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Extraction of Water from Ambient Air By Using Thermoelectric Modules

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ABSTRACT

Water scarcity is one of the burning issues of today's world. Though the water covers more than two third (about 70%) of the earth's surface but still fresh water which can be used for drinking and carrying out every day remains scarce. So, to overcome this we need to develop a method to condense water from air. However, in highly humid areas such as places close to the water source water can be obtained by condensing water vapour present in air. Here to develop water from air we use the convergent nozzle, axial fan, thermoelectric, filter and collecting tank etc. here the air from atmosphere is sucked by air fan through filter then pass it to through nozzle, which is provided with fins. While the air passing through the nozzle at exit of nozzle we place a thermoelectric to get the reduced pressure about 1atm and temperature about 18°C i.e. below the dew point temperature at that temperature and pressure the phase change takes place from the air to water thus the condensation takes place and forms the water. The power consumption for this process is very low and the obtained water is pure to drink safely.

Keywords: Thermoelectric, Condensation, Dew Point, Phase Change.

I. INTRODUCTION

Water is needed in all aspects of life. Difficulty to purify, expensive to transport and impossible to substitute, water is an indispensable element of life nearly 45 cores of people in 129 countries are staying in water-deficit regions. Nearly 70% of the fresh water is used for irrigating the agricultural fields which has raised water conflict between the urban and rural areas if all this continues, then very soon i.e. by 2032, nearly half of the world's population will be facing water shortage problem. It is predicted that in the 21st century there will be water wars.[1] 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 if we are able to extract the water that present in the air in the form of moisture. The project is an attempt to make device that is capable of converting atmosphere moisture directly into usable and even drinking water.[2]

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 of the projects have already been done to establish the concept of the air condensation as well as generation of the water with the help of peltier devices, such as harvesting water for young trees using peltier plates that are powered by photovoltaic solar energy etc.so,[9] this projects 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 practically or experimentally to condense water with the help of some electronics devices. This project consists of a thermoelectric peltier (TEC) couple, which

is used to create the environment of water condensing temperature or dew point.[3]

II. NOMENCLATURE

T temperature (˚C)
Tamb ambient temperature (˚C)
Tc cold side temperature (˚C)
Th hot side temperature (˚C)
ΔT temperature difference (˚C)
COP coefficient of performance
TEC thermoelectric cooling module

III. PELTIER COUPLE

The peltier thermoelectric device has two sides (a P-type and an N-type semiconductor), and when DC current flows through the device, it brings heat from one side to other, so that one side gets cooler while the opposite one gets hotter. This is called peltier effect and electron hole theory. Peltier coolers consists of a peltier element and a power full/fan combination. Peltier elements come in various forms and shapes. Typically, they consists of a larger amount of thermocouples arranged in rectangle form and packed between two tin ceramic plates. This type of device is so powerful that it can freeze good amount of the water within several minutes.

A conventional cooling system contains three fundamental parts-the evaporator, compressor and condenser. A TEC also has some analogous parts. Energy (heat) is absorbed by electron at the cold junction, as they pass from a low energy level in the P-type semiconductor element, to a higher energy level in the N-type semiconductor element. It is the power supply that provides the energy to make these electrons to move through the system. At the hot junction, energy is expelled to heat sink as electrons move from a high energy level element (N-type) to a lower energy level element (P-type).[4-6]

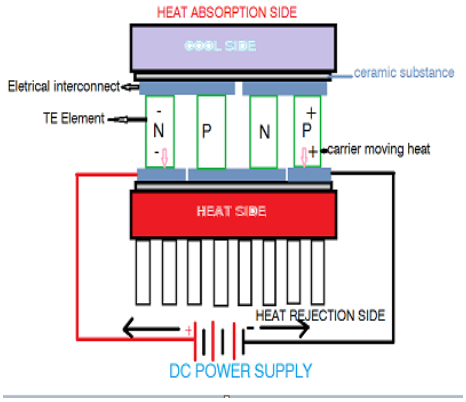


Figure 1. Thermo Electric Module

IV. WORKING FEATURES

Practically TE couples are combined in a module, connected electrically in series and thermally in parallel to obtain a promising output. But it will be inconvenient to use such a device that has less advantageous work done to the power ratio. There are modules available in the market according to variety of the size, shape, operating voltages-currents and ranges of heat pumping capacity. The present trend, however, is towards a larger number of couples operating at the lower currents; before choosing an efficient device, some parameters must be determined.[7] These are:

