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Fabrication of A Prototype for Condensation of Water on Metal Surface Using Peltier Modules

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ABSTRACT

Collection of water is an utmost and important necessity for our survival because 70% of our body is composed of it. The available water on earth can be estimated as 73% but only 10% of which is consumable. The available drinking water sources are from ground and fresh water bodies and rainwater harvesting as well. Here arises a need for better solution for water collection and its purification. Many distillation units are accompanied for filtration of water by evaporation, reverse osmosis and chemical compounds. In all this we always forget to mention another source of water that is the air. Appreciably, the air has a distinct property, i.e. there is some percent of water present in the air. During winter season, fog on car's windshield is because of condensation of water molecules present in the air. Despite being a hard task to extract water from humid air as it is required to cool it below its dew point temperature and it needs high amount of energy input thus it is a necessary to find new sources of energy. Thus there arises a need for research of moderate systems those would work on renewable energy sources like solar energy. Traditional VCRS cycles have harmed the nature since 1970s and despite their modifications there lies a risk for human life. Hence there is a need for other cooling systems like thermoelectric cooling and heating. Thus we had made use of one of the thermoelectric module i.e. peltier module. Currently we fabricated a prototype that is in a development stage for condensation of water.

Keywords : Peltier modules, reverse osmosis, thermoelectric cooling, condensation, dew point

I. INTRODUCTION

E It is known that, if humid air is cooled below the dew point temperature, the water molecules present in the air can be condensed. This phenomenon can be used to find out the condensation process at different temperature and humidity.

In our project, using peltier devices for dehumidifying the air to condense water, we are analyzing the amount of water condensed on metal surface.

Thermoelectric cooling uses the Peltier effect to create the heat flux between the junctions of two different types of materials.

Peltier uses p-n junction diode and it works on thermoelectric effect. This is the only source for cooling which can work on non-conventional sources.

Instead of using the conventional method of cooling i.e. VCRS & VARS which needs heavy input load to operate compressors and generators, we are making use of

II. LITERATURE REVIEW

U.S. NAVAL LABORATORY [1] states that "Both forms of condensation (film & drop wise) takes place when a cold surface comes in contact with humid air and in general smooth clean surfaces tend to induce film type condensation and oily and greasy surfaces tends to induce drop-wise condensation".

Umesh V Sangle [2] made use of thermoelectric modules in a unique way by using solar cell powered Peltier junctions for refrigeration purpose. The author has used 4 Peltier modules for obtaining a refrigeration thermoelectric coolers.

Kabeela [3] in his paper 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. Here the goal is to obtain that specific temperature, called the dew point temperature, practically or experimentally to condense water from humid air with the help of thermoelectric Peltier couple.

Aditya Nandy, Sharmi Saha, Souradeep Ganguly[4] in their project of water generation using Peltier modules as cooling surfaces found that their system produces 1 litre of condensed water in a highly humid region as a promising result.

Laguerre [5] in his research illustrated that a large proportion of refrigerators operate at too high temperatures so it is necessary to understand the mechanism of heat transfer and air flow in refrigerators because of 1 litre capacity. He used fans to cool the hot junction of Peltier module and we wish to do the same if required.

Peltier effect

The thermoelectric module called Peltier gives effect which is, when a 12 V DC is supplied through its terminals, one side of the module gets cooled where as another side gets heated. This module generally works on the reverse Seebeck effect.

Setup of the prototype

Fig.1. Side view of the prototype

The setup of the prototype had the following components:

1. **Peltier module-1 nos**. They are made from p-type and n-type semiconductors by placing them in parallel to each other and the are joined With a

thermally conducting plate on each side. When the current flows through the terminals there occurs a temperature difference on either aside of conducting plate.

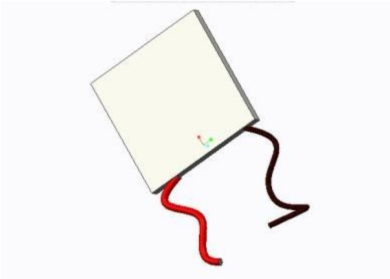


FIG.3. Peltier Module

Fig.2. Prototype(front)

2. Radiator

It is a simplest type of heat Exchanger that intakes hot water from one side and cools it through natural or forced convection.

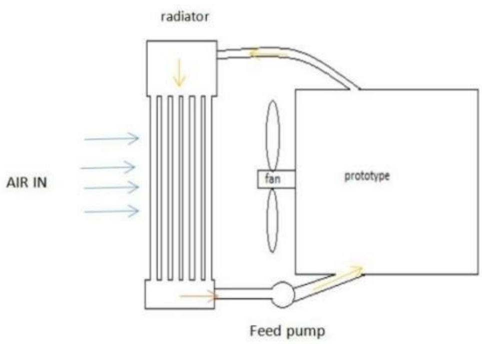


Fig . radiator

3. DC source (12 V battery)- 3 nos The battery we used in the prototype was lead acid battery of 12 volts and 8Ah.the battery was rechargeable.

4. Fan- 2 nos

The fans were used for forced convection of air for the radiator and the supply of air inside the container. The flow rate of fan was given in cfm and the fans used were brushless DC fan model no. LD8025. The only requirement was 12 V- 0.16A - 1.92W.the fan has a maximum velocity of 200 cfm at full load.

5. Pump

Pump was used for feeding of water to the hotter side of the peltier for extraction of heat. It works on 9 volts battery.

