Desiccant Air Conditioner Using PELTIER Plate

Chetan Khairnar[1], Kumar Karale[2], Abhinav Gund[3], Prof. N. A. Doifode[4]

[1]*BE Mechanical, Department of Mechanical Engineering, BSCOER narhe* ***chetandk21@gmail.com***
[2] *BE Mechanical, Department of Mechanical Engineering, BSCOER narhe,* ***karalekumar07@gmail.com***
[3] *BE Mechanical, Department of Mechanical Engineering, BSCOER narhe,* ***gundabhinav99@gmail.com***
[4]*Asst. Prof., Department of mechanical engineering, SKNCOE pune,* ***pnitindoifodegmail.com***

ABSTRACT

Now a day's air conditioning is one of the major aspect of our society. While using conventional air conditioning system there is lots of energy consumption because of the compressor. Also conventional air conditioning system uses refrigerant which causes harm to the environment. Our motive to introduce this system is to provide alternative to conventional air conditioning system which mainly runs on vapour compression cycle requiring compressor, evaporator and other auxiliaries. This system runs mainly on two components which are newly introduced into the air conditioning system that are peltier plate and desiccant wheel. In this research work the idea is to build an alternative for air conditioning and to provide air conditioning effect without using the compressor. By using this system we can reduce energy consumption up to certain extend and provide comfortable air conditions for human working. This system does not use any kind of refrigerant so that it will not cause any harm to the environment

Keywords: ***Peltier plate, Desiccant wheel***

---

1. INTRODUCTION

An air conditioning is defined as the process of conditioning the air for the simultaneous control of indoor air within the acceptable limits. Air-conditioning has been attained reliably and efficiently from the last few years due to the popularity gained by vapour compression system as a result of hydrocarbon discovery. Nearly all air - conditioning systems in use are built around vapour compression systems driven by electricity. A conventional air conditioner consumes large amount of electrical energy especially in hot and humid climatic conditions because of high latent load which is decide by the outside contents. Desiccant wheel based hybrid air conditioning system is one of the promising alternative to handle the high latent load efficiently where sensible and latent heat of air are separately removed. Desiccant wheel consist of dehumidifying the incoming air steam by forcing it through a desiccant material and then draying the air to the desire indoor temp to make the system working continuously, water vapour absorb must be driven out of the desiccant material (regeneration) so that it can be dried enough to absorb water vapour in the next cycle. This is done by heating the material desiccant to its temp. of regeneration which is dependent upon the nature of desiccant.

A normal thermoelectric module consists of an array of semiconductor pellets that have been "doped" so that one types of charge carrier– either positive or negative–carries the majority of current. The pairs of P/N pellets are configured so that they are connected electrically in series, but thermally in parallel. Metalized ceramic substrates provide the platform for the pellets and the small conductive tabs that connect them. When DC voltage is applied to the peltier module, the positive and negative charge carriers in the pellet array absorb heat energy from one substrate surface and release it to the substrate at the opposite side. The surface where heat energy is absorbed becomes cold; the opposite surface where heat energy is released becomes hot. Reversing the polarity will result in reversed hot and cold sides. The word air-conditioning is used in this paper it refers to dehumidification and cooling

2. BASIC PRINCIPLE AND WORKING

This system mainly works on two principles that are desiccant dehumidification and peltier effect. For many industrial and domestic applications, dry air is produced by using solid desiccant. This desiccant can be used

once or many times. When it is used once, there is wastage of desiccant. For using it again, it is regenerated by using conventional heater which consumes high grade energy. In this system conventional heater is replace by peltier plate, hot side of peltier plate will perform the function of conventional heater. This process saves lot of energy. Various solid desiccants like silica gel, activated charcoal, activated alumina and zeolite etc. can be regenerated at low temperature by using minimum energy, temperature required for regeneration of desiccant wheel is depended on the desiccant materials which were being used for the regeneration

