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Development of a Kit to Extract Water from Atmospheric Air

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***Abstract* — Fresh water supply is one of the most limiting conditions for the populations of arid regions. A concept of extracting water from humid air has proven to offer a viable solution for such regions in world energy scenario. Limits of water production from atmospheric water vapour are investigated for cases where fresh hot humid air is cooled over evaporator coils of refrigeration machines and then directed to open localized areas. This application may be considered as a source of limited amounts of potable water at a free cost since the water is a by-product of the climate conditioning process. For high air velocities, water yield was found to diminish due to insufficient evaporator capacity. On the other hand frosting effect was found to bind the vapour condensation process due to coolant starvation. A working chart was developed for quick prediction of water yield for any combination of atmospheric air temperature in the range (25 < T_a < 40°C) and relative humidity in the range 30% < ϕ<100%. The water yield due to air dehumidification on finned evaporator coils was calculated using a developed model that relates the surface efficiency to the enthalpy change of cooled moist air. The surface was treated as an extended finned coil with mean efficiency for wet and dry conditions. For typical hot humid weather (Yelahanka, Bengaluru, 13.1139° N, 77.5983° E), the daily variation of water yield showed to follow the relative humidity pattern with minimum during midday hours. With regard to some assumptions, approximately 4321.15 cubic centimetres per month water is extracted which is suitable for drinking.**

Keywords — Atmospheric water generator, Cooling condensation technique, Dehumidification, Potable water scarcity, Vapour compression

1.0 INTRODUCTION

Pure Drinking water is the single biggest problem India is facing today. Most water sources are contaminated by sewage and agricultural runoffs. There are over 100 million cases of diarrhoea a year & over 0.5 million die of this disease. 66 million people in over 200 districts are facing fluoride contamination. Over 15 million people are facing arsenic poisoning. The initial problem statement for our team is posed by this scenario which made us to focus on extracting water from humidity. Upon focusing on this project, our team defined a problem statement to better reflect the realities of atmospheric water generation. Atmospheric water generators already exist as products on the market; thus there is a need for this design to differentiate itself, through some innovation or better utility in order to justify the expenditure of time and money on this project. Furthermore, atmospheric water generation is an energy intensive process. Existing implementations aren't capable of producing significant amounts of water at a decent price. In light of these considerations, statement has been formulated like this,

"To develop and prototype a system for obtaining clean drinking water from air, focusing on improvements in the energy requirement with an end goal of powering the device with renewable energy."

1.1 Development Norms

1.11 Transparency

This work is carried out to make the process understandable, consistent, and reliable. Any changes in the design, new ideas and innovations can be easily incorporated and research can be continued in order to get a better product for the public usage.

1.12 Integrity

The integrity involves looking at the harmony between form and function, completeness, promotion of human values and relationships, and is pleasing and intuitive to use. Developing this AWG so that it accomplishes and reflects integrity in design meshes well with the other design norms of trust and transparency. Our goal is to accomplish all of these norms to effectively make a better product that takes into consideration the rights of others.

1.13 Trust

The main objective is to make people very comfortable using our AWG so that they use it to its fullest potential and their maximum benefit. Our desire is to make a good product that is dependable and reliable.

2.0 CONSTRAINTS, OBJECTIVES & DESIGN EVALUVATION

2.1 Constraints

Three requirements are identified while developing the kit in order to ensure that the final project would effectively fulfil its intended purpose.

- Pot ability of Water - Water produced by this technique must conform to the World Health Organization (WHO) drinking water quality standards.
- Simplicity of Use - This must be operable by persons of limited technical experience.
- Safety - This must not pose a hazard to users at any point during its normal operation.

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2.2 Objectives

- 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.
- 1 Litre of Water Production per Day - The design should produce at least one litre of drinkable water per day.
- Maximize Efficiency - The design should maximize the water produced per unit energy.
- Minimize Cost - The design should minimize the cost per unit water production for both capital cost and production cost.