6. Container

The container is used for collection of water and as a surface for condensation of water.the material of the container used is stainless steel and its thickness was about 2 mm and it has a Polish chromium coated surface. The rate of condensation is higher on a coated surface than that of an uncoated and unpolished surface.

7. Sump

Sump is a reservoir of water that stores and provides sufficient quantity of water for cooling off peltier device.

8. Heat sink (liquid cooling). A heat sink is a device that Is connected on the hot side of peltier and has a high thermal conductivity. It is generally blue in colour and it has one inlet and one outlet port.

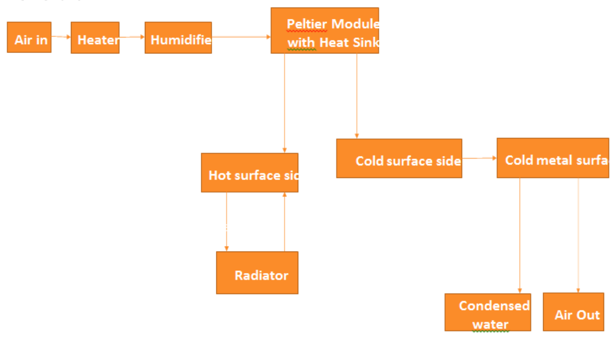
Fig.4. Heat Sink

The container used for collection of water was directly placed on the cold side of the peltier, while the hot side was connected with the heat sink through which water was flowing.The medium of heat transfer is water as it is a non-toxic liquid and it removes the heat at a higher rate than air. As the peltier have had to be fully efficient we operated it at full load conditions i.e., 12 volts and 8 amp current (DC).

After carrying the heat from the peltier's hot side the water is passed through a radiator and then to the sump and the process was repeated with the help of submersible pump.

The condensation occurred due to the reason that the surface of container was colder than the dew point of the air contacting the surface and for a higher condensation rate we used a dc fan.

Flowchart



Data regarding the humidity and temperature during various seasons

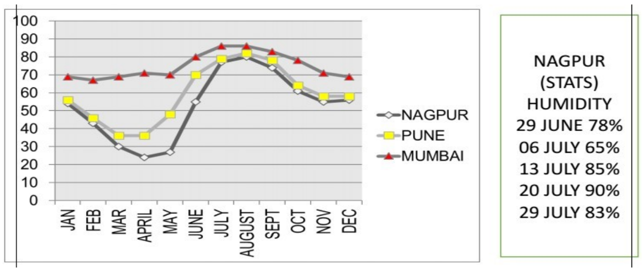


Table 1 Humidity of Various Cities During The Year[6]

Relative humidity (%)	Temperature of air(°C)	Specific humidity (gm/kg of dry air)	Temperature of cold surface(°C)	Amount of water condensed (g/kg of dry air)
10	30	2.6	5	-
20	30	5.25	5	-
30	30	7.919	5	2.52
40	30	10.604	5	5.20
50	30	13.31	5	7.91
60	30	16.02	5	10.62
70	30	18.79	5	13.39
80	30	21.57	5	16.17
90	30	24.38	5	18.98
100	30	27.20	5	21.80

Table 2 amount of water that can be condensed per kg of dry air at a given relative humidity

Cycles

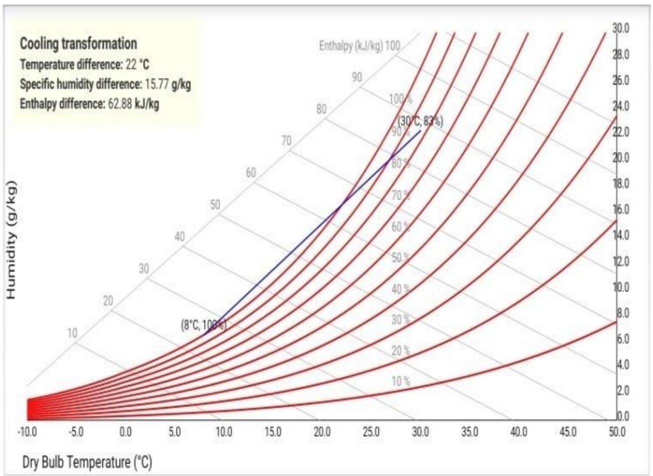


Chart 1. Psychrometric analysis

The above mentioned chart is a psychrometric chart showing initial and final state of air after entering in the container.

Difficulties and findings

1. the main difficulty that we faced was that the properties of air at outlet was difficult to measure as the air flowing in the container was coming back through the inlet after striking back the base of the container.thus, the bypass factor was assumed.

2. The cooling effect is directly proportional to the amount of heat carried away from the hotter side thus the efficiency of peltier reduces if the flow is not uniform and fast. 3. Another problem we faced was that the water flow has to be switched on before the peltier starts heating because if more heat is accumulated on the hotter side it may damage the peltier.

4. The output of the peltier was not constant as it depends on the amount of heat extracted, the current flowing from the battery, and the humidity of air was not constant.

5. The heat sinks that we used I.e., blue box was quiet expensive.

6. The water that is collected was higher than that which could have been collected when we used air cooling rather than liquid cooling.

7. Due to forced air circulation in the container the problem of freezing of water and reducing the rate of condensation was eliminated as the friction between the container and contacting air gives out heat thus the formation of droplets was possible.

8. The power consumption of our module is quiet less than those that used VCRS and VARS system because there is no compressor or generator that needs high input current mostly A.C.

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