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Design Optimization of Atmospheric Water Generator

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Abstract: Atmosphere contains large amount of water in the form of vapour, moisture etc. Within those amounts almost 30% of water is wasted. This amount of water can be used by implementing a device like Atmospheric Water Generator. This device is capable of converting atmospheric moisture directly into usable and even drinking water. The device uses the principle of latent heat to convert water vapour molecules into water droplets. From the previous literature it is learnt that the AWG units are more efficient only at coastal regions where the relative humidity is high. According to previous literature, it is also learnt that the temperature required to condense water is known as dew point temperature. The atmospheric water generator consists of a draft fan, heat sink, casing and a thermoelectric peltier (TEC) couple, which is used to create the environment of water condensing temperature or dew point. The objective of this paper is to obtain that specific temperature (dew point temperature) to condense water with the help of peltier devices and aims at optimizing the AWG unit to be efficient at locations where humidity percentage is low. CFD analysis is carried out to optimize the design by changing the number of peltiers and location of peltiers till the desired temperature for condensing is achieved.

Keywords: Heat sink, TEC, CFD, and AWG

I. INTRODUCTION

Atmosphere contains large amount of water in the form of vapour, moisture etc. Within those amounts almost 30% of water is wasted. This amount of water can be used by implementing a device like Atmospheric Water Generator. This device is capable of converting atmospheric moisture directly into usable and even drinking water. The device uses the principle of latent heat to convert water vapour molecules into water droplets. In many countries like India, there are many places which are situated in temperate region; there are desert, rain forest areas and even flooded areas where atmospheric humidity is eminent. But resources of water are limited. In the past few years some papers have already been done to establish the concept of air condensation as well as generation of water with the help of peltier devices, such as harvesting water for trees using Peltier plates that are powered by solar energy etc. So, this paper will be helping to extend the applications of such devices further in the near future. According to previous knowledge, we know that the temperature require to condense water is known as dew point temperature. Here, the goal is to obtain that specific temperature (dew point temperature) practically or experimentally to condense water with the help of some electronics devices. This paper consists of a thermoelectric peltier (TEC) couple, which is used to create the environment of water condensing temperature or dew point, indeed conventional compressor and evaporator system could also be used to condense water by simply exchanging the latent heat of coolant inside the evaporator. The condensed water will be collected to use for drinking purpose and various other uses.

II. METHODOLOGY

A. CAD

Computer aided design (CAD) is assistance of computer in engineering processes such as creation, optimization, analysis and modification. CAD involves creating computer models defined by geometrical parameters which can be readily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real world conditions. There are several good reasons for using a CAD system to support the engineering design function:

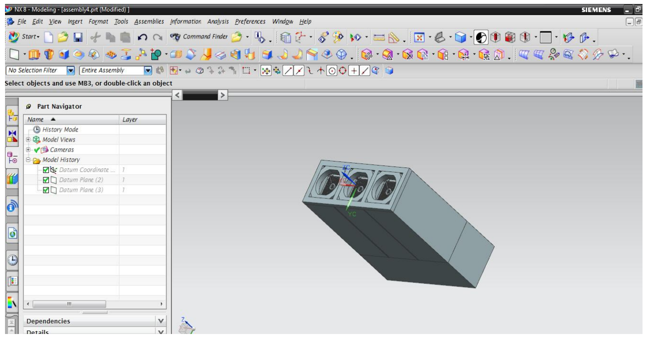

Figure 2.1 Final assembly of atmospheric water generator

B. Peltier Device & Its Specifications

The basic thermoelectric (Peltier) plateis a thermocouple, which consists of a p-type and n-type semiconductor elements, or pellets (figure 2.2). Copper commutation tabs are used to interconnect pellets that are traditionally made of Bismuth Telluride-based alloy. Thus, a typical thermoelectric cooler (TEC) consists of thermocouples connected electrically in series and sandwiched between two Alumina ceramic plates. The number of thermocouples may vary greatly **-** from several elements to hundred of units. This allows constructing a TEC of a desirable cooling capacity ranging from fractions of Watts to hundreds of Watts.

