the evaporator the bypass factor can be improved which will result in improved water production with no additional operating cost.

There is a two method which have great performance

1) Vapor compression refrigeration system
2) Thermoelectric cooling (peltier device)

Technology	Pros	Cons	Typical cop	Typical size
VCC	Evaporator temperature easily controll	No moving parts (less maintenance	3-5	Small - Large Domestic - Industrial applications
TEC		Not efficient, can't obtain high Q values	>1	Small Milliwatts- thousand

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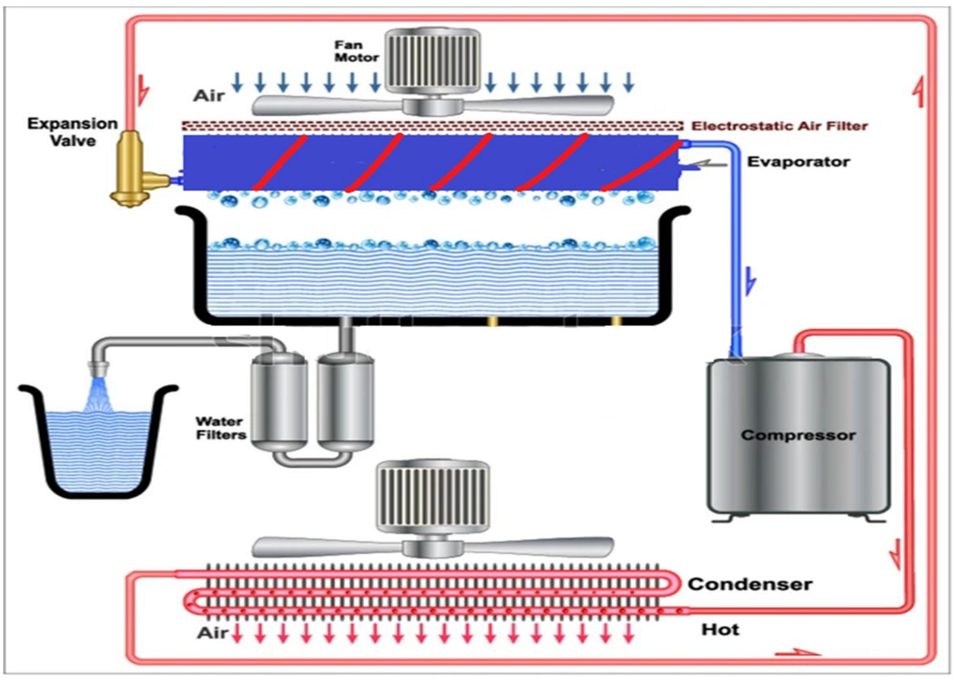
III. METHODOLOGY

After study numbers of paper on the basis of cop and ecofriendly and easy to operate we are going to try to make atmospheric water generator by using vapour compression refrigeration system Vapor-compression refrigeration is the most widely used method for air-conditioning in today's world. The vapor-compression consists of a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat to the atmosphere. Figure depicts a single-stage vapor-compression system. Basically the system has four components: a compressor, a condenser, a thermal expansion valve and an evaporator. Circulating refrigerant enters the compressor as saturated vapor and is compressed This results in high pressure which in turn is responsible for higher temperature. The compressed vapor then comes out as superheated vapor and attains a temperature and pressure at which condensation can take place with the help of cooling water or cooling air. That hot vapor is passed through a condenser where it is cooled and condensed. This is liquid refrigerant known as saturated liquid is next passed through an expansion valve where there is a sudden drop in pressure. This results in the adiabatic flash evaporation of the liquid refrigerant. As it is called lowers the temperature of the liquid and vapor refrigerant mixture which makes it colder than the temperature to be achieved (temperature of the enclosed space). The cold mixture is passed through the coils in the evaporator. A fan circulates the warm air in the enclosed space where the circulating refrigerant rejects heat from the system. The condensed across the coils carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant and at the same time, the circulating air is cooled and as a result it lowers the temperature of the enclosed space to the temperature to be achieved. The circulating refrigerant absorbs and removes heat from the evaporator (cover by a cylindrical plate) which is then rejected in the condenser and transferred by the water or air used in the condenser. For the completion of the refrigeration cycle, the refrigerant vapor coming out of the evaporator which is again a saturated vapor is returned back into the compressor.



The components which make up a refrigeration system are as follows:
1) Compressor
2) Condenser
3) Receiver tank
4) Expansion / throttle valve
5) Evaporator
6) Refrigerant
7) Auxiliary components
8) Fan

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A. *Calculation*

First we have calculate dew point temperature (at which vapour start condense) at different DBT (dry bulb temperature) and different relative humidity.

$$\gamma(T, RH) = \ln(\frac{RH}{100}) + \frac{bT}{c+T} \quad \text{......(1)}$$

$$Tdp = c\gamma(T, RH)/ b - \gamma(T, RH) \ldots \ldots \ldots (2)$$

(Where, b = 17.67 & c = 243.50C and T is in 0)

RH= Relative humidity
T= DBT(Dry Bulb Temperature)
Tdp=Dew point temperature
Amount of Water present in one m3 of atmospheric air

$$RH = \frac{p_w}{p_s} \times 100 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .(3)$$

$$Humidity\ Ratio = 0.622\ \frac{p_w}{p_{a-p_w}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .\ ()$$

Pw =partial pressure of water vapour
Pa =Atmospheric pressure 1.01325 bar
From aquation 3 & 4 humidity ratio can find

Humidity ratio gives the amount of water (in m3) present in 1m3 of air. Also we know that 1m3 is equal to 1000 litres. Thus multiplying humidity ratio by 1000 gives the maximum amount of water (in litres) that is present in 1m3 of air.