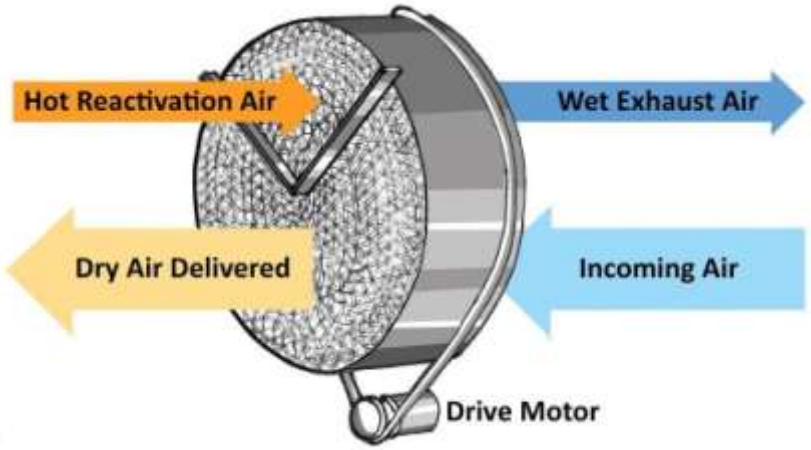

Fig-1: Desiccant wheel assembly

Silica gel was one of the most extensively investigated and promising solid desiccant material which required a regeneration temperature of about 65℃. In this system desiccant material use for regeneration is silica gel; Silica gel is a granular, vitreous, porous form of silicon dioxide made synthetically from sodium silicate. Silica gel contains a nano-porous silica micro-structure, suspended inside of a liquid. Most applications of silica gel require it to be dried, in which case it is called silica aerogel.

To design a cooling system using thermoelectric module (TEC) one has to know the basics of thermoelectric effect, thermoelectric materials and thermoelectric cooling. Thermoelectric effect can be defined as the direct conversion of electric voltage to temperature difference and vice versa. Thermoelectric effect mainly covers three different identified effects namely, the See back effect, Peltier effect and the Thomson effect, Thomas Seebeck and Jean Peltier, first discovered the phenomena that are the basis for today's thermoelectric industry.

Seebeck found that if you placed a temperature gradient across the junctions of two dissimilar conductors, electrical current would flow. Peltier on the other hand, learned that passing current through two dissimilar electrical conductors, Caused heat to be either emitted or absorbed at the junction of the materials. It was only after mid-20th Century advancements in Semiconductor technology, however, that practical applications for thermoelectric devices became feasible. With modern techniques, we can now produce thermoelectric "modules" that deliver efficient solid state heat-pumping for both cooling and heating so peltier plate is one of the applications of peltier effect which absorb energy from one side of plate and reject it to other side

Once it is decided that thermoelectric cooler is to be considered for cooling system, the next step is to select the thermoelectric module or cooler that can satisfy a particular set of requirements. Modules are available in great variety of sizes, shapes, operating currents, operating voltages and ranges of heat pumping capacity. If the object to be cooled is in direct contact with the cold surface of the TEC, the required temperature can be considered the temperature of the cold side of TEC. Here in this system the object is air, which has to be cooled when passed through a cluster of Aluminum heat sinks. The aim is to cool the air flowing through the heat sinks. When this type of system is employed the cold side temperature of the TEC is needed to be several time colder than the ultimate desired temperature of the air.

 ISSN: 2321-8169
949 – 953

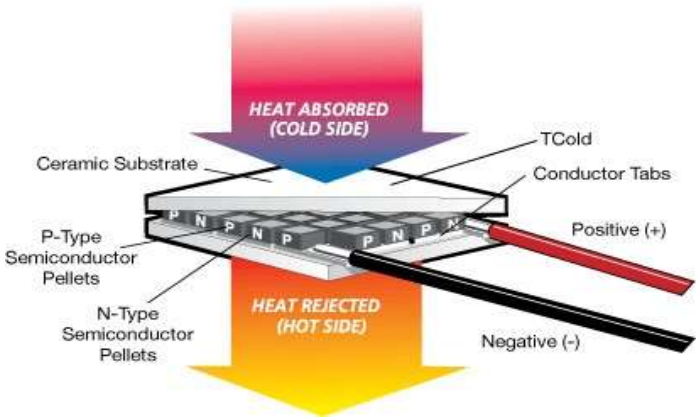

Fig-2: Peltier Plate

3. METHODOLOGY OF DESIGN

During summer season we require cool and dry air and for winter condition we require humidified hot air for human comfort. For fulfilling this requirement we require hot air and cold air systems. In this project we are integrating these systems by using peltier effect. In this system we charge the battery by solar energy and use this energy to operate Peltier plate, Peltier plate produces two different temperatures at both ends, one side is cold and other is hot. The air which is passes through desiccant wheel is further passes over cold side of peltier plate and gives dry and dehumidified air at the other end of duct, on the other hand air passes over hot side of peltier plate becomes hot by absorbing the heat of plate and further passes through desiccant wheel and regenerating the material. Hot side is used to remove the moisture from desiccant wheel which is absorbed during dehumidifying process. Cold side is used to cool the air by passing over it. This will decrease air temperature and specific humidity.