As discussed above, When DC moves across Peltier cooler**, it** causes temperature differential between TEC sides. As a result, one thermoelectric cooler face, which is called cold, will be cooled while its opposite face, which is called hot, simultaneously is heated. If the heat generated on the TEC hot side is effectively dissipated into heat sinks and further into the surrounding environment, then the temperature on the thermoelectric cooler cold side will be much lower than that of the ambient by dozens of degrees. The thermoelectric coolers cooling capacity is proportional to the current passing through it.

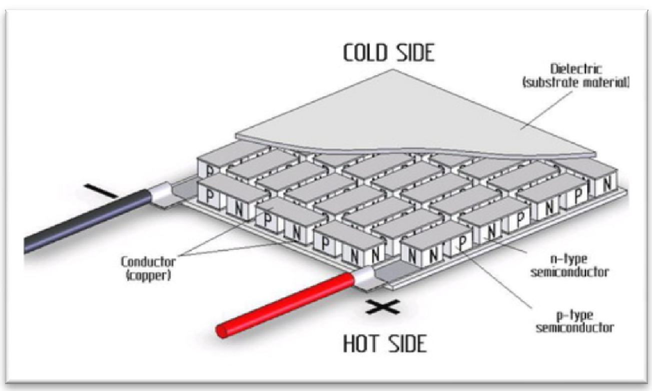

Figure 2.2: Model of Peltier plate

C. Unigraphics

The NX software integrates knowledge-based principles, industrial design, geometric modeling, advanced analysis, graphic simulation, and concurrent engineering. The software has powerful hybrid modeling capabilities by integrating constraint-based feature modeling and explicit geometric modeling. In addition to modeling standard geometry parts, it allows the user to design complex free-form shapes such as airfoils and manifolds. It also merges solid and surface modeling techniques into one powerful tool set. Our previous efforts to prepare the NX self-guiding tutorial were funded by the National Science Foundation's Advanced Technological Education Program and by the Partners of the Advancement of Collaborative Engineering Education (PACE) program.

D. Solid Works

Solid works flow simulation easily simulates fluid flow, heat transfer, and fluid forces that are critical to the success of your design. SOLIDWORKS Flow Simulation is fully embedded with SOLIDWORKS 3D CAD, SOLIDWORKS Flow Simulation intuitive CFD (computational fluid dynamics) tool enables you to simulate liquid and gas flow in real world conditions, run "what if" scenarios, and efficiently analyze the effects of fluid flow, heat transfer, and related forces on immersed or surrounding components. You can compare design variations to make better decisions to create products with superior performance. Driven by engineering goals, SOLIDWORKS Flow Simulation enables Product Engineers to use CFD insights for making their technical decision through a concurrent engineering approach. Additional HVAC and Electronic Cooling modules offer dedicated fluid flow simulation tools for detailed analysis.

III. RESULT AND DISCUSSION

A. Dew-point temperature (T_{dp})

Is the temperature at which humidity in the air starts condensing at the same rate at which it is evaporating at a given constant barometric pressure.

B. *Sample Calculations*

(For DBT=30^0c and RH=45%)

γ (30, 45) =ln (45/100) + (17.67×30/243.5+30)=1.139

Tdp= (243.5×1.139/17.67−1.139)=16.77735769

The table for the dew point temperature calculation for different atmospheric conditions is as follows:

Dry Bulb temp (in Degrees)	Relative Humidity (%)	Required Dew point Temp (in Degrees)
30	45	16.77735769
30	50	18.46356201
30	55	19.99121587
30	60	21.40183613
30	65	22.71309952
30	70	23.93889215
30	75	25.09032956
30	80	26.17645367
30	85	27.20472258
30	90	28.18136311
30	95	29.11163002
30	100	30

Table 3.1: Dew point temperature calculations at 30^0C and different relative humidity conditions

Amount of water (in L)present in 1m3 of air for different humidity and temperature conditions

1) *Relative Humidity (RH) is* the ratio of partial pressure of water (Pw) to that of saturation pressure (Ps) i.e. RH= (Pw/Ps) ×100

Thus from saturation pressure (Ps) and relative humidity (RH) data partial pressure of water (Pw) can be obtained as

$$Pw = (RH/100) \times Ps$$

2) *Humidity Ratio*gives the volume of water (in m3) present in 1m3 of air.