TC: Temperature at cold surface
Th: temperature hot surface

The object to be cooled is intimately confined with the cold surface of TEC, thus the temperature of that object starts falling until it is as same as the temperature of the cold surface of the TEC.

Now, ΔT = TH –TC

This conflict should be accurately determined if the design is to operate as desired.

V. WORKING OF THE DEVICE

According to the previous elaboration, the objective is to calculate the dew point temperature Tdp from the gathered information regarding Hr and Ta. Once the dew point temperature is obtain, the peltier coefficient P and the current rating of the device (TEC1) can also be obtain from device data table; thus the estimated time for generating water droplets from the humid air is calculated readily. As soon as the device is powered the

hot side starts getting hotter and cold side cooler; reaching the dew point temperature. The cold side of TEC starts to cool the air passing through its heat sink area and water vapour start to condenses just like the water condense happens outside a glass full of ice. It is important to keep in mind that when TEC starts it takes a longer time to actually produce water according to the experiment result of this project.

TEC1 is a device that is used for average efficiency requirement according to the power is fed and the time taking to reach its optimum level of cooling effect. As this project mainly lies uses on the dc power supply, it immediately not possible to use higher TEC as those will require higher voltage rating. So comparatively its fruitful to use TEC1 through it takes a bit longer time to run efficiently.[8]

VI. EQUIPMENT USED

Convergent nozzle, Air filters, axial fan, copper coil, thermo electrics (peltier devices) size 4×4×0.4cm, maximum temperature difference i.e. ΔT of 73˚C. Heat Sinks, Power Source with rated voltage and current is about 12V and 6A. Temperature indicator and humidity indicator.

A. Explanation

Air capacity of holding water vapour varies according to the temperature of air and humidity, warm air can hold more water vapour. Initially the ambient air is sucked by centrifugal fan through the filter and into the nozzle. As the air passing through the nozzle the temperature and pressure of the air start decreasing. We need to send the cool water about 2°C through the copper coil. The coil here is absorbing the temperature of air thus we get the reduced temperature of air. To achieve this the water circulation should be continuous. In divergent portion we have to place thermo electrics and heat sink. When the electric supply applied to a TE module one face becomes cold while other is heated. In accordance with laws of thermodynamics, the heat from the (warmer) area being cooled will pass from the cold face to hot face. To complete the thermal system, the heat sink is attached to the hot face of TE, to dissipate the heat. Thus while passing air through the divergent portion air touches the heat sink which held on the peltier cold side. Formation of water takes place i.e., phase change takes place from gaseous state to liquid state, as the air is cooled to the below dew point temperature. Finally the water is collects in collecting tank.As we have to run the thermoelectric continuously it gets heated, we need to cool down the temperature otherwise it may get damaged. To monitor the voltage, current, humidity and temperature, we have keep the indicators with displays. So that we can performs the operations safely.

