Design of Peltier Operated Dehumidifier

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Abstract - *Humidification and dehumidification of air (air conditioning) is mainly concerned with the following variables of human comfort, relative humidity, temperature and air quality. Evaporative coolers and air conditioner are expensive and to a great extent are insufficient in humid condition. In addition to that they have adverse impact on our environment. As the debate on climate change is expanding day by day. So, it is the need of an hour to find an efficient and eco-friendly way of air conditioning. Here the aim is to develop an peltier operated dehumidifier to achieve the dehumidification and sensible Cooling. The design is mainly for testing the performance of peltier for household indoor cooling application. The design is expected to provide a good alternative to air conditioners which consume high power and has quite high initial cost.*

Key Words: Peltier, Heat sink, Air conditioner, Dehumidifiers, Evaporator cooler.

1. INTRODUCTION

Everybody in his life wants comfort. Comfort of different types like physical, mental comfort. Like this there is another known as thermal comfort which is the condition in which the mind expresses satisfaction with the thermal environment (temperature, moisture). The main goal of air conditioning is to maintain this standard of thermal condition (T=25°C, relative humidity=50%) for the people of household. The two main variables that are taken into consideration while evaluating thermal comfort are ambient temperature and relative humidity. The range of relative humidity for comfort condition may vary from 45 to 55%.

Normally we can use ceiling or table fan when we feel hot in summer which is an affordable option to get rid of the discomfort caused by the temperature rise in summer, but this becomes ineffective as the temperature rises. As the temperature increase the temperature of the blades as wells as atmospheric temperature increases causing it to blow hot air. There are Many safety concerns present with respect to table fan that's why it has safety rings for protection and as the blade attracts the dust causing it to blow impure air.

Along with this we have different alternatives available which can help in summer like air conditioners, Evaporative coolers which can help to attain the comfort condition but are expensive, ineffective in humid condition and hazardous to environment. So, to overcome all these drawbacks we made an attempt to build a dehumidification system which will help us to achieve thermal comfort. This dehumidifier will reduce air temperature and help to regulate relative humidity.

In this we are using a peltier Module in place of coolant, along with peltier the other main components are dc fans, heat sink. The Peltier Module works on principle of peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction.This project aims inexpensive, reliable and provide an eco-friendly way to deal with hot summer. This project focuses on providing thermal comfort at minimal cost.

2. LITERATURE REVIEW

[1]Kadhim K. Idan Al-Chlaihawi (An Experimental and Theoretical Study of Forced Convection from a Peltier Thermoelectric Cooling):In this paper an experimental study of heat transfer through thermoelectric cooling system is presented. An experimentation was conducted for evaluating the performance of a thermoelectric module fitted to a sunflower heat sink with a similar sized heat source. The experimental investigation was done for evaluation of the effects of various performance parameters such as TE input voltage, flow rates of cooling air and heat source(heating element) Power input on the performance of a TE cooling system. In this experimentation they used Four low heating load (1.7, 2.4, 3.6 and 5 W) and fitted their hot sides to a sunflower type heat sink having forced convection. The results showed that the system performance improves with increasing air flow

rates, while increasing in applied TE voltage leads to deterioration of system performance. The obtained COP_{max} is about 4.7 at 2V TE voltages and 5W heating load, then decreased sharply with further increment in voltage and reaches 0.13 at 12V. The results of the current study shows that all Thermoelectric Cooling system attains higher temperatures with increase in heating load at a constant TE voltage and air flow rate. It was also found out that the T_c decreases and T_h increases with the increase in the input voltage and which can ultimately cause rise in the air temperature passing over heat sink. TE performance is highly depends upon the air flow rate. The theoretical results were validated experimentally, and shows an acceptable agreement between them.

Conclusion: The research paper presents an experimental study of heat transfer through thermoelectric cooling system. In this they evaluated the performance of a thermoelectric module fitted with sun flower heat sink and similar sized heat source against various parameters. From this research paper we got the idea about various parameters of TE module which greatly affects the performance of TE system i.e. TE input voltage, cooling air flow rate, etc. In addition to that, we learnt about the effects on the TE system due to variation in these parameters.

[2]Wang Huajun (Experimental study of operation performance of a low power thermoelectric cooling dehumidifier) :The present work was performed to review the performance of thermoelectric technology to a low power dehumidifying device as possible substitute to the traditional vapor-compression refrigeration systems. The experimental small scale prototype of thermoelectric dehumidifier (TED) with rectangular cooling fins was built and its performance was studied experimentally. The results showed that the thermoelectric Device experienced two typical thermodynamic processes which includes the cooling dehumidification and also the isothermal dehumidification, which was latter dominated. It was also found that there existed a peak during the variation of the average coefficient of performance (COP) as a function of the input power of the thermoelectric module. Under the experimental conditions, the COP of the TED reached the maximum of 0.32 and therefore, the corresponding dehumidifyingratewas0.0097g/min, at input power rating of 6W.Thequickeliminationofcondensed liquid-drops on the cooling fins amounted on the thermoelectric module may be a major approach for improving the operation performance of the TED.