2.3 Design Evaluation

2.31 Dehumidification

When approaching the problem of atmospheric water generation it is clear that the heart of the system is dehumidification, which is the removal of water from a stream of air. In this application, the aim is to capture this water and utilize it for drinking purposes.

2.32 Dehumidification by Cooling Condensation Technique

In a cooling condensation type atmospheric water generator, a compressor circulates refrigerant through a condenser and then an evaporator coil which cools the air surrounding it. This lowers the air temperature to its dew point, causing water to condense. A controlled speed fan pushes filtered air over the coil. The resulting water is then passed into a holding tank with purification and filtration system to help keep the water pure and reduce the risk posed by viruses and bacteria which may be collected from the ambient air on the evaporator coil by the condensing water. The rate at which water can be produced depends on relative humidity and ambient air temperature and size of the compressor. Atmospheric water generators become more effective as relative humidity and air temperature increase. As a rule of thumb, cooling condensation atmospheric water generators do not work efficiently when the temperature falls below 18.3°C (65°F) or the relative humidity drops below 30%. This approach is expressed in Figure 1,

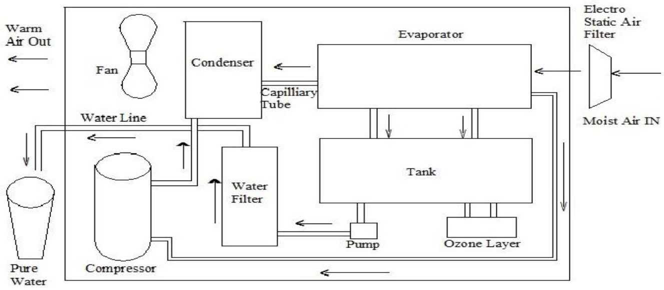

Figure1: Dehumidification by cooling condensation technique

There are several advantages to this approach. First, it is founded on decades of technical work and innovation. Furthermore, it is a very direct approach and relatively simple to evaluate given psychometric theory and the latent heat of condensation. A primary disadvantage to this approach is the magnitude of the heat transfer needed to generate a significant quantity of water. Virtually all commercial atmospheric water generators utilize this approach to dehumidification.

3.0 SYSTEM ARCHITECTURE

The cooling condensation system can be divided into three overall sections: system structure, process and electronics.

3.1 System Structure

The system structure is the physical components that go into the system not including any electrical components.

3.11 Frame

The entire system needed to be supported by some kind of frame; discussions were made with our team guide to identify the suitable material, dimensions, and the location for the frame. Finally we come to a conclusion that Cast Iron can sustain the weights and the material will be conveniently available at the cheapest rate in local markets, where as for dimensions we defined a length of 1.5m, width of 1.1m and the height of 0.9m. Hence the Evaporator coil can be placed at the top, an outdoor system consisting of compressor, condenser, suction fan and water collection tank, pump and heating coil can be placed at the bottom. The entire frame was fabricated by welding, drilling and through various mechanical operations in our departmental workshop and strength tests were simulated practically. Therefore this frame is sufficient to support all equipment necessary for the system.

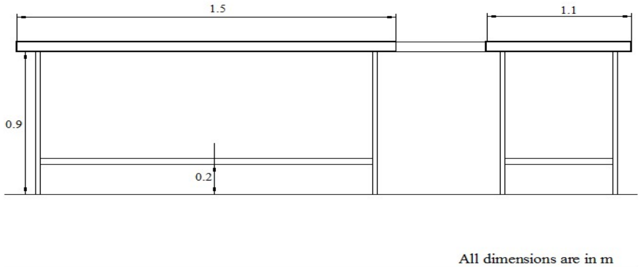

Figure 2: Design of the system's frame

3.12 Upper and Lower shelves

The stand was divided in to upper and lower shelves. The shelves were added to hold all of the equipment for the system between the supports of steel frame. Distance between two shelves is 0.7m where as the distance between the ground and the lower shelf is 0.2m. They were made out of medium density fibreboard (MDF) which was chosen because of its availability and high strength.