Humidity ratio can also be expressed in terms of partial pressure of water (Pw) as

$$HumidityRatio = 0.622 \times Pw / (Pa - Pw)$$

(Where Pa is the atmospheric pressure i.e. Pa=1.01325 bar)

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

C. *Sample Calculations*

(For atmospheric temperature 25^0C and relative humidity 35%)

Saturation Pressure of water vapour (Pw) at 25^0C is obtained from steam table as 0.03167 bar.
Thus Partial pressure of water, $Pw= (RH/100)\times Ps$=35100×0.03167=0.0110845 bar
Humidity Ratio = 0.622× $(Pw/Pa-Pw)$ =0.622×0.01108451.01325−0.0110845=0.006879661
Therefore amount of water (in liters) present in 1m3 of atmospheric air
= $Humidityratio$×1000=0.006879661×1000=6.879661 liters
The amount of water present in 1m3 of air consisting of the above mentioned calculations for different atmospheric conditions are tabulated below:

Temp.	Saturation Pressure-Ps (in bar) from psychometric chart	Relative Humidity (in %)	Partial Pressure of water-Pw (in bar)	Humidity Ratio (Amount of water in 1m^3 of air)	Amount of water (in l)
25	0.03167	45	0.014252	0.00887332	8.87331963
26	0.03361	45	0.015125	0.009425106	9.425106362
27	0.03565	45	0.016043	0.010006378	10.00637781
28	0.03779	45	0.017006	0.010617294	10.61729425
29	0.04005	45	0.018023	0.011263751	11.26375125
30	0.04241	45	0.019085	0.011940224	11.94022424
31	0.04492	45	0.020214	0.012661281	12.66128116
32	0.04755	45	0.021398	0.013418573	13.41857282
33	0.05031	45	0.02264	0.014215243	14.21524302
34	0.0532	45	0.02394	0.015051581	15.05158141
35	0.05624	45	0.025308	0.015933705	15.93370461
36	0.05942	45	0.026739	0.01685907	16.85907
37	0.06276	45	0.028242	0.01783389	17.83388967
38	0.06626	45	0.029817	0.018858605	18.8586045
39	0.06992	45	0.031464	0.01993368	19.93368005
40	0.07376	45	0.033192	0.021065512	21.06551245
4	0.07779	45	0.035006	0.0222	22.25764724

1				57647	
42	0.08201	45	0.036905	0.023510734	23.51073365
43	0.08642	45	0.038889	0.024825458	24.82545792
44	0.09103	45	0.040964	0.026205544	26.20554435
45	0.09585	45	0.043133	0.02765481	27.65480986

Table 3.2: Amount of water which can be obtained by processing 1m3 of air at 45% relative humidity for different temperature conditions

After the solution is converged the temperature and velocity profiles for various inlet and temperature conditions are plotted. The profiles are plotted for the mid plane and also for the total body. The results are displayed below:

