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Design of Thermoelectric Air Cooler: A Review

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Abstract-
The impact of ongoing progress in Science and Technology has created variety of systems that can be used in producing of refrigeration effect with the use of thermoelectric module and photovoltaic module for generation of energy in which we further use for cooling and heating effect. The most important utilization of this portable air cooler is for to deliver cold air. A Thermoelectric module (Peltier Module) is used instead of refrigeration system (VCC or VAC cycle). The most important utilization of this air cooler is for to deliver cold air. A Thermoelectric module (TEM) is used as it is based on the principles of Peltier effect. The use ofPeltier effect is to create heating side and cooling side and also to maintain effectiveness.
Thermoelectric Air cooler (TEAC) is a solid state heat pump in which uses the components that are available commercially. The thermoelectric refrigerator does not produce chlorofluorocarbon (CFC). It is pollutant free-contains no liquids or gases, portable, compact, creates no vibration or noise because of the difference in the mechanics of the system. It is a prototype and its semiconductor materials, by Peltier effect, to provide instantaneous cooling or heating. It has the advantage of having no moving parts and thus maintenance free.
Keywords- Thermoelectric*Module (Peltier Module), Thermoelectric Air cooler.*

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I. Introduction

The present Air Conditioning system produces cooling effect by refrigerants like Freon & Ammonia. Using of theserefrigerants can get maximum output but one of major disadvantages is harmful gas emission and global warming.

Problems like global warming can be overcome by using Thermoelectric Module (Peltier effect) air conditioner and by protectingenvironment clean.this paper deals with the study and working of Thermoelectric air conditioner by using different modules is discussed.

Advantages of Thermoelectric cooling systems are over the conventional cooling devices, such as compact size, light in weight, high reliability, there is no such mechanical moving parts and no working fluid.

Thermoelectric cooling system, commonly refers to cooling technology using thermoelectric coolers (TECs), has advantages of high reliability, no mechanical moving parts, compact in size and light in weight, and no working fluid. In addition, it possesses advantage that it can be powered by direct current (DC) electric sources, When a voltage or DC current is applied on two dissimilar conductors, circuit can be created that allows continuous heat transfer between the conductors junctions this is the principle of thermoelectric air-condition. air-conditioning is the process that removesheat from room or other appliances. Many ways of producing a cooling effect like vapour compression and vapour absorption air conditioning. These air conditioners are produces cooling effect by using the refrigerants like Freon and ammonia.

It gives maximum appropriable output butone ofthe disadvantage is producing harmful gases to the atmosphere during working condition. The harmful gases likecluro-flurocarbonand some other.

These air conditioners have wide range of applications in domestic as well as in commercial. Airconditioner is the major used home appliance,system or a mechanism to change the air temperature and humidity within asurrounding area. cooling is done by using simple refrigeration cycle, but sometimes evaporation is used in that, commonly for comfort cooling in buildings and motor vehicles. Normally we are used in the vapour compression air condition system(VCC), it has many moving parts and as well as produce harmful gases to the environment. By using thermoelectric modules air conditioners we can regrate the existing air conditioning system by modifying it to protect the environment.A conventional cooling system may contains three fundamental parts in the system
i)evaporator ii)compressor and iii)condenser.

Theevaporator is a part where the pressurized refrigerant is allowed to expand, boil. Duringthis change of state from liquid to gas, energy (ie. heat) is absorbed. The compressor acts as a refrigerant pump andrecompresses gas to liquid. The condenser expel the heat absorbed in the evaporator and the heat produced during compression, into the environment.

A thermoelectric has analogous parts. At cold junction heat isabsorbed by electrons as they passes from low energy level in p-type of semi-conductor element, to higher energy level in the n-type of semi-conductor element. Power supply provideenergy to move the electrons in the system.

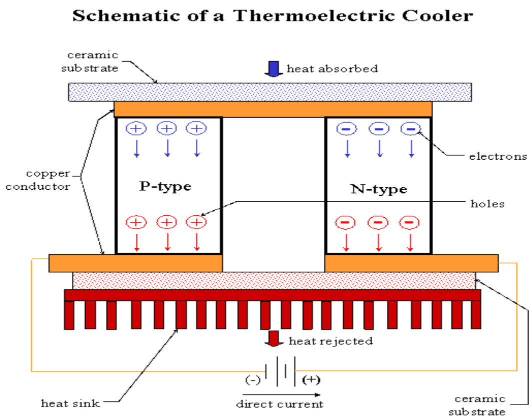
At hot junction part,heat is expelled to the heat sink as electrons move from a high energy level element (n-type) to the lower energy level element (p-type).

Components of Ac Air Cooler-

a) Thermoelectric peltier Module.
b) Cooling fan.
c) Heat sink cooling side & hot side.
d) Thermal interface material.
e) Power Bank.
f) SMPS.
g) Air cooler model
h) Thermostat

a) Thermoelectric Module.