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3.2 Process

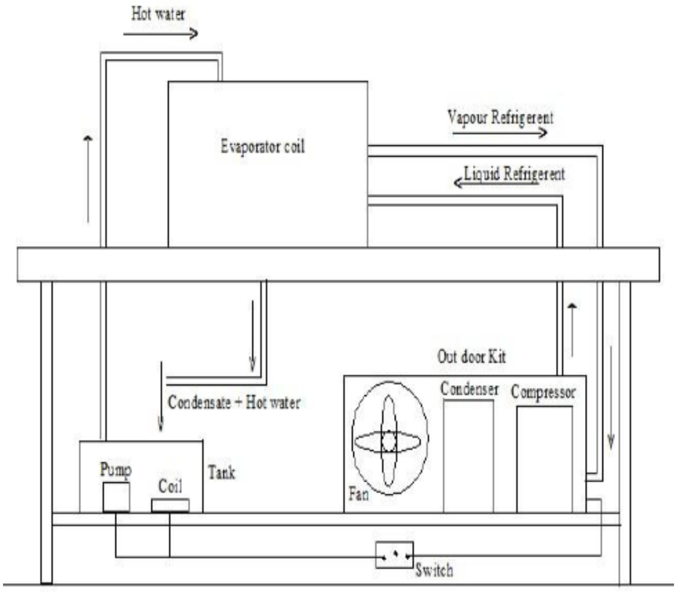

Figure 3: Block diagram of the cooling condensation process

The process section is composed of the mechanical and chemical methods that generate water. The process is divided into three loops: compressor, evaporator and condenser. Figure 3 is a block diagram showing all of the necessary parts for the system to help visualize the process portion of the design. In this type of atmospheric water generator, a compressor compresses the vapour state refrigerant into higher pressure. Then the pressurized refrigerant enters the condenser, a suction fan passes the air over the condenser coil in order to carry away the heat in the refrigerant. By liberating heat, refrigerant changes its state from vapour to liquid but the Pressure remains high. Liquid refrigerant undergoes expansion in the condenser coil by absorbing the heat of the ambient air that is passing over the coil, due to this expansion the moisture in the air being trapped by the fins of the evaporator coil. The refrigerant changes its phase from liquid to vapour and reaches back the compressor, thus the refrigeration cycle repeats. The trapped moisture in the fins of the evaporator coil will be in the solid state i.e. Ice. This ice needs to be converted into water, so we are passing the hot air over the fins from the air blower, and the heat in hot air melts the ice and converts it into water droplets. The collected water droplets in the collection tank can be further sent for purification.

An alternative way is developed for the melting of ice. The pre-collected water in the tank is being heated by the heating coil and this hot water is circulated over the evaporator coil with the help of pump. Ice gets melted and carried to the collection tank by this hot water.

Figure 4: Experimental Setup

3.3 Electronics

The electronic section covers the power and control systems necessary for the operation of the design.

3.31 Power

The power systems are responsible for two primary functions. First, they must supply the necessary voltages and currents to all of the design's various components. Second, the power systems need to be safe: electrocution is one of the greater hazards associated with this design, and as such, safe power system design can significantly reduce this danger. Additionally, one of the goals of this project is to produce a device that is compatible with renewable energy sources. Unfortunately, it is outside of the scope and budget of this project to implement this design consideration in our prototype. Table 1 below contains all of the power requirements for the prototype.

Component	Voltage (V)	Current (A)	AC/DC
Compressor	240	3.1	AC
Water Pump	240	0.167	AC

Table 1: Component wise power requirements of Prototype

3.32 Control

Control systems are responsible for making decisions as to the operation of the prototype. We have opted not to implement full electronic control in the prototype. Instead, the user will be responsible for engaging the valves and pump in the prototype to achieve operating conditions. This decision was motivated by several factors. First, electronic control is an additional layer of complexity; user-based control simplifies the prototype electronics considerably. Second, the exact nature of the required electronics is dependent on the desired Control. As we had no experience with controlling this process, the requirements were unknown prior to prototype construction. Finally, we were limited resources in terms of expertise and budget.