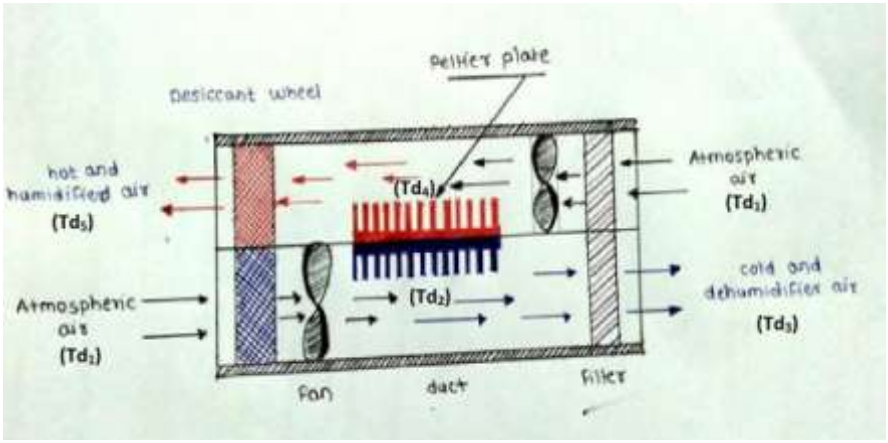

Fig-3: Schematic Diagram of System

1. DC power supply is given to the system by means of AC to DC convertor
2. Desiccant wheel is placed at front of system duct; ambient air will pass through lower passage of wheel. Silica gel which is used in wheel will adsorbed moisture from air and makes dry and reduced relative humidity of ambient air.
3. This dry air is move toward cooling unit. In cooling unit air get cool with the help of peltier plate using peltier effect.
4. In cooling unit temperature of air is reduced; this cold air is move toward filter.
5. After passing air from filter we obtain cold, clean and dry air.
6. We used hot side of peltier plate for heating the air in upper compartment.
7. Desiccant wheel is rotate at very slow speed, so that adsorbed side of wheel is move toward upper compartment.

8. For regenerating purpose we required heat so we pass the hot air through desiccant wheel.
9. At outer side of the desiccant wheel, we obtain hot humidified air.

3. COOLING CAPACITY

Readings are taken on three different days in the month of March and April these are as follows

Temperature (0C)	Day 1	Day 2	Day 3
Td^1	35	38	34
Td^2	12	12	11
Td^3	30	32	29
Td^4	51	52	50
Td^5	40	42	41

Table-1: Temperature readings

We can calculate bypass factor using following relations between temperatures
Bypass factor = (td3 –td2)/ (td1-td2)
0.7 = (30– 12)/ (35 – 12) Bypass
factor = 0.7

We can obtain temperature difference between hot side and cold side upto $10\text{-}12^0$C
We can find total heat transfer by separately calculating heat transfer during dehumidification process and heat transfer during cooling process

firstly calculate heat transfer during cooling process
Sensible heat transfer (SHT)
SH = (1.2264 V ×Δt)/60
SH = 12.8772 KW

Now calculate heat transfer during dehumidification process
Latent heat transfer (LHT)
LH = 50V × (Δw) KW
LH = 1.03425 KW

Total heat transfer (remove) from air during cooling & dehumidification q total =
LH + SH
q total = 1.03425 + 21.4620 q total =
13.9114 KW

The most important factor to be accurately calculated for this system is the amount of heat to be removed or absorbed by the cold side of the TEC. In this system cooling capacity *w*as calculated by finding the product of mass flow rate of air, specific heat of air and temperature difference. Here the temperature difference is the the difference between the inlet temperature and outlet temperatures of the cooling system. The mathematical equation for cooling capacity is as shown below.

Cooling capacity
Q = ma × Cp × (td1 – td2) KJ/min
Q = 13.09 KJ/min
Q = 0.2181 KW

4. CONCLUSION

By using this air-conditioning system we can get the cooling effect without help of compressor, but peltier module must be operate with a sufficient heat rejection from the hot side which is beneficial for regeneration also. With the help of this system we can say that this type of system gives the cooling effect up to 29^0C. This system is work well in warm sunny days and analysis shows that this system will be significantly more economical to own and operate then the conventional AC. In spite of a slightly higher initial cost, this system proves to be more economical, mainly due to its significantly lower operating cost. Because of desiccant wheel load get completely separated there by performance of system improve by certain level as performance of air conditioning is significantly governed by latent load. It can be good option when the humidity level is high.

REFERENCES

[1] Yadav, S. Singh, G. Gupta, "Solar Air-Conditioning: Design for a Compressor-Less System using Peltier Effect", International Journal of Advance Research and Innovation Volume 2, Issue 2 (2014) 429-432, January 2014.

[2] R. Atta, "Solar Water Condensation Using Thermoelectric Coolers", International Journal of Water Resources and Arid Environments 1(2): 142-145, July 2011.

[3] U. Kongre, A. Deshmukh, A. Mirashe, "Design of Solar Desiccant Air Conditioner", International Journal of Innovative Research in Science, Engineering and Technology An ISO 3297: 2007 Certified Organization, Volume 3, Issue 3, March 2014.

[4] Tiwari, "Design and Fabrication of Desiccant Wheel Dehumidifier", International Journal of Advance Research in Mechanical Engineering & Technology (IJARMET), Volume 1, Issue 1 (April – June 2015).