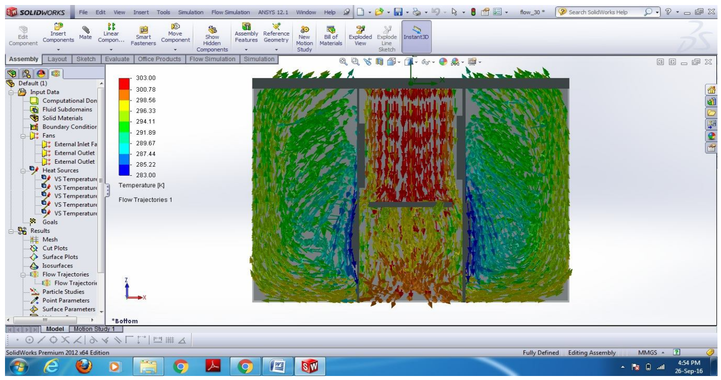

Fig 3.1: Temperature plot in vector format for inlet air temperature of 30^0 C

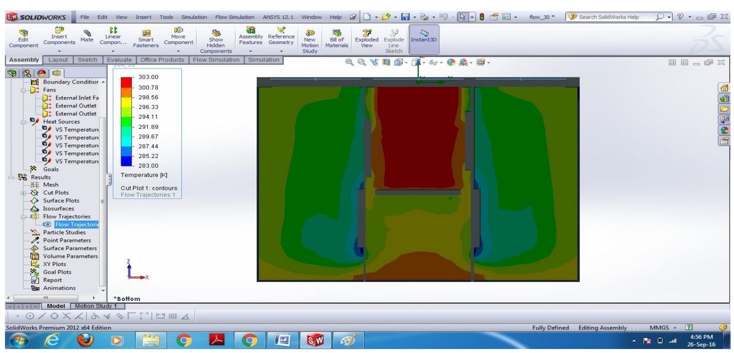

Fig 3.2: Temperature plot in contour format for inlet air temperature of 30^0 C

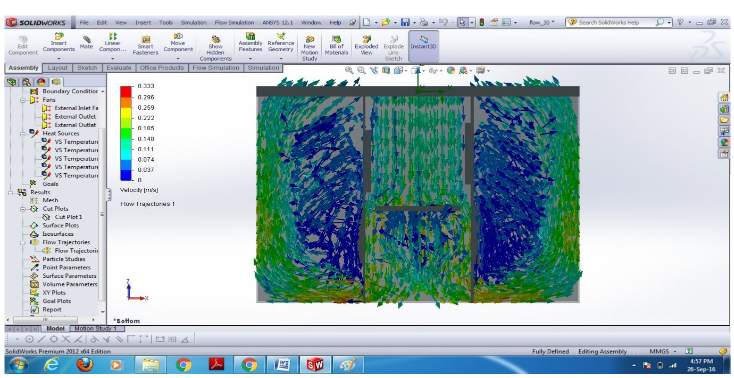

Fig 3.3: Velocity plot in vector format for inlet air temperature of 30^0 C

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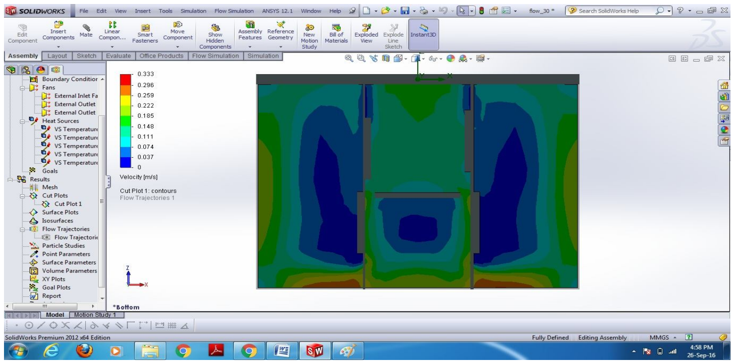