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4.0 PROTOTYPE OPERATION & EXPENSES

The prototype is constructed to be a proof-of-concept and it requires certain considerations while it is operating.

4.1 Description of operation

4.11 Selection of Refrigerant

A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. A refrigerant under goes a change of phase from liquid to vapour and back from vapour to liquid. Due to these phase changes moisture could be condensed to water. We were looking for a refrigerant that has the capability to condense more amount of moisture into water, and we found that R-404A will be the compatible one due to its following specifications.

R 404-A	
Replaces	R22 & R502
Applications	Medium and low temperature commercial and industrial direct expansion refrigeration and ice machines
Performance	➢ Similar PT and flow properties to R-502 ➢ Higher capacity than R-22, therefore requires 'Thermostatic Expansion Valve' change
Lubricant Recommendation	Compatible with polyolester lubricant

Table 2: Specification of Refrigerant 404-A

R-404A is a blend refrigerant developed as a substitute for R-502 (HCFC/CFC blend refrigerant) which has been widely used for commercial-use refrigeration equipment. It is a mixture of HFC-125, HFC-143a, and HFC-134a, and is a pseudo-azeotropic refrigerant. It requires liquid filling to prevent change in composition. The discharge gas temperature can be kept as low as or even lower than that of R-502. It is highly compatible with ester oil and ether oil (It is not compatible with mineral oils like naphthenic oil etc. which is normally used with R-502). Compared to R-502, its moisture solubility is slightly higher. R-404A is mainly used as a refrigerant for mid-to-low temperature refrigerating systems.

General properties	R-404A	[Reference] R-502
Components	HFC-125/143a/134a	HCFC-22/CFC-115
Blend ratio	44/52/4	48.8/51.2
Boiling point (°C)	-46.1	-45.6
Saturated vapor pressure (MPa, 25°C)	1.25	1.16
Range of flammability (vol% in air)	Non-flammable	Non-flammable
Ozone depletion potential (ODP) *1	0	0.33
Global warming potential (GWP) *2 ( ) *3	3920 (3260)	4660

*1 The ODP of R-404A is based on December 1991 announcement by AFEAS. The ODP of R-502 is based on the Montreal Protocol.
*2 integrated time of 100 years based on IPCC 4th Report 2007.
*3 integrated time of 100 years based on IPCC 2nd Report 1995.

Table 3: General properties of the refrigerant R-404A

4.12 Batch Process

In the system the refrigerant circulated in three loops. First loop is from compressor to condenser, condenser to evaporator coil, evaporator coil to compressor. In the first loop the liquid refrigerant will be compressed to a very high pressure and also increasing its temperature. Then the refrigerant in the second loop is made to pass through condenser coil, where the suction fan allows air to pass over the condenser coil to decrease refrigerants temperature. As the refrigerant circulates in third loop to the condenser and passes in to evaporator coil, it undergoes expansion thereby decreasing its pressure and condensing the air below its dew point such that moisture turns to ice. Ice can be melted by passing hot water over condenser coil and thus atmospheric water is collected.

4.13 Manual Switches

Manual switches are essential part of the system as they need to control the flow operations. Three switches are necessary, one switch to control pump, one for the heating coil and the other to control the outdoor system. This process could be automated and electronically controlled after extensive testing, but automation is outside the scope of this project. With time not available this semester, the prototype could be run through many different operating conditions and flow rates to determine the time it would take to condense. For the pump automatic water level controllers would be installed along with sensors. Installing thermocouple can automatically turn off the heating coil after reaching a certain temperature.

4.2 Operating instructions

The following information is a step by step process of turning on and turning off the AWG.