Conclusion: The purpose of this experimentation was to test the operation performance of the TED, and to obtain the relationship between input power and the COP of TE module, which will be beneficial for the optimal design of similar TEDs. This paper compares the variations of COP under different input powers of the thermoelectric module. From the results it can be seen that during initial stage the COP of TED increases quickly, then keeps a slowly increasing tendency upto reaching the maximum level, and finally drops quickly. From this paper, we have understood the variation in COP behavior with change in the input power and found out that there is a great necessity of effective elimination of condensed liquid-drops on the cold-side fins for performance improvement.

3. AIM AND OBJECTIVE

Objective: To provide air at the comfort Humidity conditions.

Aim: Design of a Peltier operated portable dehumidifying apparatus.

4. DESIGN LAYOUT, COMPONENTS AND CALCULATIONS

The dehumidifier involves reduction of moisture content in air, and makes air comfortable. Air of high humidity enters the dehumidifier where the humidity in the air is extracted till it become friendly with the human body. The surrounding air is firstly brought inside the chamber. The chamber is equipped with the peltier module, metal plate and container of water storage. When we supply electricity to peltier module two junctions are created. First one is cold junction to which metal plate(or heatsink) is connected, and second one is hot junction to whoch another heat sink is connected for heat dissipation. When the air comes in contact with metal plate its temperature falls below Dew Point Temperature [DPT]. It leaves droplets on metal plate and air becomes dehumidified. Then air passes through filter and release to surrounding. Water droplets are stored into container As shown in fig.1.

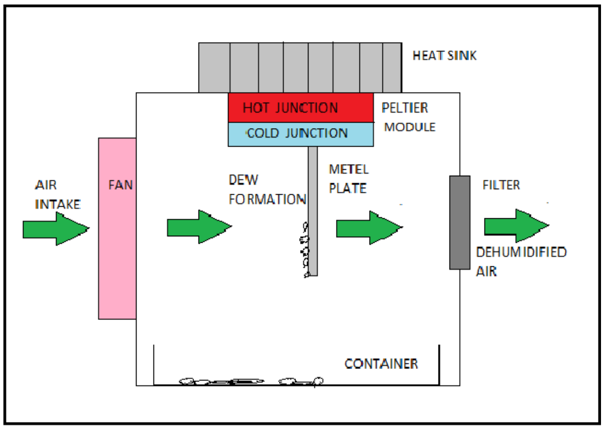

Fig -1: Dehumidifier Apparatus Diagram

4.1. Components of Dehumidification Appartus

1. Cooling Fan-It is used to suck ambient air into apparatus.

2. Peltier Module–It is a 12V DC device used to cool the air from its cold side.

3. Heat Sink–It is used to dissipate the heat from the hot side.

4. Water Storage –It is used for collecting moisture content extracted from moist air.

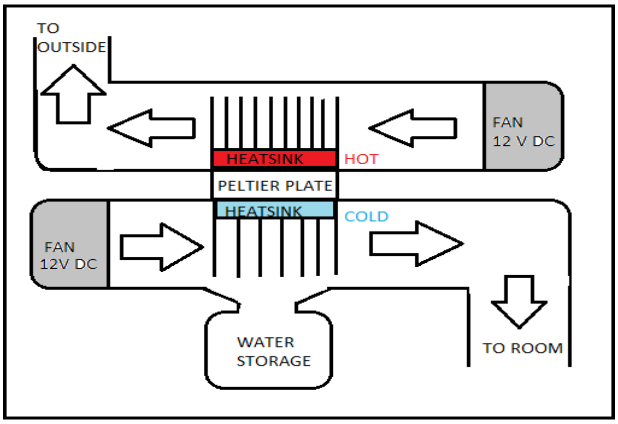

Fig -2: Construction of Apparatus

4.2. Design Procedure

Here we are considering the high humidity atmosphere example like Mumbai. In summer ambient temperature of Mumbai is about 35 °C according to the weather reports. Our objective is to provide air at comfort humidity condition i.e. 25 °C, 50%RH.

With the help of psychrometric chart the thermodynamic process is shown in Chart-1.