Sample Calculation
For atmospheric temperature 25 0C and relative humidity 35%
Humidity ratio=0.006879661
Amount of water =0.006879661*1000=6.87L

IV. DESIGN CONSTRAINS

Table represent design constrain of model

DESIGN CONSTRAINTS

No	Description	Detail	Justification
1	Method used	VCC	Most market feasible solution Most consistent in performance • Well documented proven solution
2	Refrigerant Type	R-134a	• Most commonly used refrigerant for required cooling temperature range. • Compatible with most refrigeration equipment products due to large market usage. Acceptable environmental impacts.

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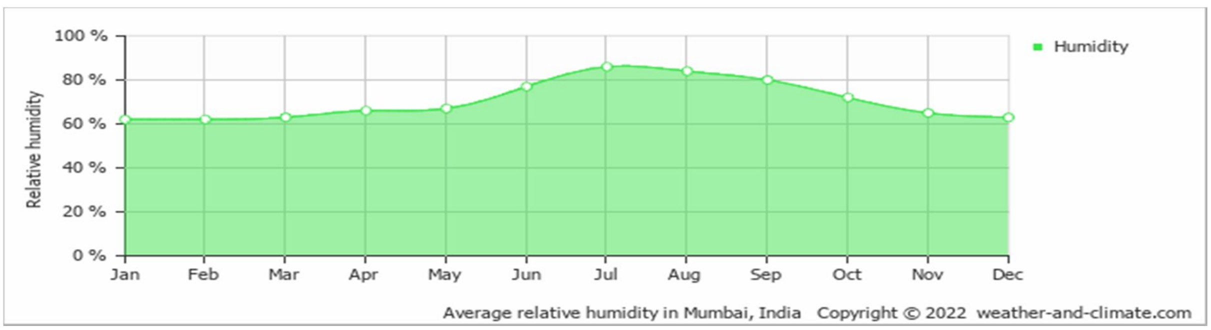
3	Lowest Recommended Operating Relative Humidity (RH_L)	40%	Lowest RH which most commercially available AWGs are rated to function Efficiently
4	Mean Relative Humidity in Case Study Location (RH_M)	65%	Average relative humidity in design location over past 100 years .
5	Optimum Relative Humidity in Case Study	80%	Upper range average annual RH indesign location
6	Lowest Design Operating Ambient Temperature ($T_{AMB\text{-}L}$)	15°C	Lowest temperature which most commercially available AWGs arerated to function efficiently Operating temperature lower than 15°C at RH of 40% leads to dew point temperature of ≥0°C which will result in freezing of condensate and inadequate performance.
7	Mean Ambient Temperature in Case Study Location ($T_{AMB\text{-}M}$)	21°C	Average daily temperature in design location year round over past 40 years
8	Optimum Ambient Temperature in Case Study Location ($T_{AMB\text{-}O}$)	35°C	Upper range extreme temperature in Summer and Spring seasons over past 40 years in design location. • Correspondences with extreme temperatures during drought. • •
9	Evaporator Type	Finned tube type - Food grade coated copper tubes, aluminium fins	High thermal conductivity.Low purchase cost.
10	Condenser Type	Finned tube type - Aluminium fins and tubes	High thermal conductivity. Low purchase cost.
11	Compressor Type	Reciprocating type compressor	Smallest, most affordable, commonly available and minimal maintenance.
12	Air inlet filter Type	Carbon Filter	Medical grade air filters, removes 99.99% air borne contaminates up to a size of 0.3µm

V. RESULT AND DISCUSSION

After carrying out various calculations the results obtained are tallied and analysed.we had calculated the dew point temperatures required for different atmospheric conditions.

1) For inlet air temperature 30^0C that temperature of air in the device drops down to that of 293 K or 20^0C for temperature 30^0C the dew point temperature is greater than 20^0C for relative humidity 60% or higher. Thus it is clear that if atmospheric temperature is 30^0C and relative humidity is greater than 60% then the device will start condensing water.
2) For inlet air temperature 35^0C at that t temperature of air in the device drops down to that of 295.5 K or 22.5^0C for temperature 35^0C the dew point temperature is greater than 22.5^0C for relative humidity 50% or higher. Thus it is clear that if atmospheric temperature is 350C and relative humidity is greater than 50% then the device will start condensing water.
3) For inlet air temperature 40^0C at that temperature of air in the device drops down to that of 298 K or 250C. for temperature 40^0C the dew point temperature is greater than 25^0C for relative humidity 45% or higher. Thus it is clear that if atmospheric temperature is 40^0C and relative humidity is greater than 45% then the device will start condensing water.
4) For inlet air temperature 45^0C that temperature of air in the device drops down to that of 300.5 K or 27.5^0C . for temperature 45^0C the dew point temperature is greater than 27.5^0C for relative humidity 45% or higher. Thus it is clear that if atmospheric temperature is 45^0C and relative humidity is greater than 45% then the device will start condensing water.

From all the above inferences we can finally conclude that if ambient temperature is 35 0C or higher and if relative humidity is greater than 50% then the device will function well and it will start condensing water. Thus in order to find if the device will work in the coastal areas of India metrological data are collected from internet for major coastal cities of India and the data are presented below.



From the above metrological data it is clear that the relative humidity of coastal cities in India remains above 50% throughout the year. Hence the developed device will work round the year without any problems.

VI. CONCLUSION

The prototype was subjected to tests at Mumbai and it was found that the water output from the device was not satisfactory. After diligent study and research we found that the following reasons may be responsible for the low water output of the device:

AWG solutions can be improved by optimising the bypass factor to achieve optimum system efficiency which will result in improved water production. As such the area of evaporator coil is generally low. So we used a copper plate in contact with the cooling surface o high conductivity expecting that the cold surface area will increase thereby increasing the condensation area finally condensation is increase.

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