Fig 3.4: Velocity plot in contour format for inlet air temperature of 30^0 C

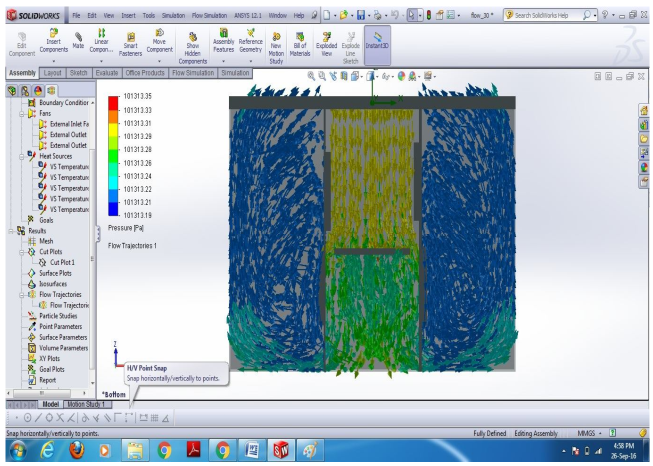


Fig 3.5: Pressure plot in vector format for inlet air temperature of 30^0 C

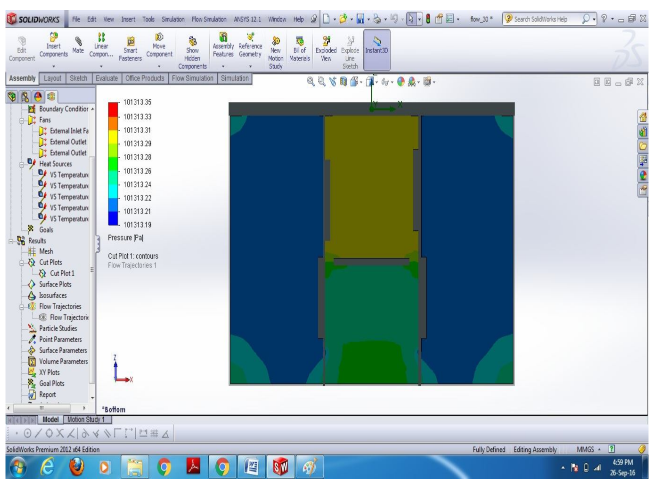


Fig 3.6: Pressure plot in contour format for inlet air temperature of 30^0 C

After carrying out various calculations the results obtained are tallied and analyzed. Earlier we had calculated the dew point temperatures required for different atmospheric conditions. Tables 1 show the results obtained for dew point temperature calculations at 30^0C and different relative humidity conditions.Then we calculated the least temperatures that can be obtained from our device by specifying the boundary conditions in SOLIDWORKS FLOW SIMULATION. The results of the analysis are shown in the above figures .Both these results are then compared. The conclusions are:

For inlet air temperature 30^0C the temperature plot shows that the temperature of air in the device drops down to that of 14^0 C (287 K). Table 3.1 show that for temperature 30^0C the dew point temperature is greater than 14^0 C for relative humidity 45% or higher.

Thus it is clear that if atmospheric temperature is 30^0C 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 nearer to 45% then the device will function well and it will start condensing water.

