THERMOELECTRIC DEHUMIDIFIER BASED WATER GENERATOR

Abstract

Water is one of the fundamental building blocks of all forms of life. Even though around 80 percent of the world is covered by water, the composition of water which is fit for domestic use is pretty much less. Having in mind that fresh water is mainly obtained through the monsoon season, chances of monsoon failure have been high in recent times making it essential to design alternatives for the production of water. There are many such existing systems which are used for water generation such as the Sea water Desalination Plant. A desalination plant can be installed only along the coast and could be made possible to provide water only to people residing nearby to the plant and also their installation costs are very high. To bring a solution to this situation we can consider the Thermoelectric Dehumidifier based Water Generator. This could be considered as a vital replacement to existing systems as they do not require many criteria's for the functioning of the system and their installation costs are also less compared to the other existing systems which are present in the market.

Keywords: Heat evacuator, Peltier device, dehumidifier unit; Relative humidity;

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I. INTRODUCTION

Water is essential for human survival as well as the advancement of industry and civilisation. Water resources, on the other hand, are quickly depleting as a result of rising count of human beings, environment contamination, and misguided agricultural practises [1–3]. According to Mesfin et al. [2,] two-thirds of the world's population experience acute water scarcity at least once a year. Throughout the year, many people around the world endure severe water scarcity. Among the available water generation methods like Rainwater harvesting, sea water desalination etc., the proposed thermoelectric dehumidifier based water generator is an alternate solution to compensate water resource shortages. The amount of renewable water in the atmosphere is projected to be greater than the total amount of fresh water available in Earth's marshes, wetlands, and rivers [8]. There are many systems which are available for the purpose of generation of water. One of those is the desalination plant. Desalination plants were used in coastal areas to remove salt from water to make it fit for drinking. Later on the atmospheric water generator was introduced but it requires the relative humidity of that particular place where the system is to be carried out to be sufficiently high. Due to this downside, it had a big letdown in certain regions. In order to overcome the setbacks, the idea of water generation using peltier device along with compressor and copper tubes is proposed.

The aim of this proposed work is to create a portable device that can be used to meet the water requirements of a regular household. The device will first condense water present in the atmosphere and then purify it so that it can be used for drinking. While designing this device it was identified that three major requirements were necessary to ensure that final project would effectively fulfil its intended purpose, they are portability of water, simplicity of use and safety. Using peltier devices alone could be able to generate only certain amount of water that may not be able to fulfil the needs. Also usage of coolant gas to increase the efficiency is not an easy task. Thus these shortcomings are overcome using the copper tubes that contain coolant gas inside them to improve the cooling.

The rest of the paper is organized as follows. Section II outlines the literature survey, section III depicts system model, and gives the detailed procedure of the proposed scheme. Section IV discusses the experimental results in detail. Finally section V concludes the paper.

II. LITERATURE SURVEY

Tu et al. (2020) proposed a paper, discusses about various water harvesting technologies in detail and presented performance, research gap and possibilities to enhance the atmospheric water generation elaborately.

A.M. Hamed (1999) proposed a system in which the description and analysis of the theoretical cycle for absorption of water vapour from air with subsequent regeneration, by heating is presented in first model. A theoretical limit for the maximum possible amount of water which can be collected from air using the desiccant through the absorption regeneration cycle at certain operating conditions of ambient parameters, heat to be added to the desiccant during regeneration and maximum available heating temperature could be evaluated through the analysis of this cycle.

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A.M. Hamed et al. (2011) published a paper about the application of solar energy to heat a sandy bed impregnated with calcium chloride for recovery of water from atmospheric air and evaluated the effects of different parameters on the productivity of the system during regeneration.

Esam Elsarrag (2011) presented the paper about water generation methods which can be adopted in Gulf regions, where water shortage is more .In this paper two methods of collecting water from the atmosphere are presented.