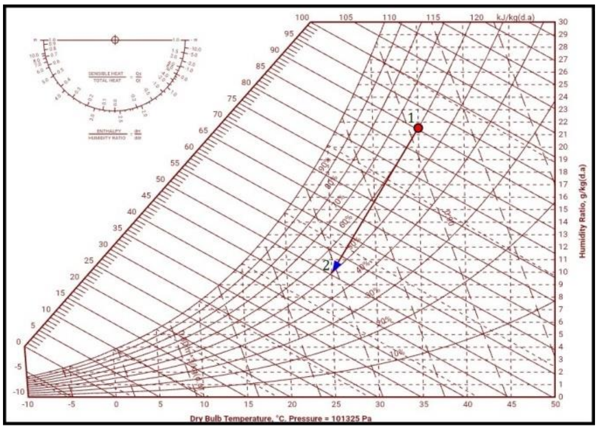

Chart -1: Psychrometric Chart

Table-1 shows the initial condition and required final condition of air. Values of various properties of moist air are found out using standard psychrometric charts.

Sr. No.	Moist Air Properties (symbol, unit)	Initial Condition (1)	Final Condition (2)
1	Dry Bulb Tempreture (DBT,°C)	35	25
2	Relative Humidity(ϕ, %)	60	50
3	Dew Point Tempreture (DPT,°C)	26	14
4	Enthalpy (h, kJ/kg)	90	50
5	Humidity Ratio (ω, kg/kg d.a.)	0.021	0.010

Table -1: Properties of Moist Air

To achieve the required condition, the air has to release some amount of energy in the form of heat. Using psychrometric chart, we can calculate the heat that needs to be extracted from the air as follows:

1. Heat Load Calculations:

For calculation Considering a room of dimensions:
Length=12ft, Breadth=18ft,Height=12ft

Rooms volume=12×18×12
=2592 Cu.Ft
CFM=Cu. Ft per minute;
K=Air exchange rate per minute

CFM Requirement=2592×K
=2592× (3/60)
=129.6 CFM
=3.6456m^3/s
=4.17 Kg/min
=0.07 kg/s

So, Mass Flow Rate[ṁ] =0.07 kg/s
Q=ṁ×(h_1-h_2).....(Q to be extracted from air)
So, Q=0.07×(90-50)=2.8 Kw

Due to the low temperature at cold side of peltier module, air coming in contact with the peltier looses its moisture content in the form of dew on peltier cold junction.

Mass condensed on peltier cold side,
$M_{condensed}$ =ṁ×(ω_1-ω_2)....(due to Tempreture drop)

$M_{condensed}$ =0.07×(0.021-0.010)
=0.00077kg/s
=0.77 gm/s

2. Units Of Peltier Module Required:

The Heat Sink and cooling fan are used for absorbing as well as dissipating the heat. Dissipation of heat is required so that peltier could work properly. We have taken Peltier TEC1-12730 as a sample peltier. It is seen from manufactures data that peltier can perform efficiently when ΔT ($\Delta T = T_{hot\ side} - T_{cold\ side}$) takes smaller value. Taking this into consideration assuming ΔT=20(To be maintained during operation) and proceeding further.

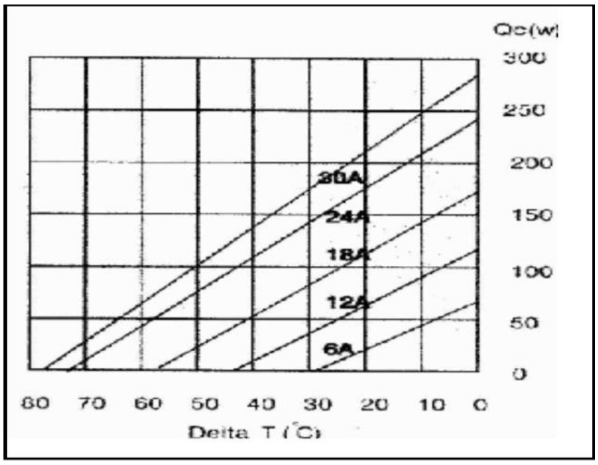

Chart -2: Q_c vs ΔT Graph (Manufacturers Data)

For ΔT=20 and current (I)=30 A
Q_c= 220W......[from manufacturer data(CHART-2)]
This means a single Peltier Module[TEC1-12730] can give the maximum cooling effect of magnitude 220W.

So, Number of Peltiers Required= 2800/220
=12.72 ≈13

5. CONCLUSION

1. The Peltier Module[TEC1-12730] can give the cooling effect of 220W at ΔT=20 and I=30 A Theoretically.
2. A minimum 13 units of TEC1-12730 should be required in order to fulfill cooling requirement of 2.8 Kw .

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