4.21 Start-Up routine

All components must start in an off position or unplugged,

- ➢ Pump switch
- ➢ Heater switch &
- ➢ Switch to control outdoor system

The next list shows the order of turning on all systems assuming that the system has been set according to the section above.

- ➢ Turn on the pump to circulate water
- ➢ Switch on the outdoor system consisting of condenser and compressor for circulating the refrigerant
- ➢ Check the temperature of water, as soon as the temperature starts decreasing
- ➢ Switch on the heating coil.

4.21 Shut-Down routine

The following set of instructions shows the step by step instructions for shutting down the system.

- ➢ Switch off the heating coil to lower the water temperature
- ➢ Switch off the outdoor system to stop refrigerant flow
- ➢ Allow the water to circulate over the coil so as to drain all melted ice
- ➢ At last switch off the water pump

4.3 Project Expenses

In order to determine the overall expense of building an atmospheric water generator, the team developed an original budget for the prototype by researching what components we have owned and what we need to own. This budget served as a baseline to guide part ordering and prototype construction. Primary component sizes were determined based on the

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necessary performance levels as determined by the system model developed. The Compressor, Condenser and Evaporator coil were the three main components and also the Three highest individual expenses.

System	Cost in Rupees
Compressor	6,100
Condenser	3,000
Evaporator coil	2,500
Capacitor	200
Cast iron rods	740
AC outdoor	3,000
CPUC pipes, Araldite & others	360
Transportation	736
Refrigerant, Copper pipes, filtering charges	4,000
Water pump	850
Hot air blowers	806
Total	**22,292**

Table 4: Main system expenses

5.0 RESULTS & DISCUSSIONS

Testing and experimentation allowed us to understand the relationship between different process variables and how the system reacts to environmental changes.

DATE	MIN_TEMP(^{0}C)	MAX_TEMP(^{0}C)	AVG_TEMP(^{0}C)	MIN_HUM (%)	MAX_HUM (%)	AVG_HUM (%)	Average Temperature(^{0}C)	Average Humidity (%)
01-Mar-15	20.3	29.8	23.48	46.8	87.7	72.91		
02-Mar-15	19.8	32.3	25.06	34	87	63.59		
03-Mar-15	19.8	29	23.65	43.3	93.1	68.1		
04-Mar-15	19.8	29.6	23.87	40.8	85.5	64.85	24.01	66.36
05-Mar-15	20.3	30.9	24.59	27.3	84.9	61.04		
06-Mar-15	20	30.4	24.36	36.8	82.4	62.83		
07-Mar-15	19.6	28.5	23.09	47.8	91.5	71.22		
08-Mar-15	18.3	31.4	24.05	24.6	89.5	58.42		
09-Mar-15	18.1	30.1	23.7	26.9	87	56.02		
10-Mar-15	20	30.3	24.78	26	76.1	51.58		
11-Mar-15	18.9	29.2	23.79	28.2	85.2	55.52	24.31	48.3
12-Mar-15	18.5	30.4	24.41	24.4	77.9	45.1		
13-Mar-15	15.4	31.6	24.41	16	57.4	32.26		
14-Mar-15	18.1	32	25.03	15.4	74.8	39.21		
15-Mar-15	15.7	32.9	24.86	11	64.2	34.22		
16-Mar-15	23.3	31.5	27.08	16.9	47.1	30.24		
17-Mar-15	17	33.6	26.2	11.9	67.8	34.66		
18-Mar-15	19.9	35	27.33	6.7	54.5	26.86	26.91	32.82
19-Mar-15	18.8	34.6	26.9	8.3	56.3	26.33		
20-Mar-15	18.7	35.1	27.96	9.6	82.9	37.87		
21-Mar-15	19.8	34.6	28.07	13.5	78.4	39.57		
22-Mar-15	22.2	33.9	27.94	23.6	67.9	42.15		
23-Mar-15	20.3	34.6	28.28	18.1	55.4	34.39		
24-Mar-15	19.9	34.5	28.06	8.9	67.4	32.23		
25-Mar-15	18.7	34.8	27.49	12	58.7	31.65	27.58	33.16
26-Mar-15	20	34.1	27.39	8.3	65.5	32.07		
27-Mar-15	19.4	33.5	26.66	9.3	69.6	32.46		
28-Mar-15	20	34.1	27.27	11.1	52	27.2		
29-Mar-15	18.1	35.7	28.03	10.1	50.8	25.51		
30-Mar-15	22.1	35.5	29.01	15.4	45.1	28.35	28.6	28.67
31-Mar-15	21.7	35.2	28.76	15.4	62.8	32.15		