IV. CONCLUSION

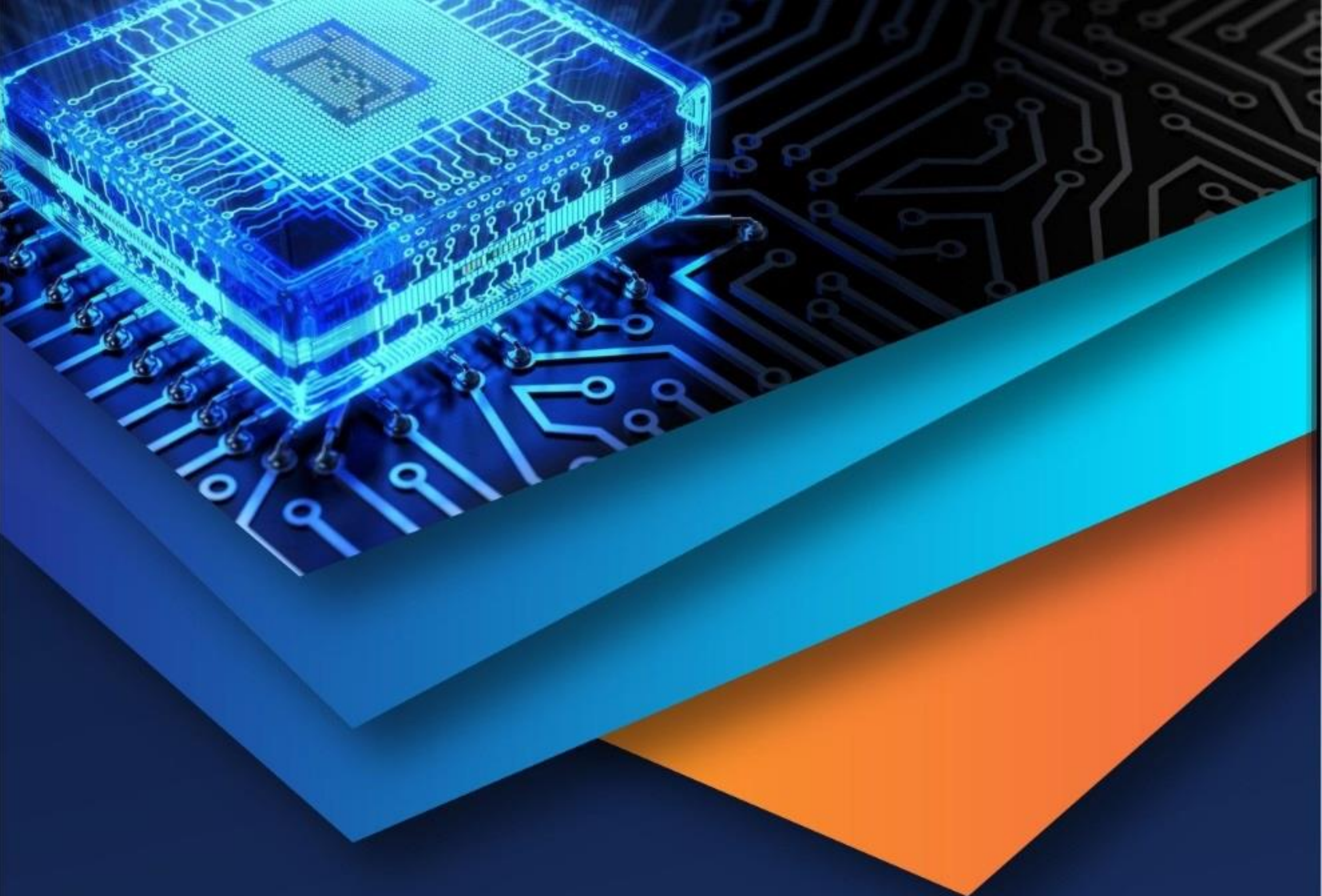
In this paper the atmospheric water generator used to generate water from the vapor has been optimized to work at relatively lower humidity levels. CFD analysis was carried out to optimize the design by changing the number of peltiers

Finally it is concluded that 5 peltiers are required for the atmospheric water generator at ambient temperature of 35^0C or higher and if relative humidity is nearer to 45% then the device will function well and it will start condensing more amount of water than the water produced by the reference paper.

By referring the table of average annual humidity for India we can say that the device will function properly all over India

REFERENCES

[1] Rao Y.V.C. An Introduction to Thermodynamics" (2nd Ed.). Universities Press, 2003.
[2] A. M. Hamed, Absorption-regeneration cycle for production of water from air-theoretical approach, Renewable Energy 19 (2000), 625-635.
[3] Siegfried Haaf, Helmut Henrici. "Refrigeration Technology" in Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, 200
[4] K. Bansal and A. Martin, Comparative study of vapour compression, thermoelectric and absorption refrigerators, International Journal of Energy Research, 24, 93-107, 2000.
[5] Thermoelectric Coolers Basics". TEC Microsystems. 2013
[6] Anbarasu T., Pavithra S. "Vapour Compression Refrigeration System Generating Fresh Water from Humidity in the Air", 2011
[7] A. F. G. Jacobs, B. G. Heusinkveld and S. M. Berkowicz, Passive dew collection in a frassland area, The Netherlands Atmospheric Research 87 (2008), 377-385
[8] Kabeela A.E, Abdulazizb M., Emad M.S. "Solar-based atmospheric water generator utilisation of a fresh water recovery: A numerical study", 2014
[9] Brown, D.R., Fernandez N., Dirks J.A., Stout T.B. "The Prospects of Alternatives to Vapor Compression Technology for Space Cooling and Food Refrigeration Applications". Pacific Northwest National Laboratory (PNL). U.S. Department of Energy, 2010
[10] Arora C.P, Refrigeration and air conditioning. Tata McGraw-Hill Education, 1July 2001



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