A. E. Kabeel (2004) studied experimentally and demonstrated the effect of using sandy bed solar collector system for extraction of water from air in Arabian countries. The results show that the system can provide an amount of 1.2 liter of fresh water per square meter of glass cover per day.

C.Cerro (2018) addressed the water scarcity problems in urban areas of United Nations. He has introduced the water generation technology for generating the water for drinking purpose as well as to satisfy the need of water in agriculture field for production of fruits and vegetables.

K. Pontious et al., (2016) developed a couple of automatic water generation concepts utilized Peltier devices and heat exchangers. Authors used the engineering concepts to generate the water at lower cost with minimum energy consumption.

A. Sondergeld et al., (2019) derived a mathematical model for water generator. Using that model as a tool, viability and productivity of water generator was studied for the given climate with heat pump and without heat pump. This paper gives the idea of designing an energy system without an electrical grid in order to operate these systems in remote area.

Shanshan Liu et al., (2017) designed a highly efficient transportable water generator and experimentally investigated by measuring the parameters like relative humidity, air flow rate and condensation rate. Authors have implemented the model in tiny size, so that it could work at lesser amount of air flow rate which is suitable for out-of-doors.

Wei He et al., (2020) developed their own prototype for water generation and performed experimental study under lower inlet air flow rate. They have investigated the operating conditions on hot climate as well as cold climate by considering humidity level and air flow rate. They have shown the remarkable performance in lower air flow rate.

The experimental augmentation approach of a transportable atmospheric water generator prototype was given by Casallas, I et al., (2021). This method was developed through an exhaustive search of the investigational solution space, which was obtained through parametric stretches of dual parameters related to the power consumption and the physical variables involved in the water compression process.

III. SYSTEM MODEL

The system comprises of a Peltier module which is made up of two different types of metals. On passing DC current through the device it makes sure that one junction becomes a

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hot junction and the other junction a cold junction. Based on the principle of Peltier effect it leads to the generation of water in the cold junction. This pretty much helps in production of water based on the humidity content which is present in the atmosphere. Also a compressor could be used to bring about rapid expansion of gas and made to pass through a copper tube will lead to condensation along the pipe. These two subsystems when put together form the total working system which in-turn helps in fast forwarding the process of water generation. This could be considered as a vital replacement to existing systems as they do not require many criteria's for the functioning of the system and their installation costs are also less compared to the other existing systems which are present in the market.

Compressor and copper tubes are used to increase the rate of efficiency of water production. Heat exchanger is used to send out the hot gases into the atmosphere and maintain the temperature of the entire setup low. A suitable program is written and fed to the nano controller, which is connected to the humidity sensor and the display kit so that it indicates us about the temperature and humidity values. The data is received and displayed to the user.