Table 5: Ambient temperature and Relative Humidity data collected from KSNDMC for March 2015

5.1 Formulae adopted for design calculations

- Heat of Compression , h (KJ/Kg)

$$h = h_{lc} - h_{ec}$$

Where,

h_{lc} = enthalpy of vapour leaving compressor (KJ/Kg)
h_{ec} = enthalpy of vapour entering compressor (KJ/Kg)

- Compression work:

$$W = h \times q$$

Where,
W= compression work (kJ/min)
h= heat of compression (kJ/kg)
q= refrigerant circulated (kg/min) =3kg/min

- Net refrigeration effect, NRE (KJ/Kg)

$$NRE = h_l - h_e$$

Where,
h_l= enthalpy of vapour leaving evaporation (KJ/kg)
h_e = enthalpy of vapour entering evaporation(KJ/kg)

- Coefficient of performance, COP

$$COP = NRE/h$$

Where,
NRE= Net refrigeration effect
h= heat of compression

- Compression horsepower per ton, p (hp/ton)

$$p = 4.715/COP$$

- Capacity, c(KJ/min)

$$C = q \times NRE$$

Where,
q= refrigerant circulated (Kg/min)=1.5kg/min

- Compressor displacement, d (m^3/min)

$$d = CV/NRE$$

Where,
C= Capacity (KJ/min)
V= Volume of gas entering compressor (m^3/kg)
NRE= Net refrigeration effect (KJ/kg)

Using these formulae calculations were done individually for four weeks of March to test how the above parameters vary with the respective Humidity and ambient temperature.

Temperature (°C)	Saturated vapour pressure (mmHg)	Saturated vapour density (gm/m^3)	Temperature (°C)	Saturated vapour pressure (mmHg)	Saturated vapour density (gm/m^3)
-10	2.15	2.36	40	55.3	51.1
0	4.58	4.86	60	149.4	130.5
5	6.54	6.8	80	355.1	293.8
10	9.21	9.4	95	634	505
11	9.84	10.01	96	658	523
12	10.52	10.66	97	682	541
13	11.23	11.35	98	707	560
14	11.99	12.07	99	733	579
15	12.79	12.83	100	760	598
20	17.54	17.3	101	788	618
25	23.76	23	110	1074.6	951
30	31.8	30.4	120	1489	1250
37	47.07	44	200	11659	7840

Table 6: Saturation vapour density

5.2 Calculations for the First week of March 2015

- Average dry bulb temperature, t_b = 24.01 ^{0}C ≈24^{0}C
- Enthalpy of dry bulb temperature = h_e, h_{ec} = 56 KJ/Kg
- Average relative humidity = 66.36 % ≈ 66%

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$$RH = \frac{\text{Actual vapour density}}{\text{Saturation vapour density}} \times 100$$

From Table 6, Saturation vapour density =21.86 g/m^3

$$0.66 = \frac{\text{Actual vapour density}}{21.86} \times 100$$

$\therefore$ Actual vapour density =14.427 g/m^3
= 0.014427 kg/m^3

- Wet bulb temperature, t_w = 20 ^{0}C
- Enthalpy of wet bulb temperature , h_l = 45KJ/Kg of dry air
- Temperature of air leaving compressor , T_{lc}=33 ^{0}C
- Enthalpy of air leaving compressor , h_{lc} = 74 KJ/Kg of dry air