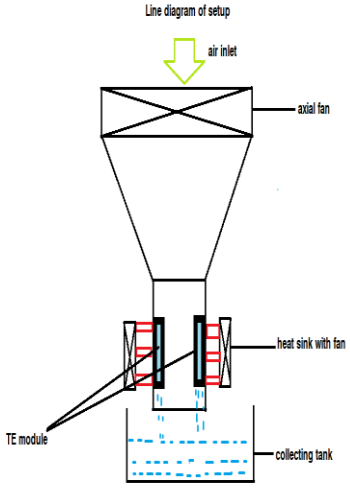


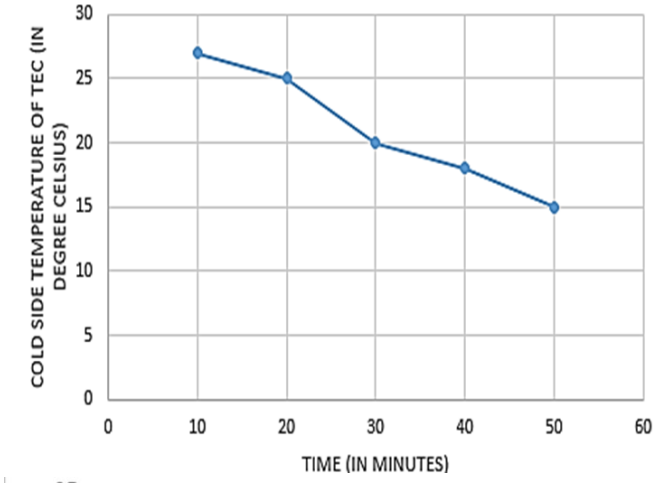
Figure 2. Line diagram of experimental Setup

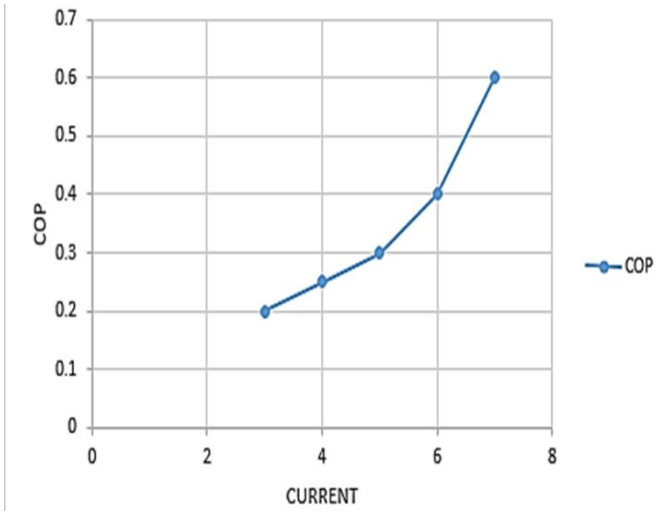
VII. RESULTS AND DISCUSSION

In experimental setup the voltage, current and air inlet kept constant. The TE module resistance depends on the cooling and hot side's temperature. TE module used are TEC1-12706 and dimension 4×4×0.8.Max voltage used 12V and 6A. The maximum temperature differences are 73˚C. As the air cools below dew point temperatures the water is obtained.

A. Graphs

Above graphs obtained from experimental analysis. The performance of TEC is depends on applied current as shown in above graphs. The cold side temperature of TEC is varies with time of operation as shown in above graph.





VIII. APPLICATION

There are hardly any chance to refuse that this device is portable for its simple design and endurance capacity. So, the atmosphere water Generator is the device which can be implement for extreme situation, to use during flood, in desert areas, 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. Many company like 'water maker India ltd', 'aero water', etc have already this type of device for domestic purpose. It can be implement for industrial development where the water is a matter of crisis.

IX. CONCLUCTION AND FUTURE WORK

Applying this system in a highly humid region almost 1 Litre of condensed water can be produced per Hour during the day, this is a promising result; and then a more enhanced system can be designed that encounters power DC power source. The economic advantage of this kind of system is low installation cost. The development and production of such equipment is a future business possibility

This idea can be extended further in future

1) For large scale implementation, RO and UV water filter can be used.
2) Peltier device has many types of models which are most efficient than TEC1. Those can be used.
3) As the project aims at producing water from atmosphere and keeping this handy.
4) The concept of this project can also be used as a better alternative in refrigeration science against conventional system.

It can also be observed in many way i.e. the usage of such low power semiconductor devices are indicating towards more prominent evolution of cooling engineering that is going to alter the whole scenario and myths about the power consumption of refrigeration science. Thus in near future we will be able to use such devices that are now limited within the project works.

X. ACKNOWLEDGEMENT

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