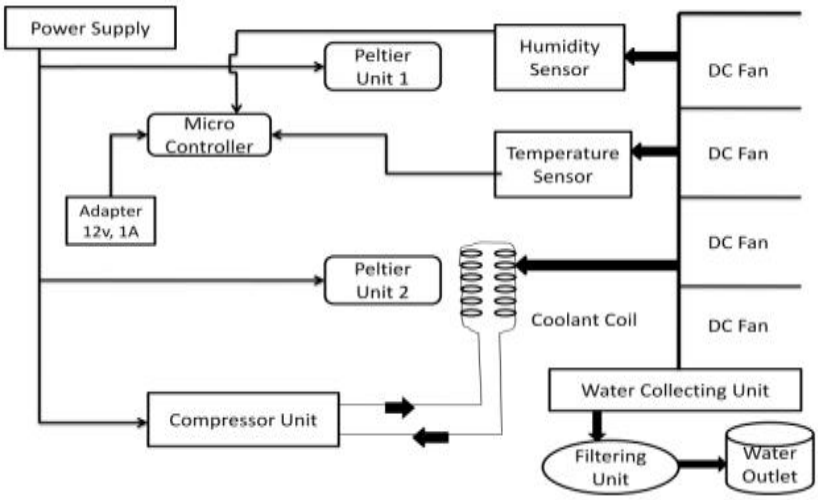

Figure 1: Block diagram of thermoelectric dehumidifier based water generator

Block diagram of thermoelectric dehumidifier based water generator is shown in Figure 1. The important modules required for water generation is clearly depicted in the figure 1. Here the peltiers are connected in series, and when current is passed through this device the peltiers start generating heat on one junction and starts to cool on the other side. The heat from the peltier device is removed continuously by using draft fans. The peltier device is mounted over a LED draft fan. By removing the heat from the hot junction, it increases the efficiency. The peltier device is powered up using the power supply of 12V. In order to maintain and to increase the chillness in the system the coppers tubes are used.

Compressor is used to increase the pressure thereby decreasing the temperature, hence it is used to pump the coolant through the copper tubes. The coolant used in this system is tetrafluroethane. The gas inside is maintained at a pressure of 5bar that is 25psi. Since the diameter of the compressor is very small compared to diameter of the copper tube, the volume decrease occurs when gas is pumped inside from the discharge port. Due to the

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change in pressure and volume there is decrease in temperature and the coolant temperature reduces further. This decrease in temperature may sometimes lead to formation of ice, in such case the humidity sensor is programmed accordingly and displays this situation in the LCD display device. These devices are connected to an Arduino Nano microcontroller.

When the coolant passes through the copper coils and finally comes out, there is a decrease in volume which causes the temperature to increase. This rise in temperature may affect the system. Hence this heat is removed using a heat exchanger condenser coil. The humidity sensor senses the humidity and temperature of the particular area, where the device is in operation and displays the values in the LCD. The Arduino Nano microcontroller is programmed according to the above requirement using IDE software. Finally the water is collected in a container placed below the entire system

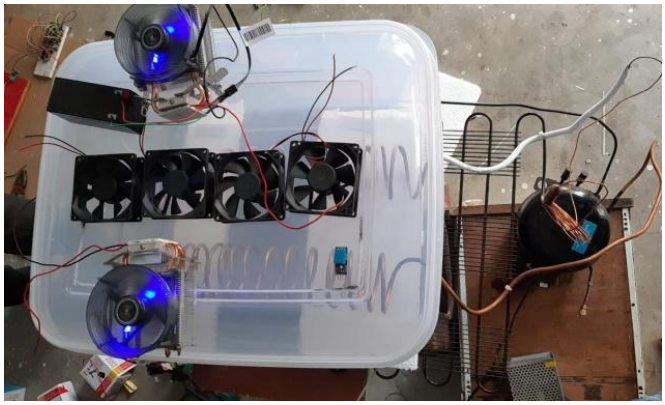

Figure 2: Prototype of thermoelectric dehumidifier based water generator

Figure 2 describes the hardware setup of thermoelectric dehumidifier based water generator. Here the Container is used to set all the devices into one casing. Copper tubes are placed at the bottom of the container. One end of the copper tube is connected to the strainer from which the coolant gas is passed. The other end of copper tube is connected back to the compressor. A pair of peltier modules are connected at the corners of the container which works on the principle of peltier effect. Heat exchanger is placed below the container and its ends are connected between compressor and strainer. Humidity sensor is fitted near the copper tube to sense humidity and temperature. At the top of the container, four coolant fans are attached to draw cooler air into the case from the outside, expel warm air from inside, and move air across a heat sink to cool a particular component.

Desalination plants are generally used to produce water suitable for both human consumption and irrigation purpose by desalinating salt water. Nearly, 16,000 desalination plants are either active or under construction across the globe. Desalination processes are either driven by thermal or electrical as primary energy types. That energy intensive process extracts salts from sea water and transforming it into water that fits for human consumption. Due to its energy consumption, desalinating sea water is usually more costly than fresh water from river or underground. It also produces more waste brine than expected. Brine is the concentrated salt water that’s left after desalination. It decreases the oxygen level in the water causing animals and plants to suffocate. The downside of desalination plant can also be harmful to human health as well. Water generation with the help of peltier devices will be capable of producing harmless water for human use. In past few years, some projects have

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already been done to establish the concept of air condensing as well as generation of water with the help of peltier devices. So this will help to extend the application of such devices in near future.