Results for the first week of March 2015 is shown in the table below,

Sl No	March 2015 - 1st Week	
1	Heat of compression , h	h = 18 KJ/Kg
2	Compression work , W	W = 900 watts
3	Compression , P	P = 1.2 HP
4	Net refrigeration effect , NRE	NRE = 11 KJ/Kg
5	Co efficient of performance , COP	COP = 61.12 %
6	Compression horse power per ton , p	p = 7.71 HP/ton
7	Capacity , C	C = 33 KJ/min
8	Compressor displacement , d	d = 72.06 m3/min

Table 7: Results for first week of March

5.3 Prototype Approximation

The goal of our project is to generate water using the air surrounding the device. Temperature and humidity are key variables that influence the rate of water production and testing them in a measureable way is essential. So the graphs ambient temperature v/s relative humidity and relative humidity v/s dew point temperature was plotted.

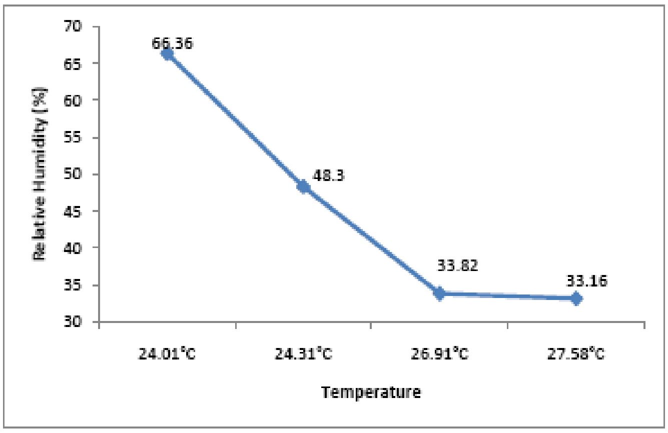

Figure 5: Ambient temperature v/s Relative humidity

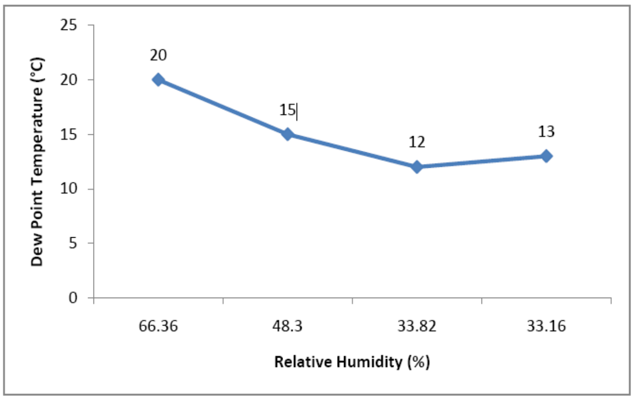

Figure 6: Relative humidity v/s Dew Point temperature

5.4 Discussions

As we were aimed to extract possible litres of potable atmospheric drinking water, relative humidity (RH) plays a vital role. RH was found to vary from day to day and time to time. During day time i.e. from morning to evening humidity decreases gradually and during night time i.e. from evening to morning it increases. So we approached Karnataka State Natural Disaster and Monitoring Centre which is an autonomous body of Government of Karnataka to study about RH variation. There we collected the maximum, minimum and average values of RH from March 1st till March 31st along with ambient temperature (Table 5 shows the data collected from KSNDMC). Weekly averages were calculated from the daily averages of RH and Temperature, then the variable parameters of the kit was determined.