IV. EXPERIMENTAL RESULTS

The developed prototype is checked by performing the experiment to generate water using the air around the system. Initially the prototype is checked for any short circuit and it is switched ON. The coolant gas is made to pass through the copper tubes from compressor. Then the testing is done to check, whether the ice formation due to over cooling is formed or not. If yes, the power supply is turned off by the relay logic module. The ice formation, temperature and humidity values are detected by the sensor and are displayed.

Temperature and humidity are the key variables that influence the rate of water production. The tests were carried out from March 2021 to April 2021. The tests were carried out by maintaining the voltage level as 15V throughout the experiment. Inlet airflow rates are adjusted by a fan, and a humidity level is controlled by a humidifier, were experimentally investigated. Temperature sensors were used to measure temperatures of air and surface. The generated water was weighed manually once half an hour by an electronic balance. Figure 3 shows the relative humidity variation with temperature. From the figure, it is observed that when temperature increases, relative humidity decreases thus the air is becoming drier.

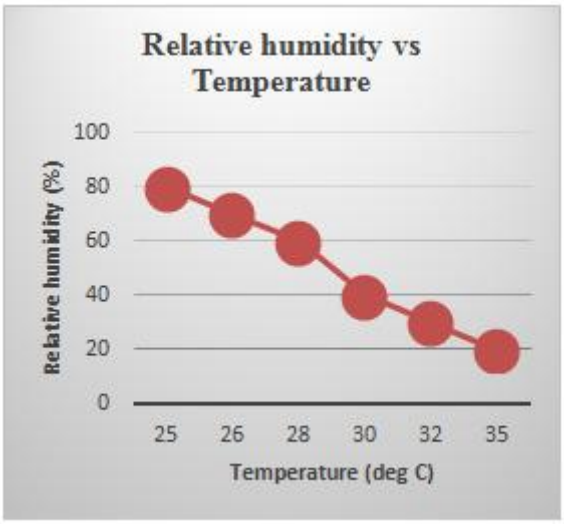

Figure 3: Relative humidity vs Temperature plot

Figure 4 shows the water content generation variation with Relative humidity. It is observed that the generation of water level is increasing, when the humidity level is increasing due to peltier effect.

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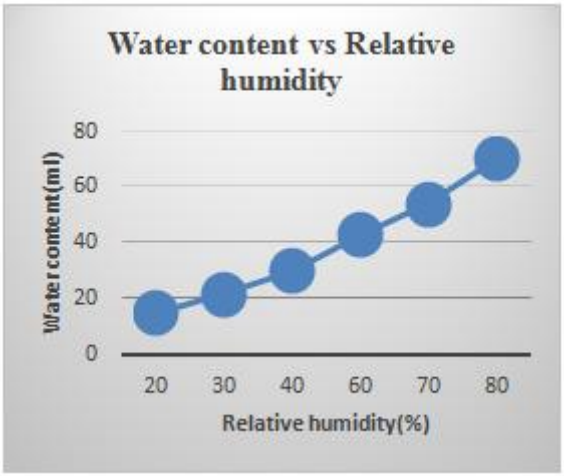

Figure 4: Water content vs. Relative humidity plot

V. CONCLUSION

Applying this system in a highly humid region almost 1 litre of condensed water can be produced per hour during the day light. The system can be designed that encounters higher power solar cells and can also store excess energy during the day light which can be used at night. The heat produced in solar panels can be used in a fruitful and utilizable way. Multiple number of peltier device can be involved to increase water production. Thus we conclude that this water generation system is one that is intended to meet the circumstances where the water turns into the emergency.

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