- For the first week of March i.e. dry bulb temperature, t_b = 240C and RH = 66%, compression work was found to be 900 watts and corresponding COP was 61.12%.
- For the second week of March i.e. dry bulb temperature, t_b = 240C and RH = 48%, compression work was found to be 1550 watts and corresponding COP was 61.29%. Here when we compare to the first week the RH has decreased about 18%, so the power
  Consumed by the compressor is more to obtain a COP of 61.29%. Since the RH is less, more power will be consumed by the compressor to circulate the refrigerant.
- For the third week of March i.e. dry bulb temperature, tb = 270C and RH = 33%, compression work was found to be 1950 watts and corresponding COP was 69.23%. The RH is still lower than previous two weeks. As we have discussed above, more power will be consumed for less RH. But in this week, even then 1950 watts of power being consumed coefficient of performance is comparably higher than previous weeks.
- For the last week of March i.e. dry bulb temperature, tb = 280 ^{0}C and RH = 33%, compression work was found to be 2100 watts and corresponding COP was 64.28%.

There is no change in RH from previous week even then the temperature is being raised by 10 ^{0}C, but the power consumed is higher than all the four weeks and also the COP was found to be lower for more consumption.

The month of March is nearer to the summer season and hence the COP lies in the range of 60-70%, whereas during the winter and rainy seasons COP gradually increases for less power consumption.

6.0 IMPROVEMENTS/INNOVATIONS AT THE LATER STAGE

Upon finishing the project prototype and performing initial testing, the results obtained are less than the goal we had set out to accomplish. However, the team recognized several areas of weakness that could be improved to yield better final results. These improvements can be separated by whether they would be accomplished with a higher budget or if more time would make them a reality

6.1 Financial-Based Improvements

Financially-based improvements would be accomplished by fund raising for the prototype. Spending more on parts would improve the capabilities of the absorption loop, heating loop, and condensation loop to maximize water production. On installing larger pumps, stronger fans, more effective heating elements, and improving how these components are connected would raise the efficiency of the system and enable the atmospheric water generator to produce more water for a given energy input.

6.2 Utilizing renewable energy as a source

Efforts are going on in order to make use of solar panels or wind energy turbines or any feasible non-conventional energy sources for generating electricity can help us avoiding more consumption of external power resource. Photoelectric principle is the best and simplest way for generating electricity using solar panels, thus generated power can be stored in batteries and can be utilized to run the compressor.

Hence by using the renewable resource, compressors of higher capacities can be installed, though the power consumption is higher it can be renewed and also the water extraction will be more.

6.3 Installing Heat Exchangers

Heat exchangers are the device that absorbs heat from hot body and transfers to the lower one. These devices can be installed at the outlet of the compressors, where the heat is available at higher rates. Hence by doing this, the heat generated at the compressor outlet will be absorbed and transferred to the evaporator inlet so that the refrigerant will be warmed instantly. No need of additional power required for warming the refrigerant.

6.4 Application of Mechatronics

Manual controlling leads to errors at higher percentage. Supplying less power to the kit, irregular monitoring of the refrigerant temperature, over heating of water collected at the tank etc. are some of the examples for human errors. Manual operating also requires labour; hence by implementing mechatronics, all the above stated problems can be easily resolved. Installing thermocouples to monitor ambient temperature, dew point and refrigerant temperatures. Hygrometer to indicate exact Humidity and sensors to automatically control water level, ON/OFF of heat exchangers. All these can reduce percentage errors.

7.0 CONCLUSIONS

After testing in ideal conditions it was found that this cooling condensation system operates at an average of 1625 watts and could produce 4321.15 cubic centimetres of water for the month of March. This results show that the kit developed by our team has successfully reached certain limits and has proved that the water can be extracted from atmospheric air.
It is also observed some drawbacks like more power consumption, relatively low COP during summer season, labour cost for operating manually, but we can overcome from these drawbacks by implementing renewable energy as a source and installing sensors at required levels to monitor the variations. By developing the kit of extracting atmospheric water; our team has promoted development and understanding of cooling condensation technique and has learned valuable lessons of design and prototyping. Through the extent of this year long design project each member of our team had an opportunity to take charge of a portion of this development. Essential skills have been cultivated for managing large projects and meeting important deadlines. All of this had been done in the context of a technical project which requires collaboration with others and grounded in design norms. These things will help our team members as they move on.

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