Thermoelectric coolers operate according to the Peltier effect. That effect creates temperature differencebetween two electrical junctions by transferring heat. Voltage is applied acrossconnected conductors forcreating an electric current and heat is deposited at the other junction.



Thermocouple Working Principle.

The thermocouple principle is depend on beloweffects ie.Seebeck, Peltier, and Thompson.

See beck-effect.

This type of effect occurs in two dissimilar metals. When the heat is offer to any one of the metal wire, then electron flows from hot metal wire to cold metal wire. Therefore, direct current stimulates the circuit.

Peltier-effect.

Peltier effect is vice versa to the Seebeck effect. This effect states that the difference of the temperature can be formed with any two dissimilar conductors by applying the potential variation between them.

Thompson-effect

Thompson effect states that the two disparate metals fix together and if they form two joints then the voltage induces total conductors length due to the temperature gradient. it demonstrates the change in rate and direction of temperature at an exact position.

b) Cooling fan (Forced Induction).

To increase effectiveness of system forced induction system is better than natural induction so that use 12v and 5 Amp cooling are used.

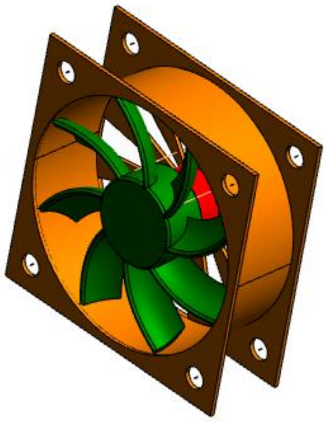


Fig 2. Cooling Fan 12v ,5Amp

c) Heat Sink-
It is aluminium/copper block which used to transfer heat from one source to another.
It is also known as mechanical heat transfer device in that conduction form of heat transfer.

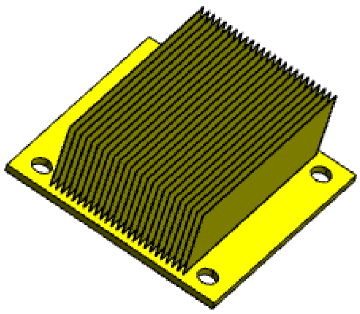


Fig 3 Heat sink

d)Thermal interface material.
Thermal paste is the chemical compound that is thermally conduct.two surfaces are not in full contact due to those imperfections, thermal paste fills in those air gaps, allowing for a more efficient transfer of heat.

e)Power Bank.
It is a power source used to operate a system in which input power comes from main switch of air cooler.

f) SMPS.
It stands for switch mode power supply.
It is used for switching regulator to change the electrical power from one form tothe another form.
A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state

Fig 4. SMPS

g) Air cooler model.

It is actual air cooler model where we attach our designed peltier module which gives cold effect through cold site that help to cool inside water when cooler fan start rotating because of cold water indirectly outcome air is in cold condition that cold air gives comfortable environment for human being.

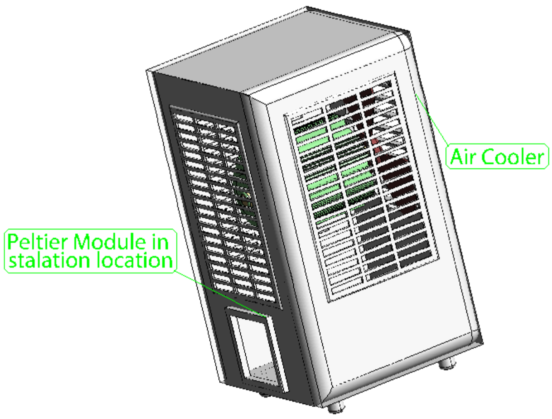


Fig 5 Ac Cooler module

h) Thermostat.

Thermostat is the device used for controlling heating and cooling systems. It consists of a circuit controlled by temperature sensitive device and connected to the system. It shows the output temp. of that system.

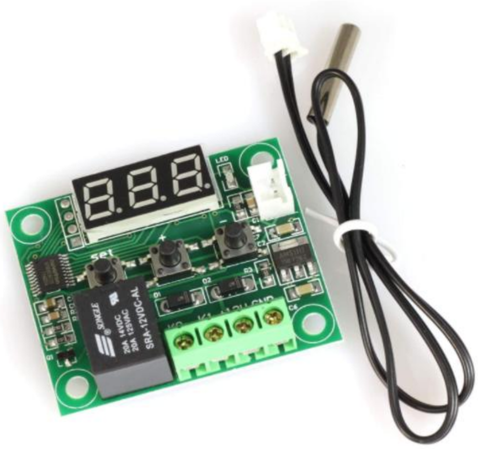


Fig 6 Thermostat.

CAD Module of Peltier-

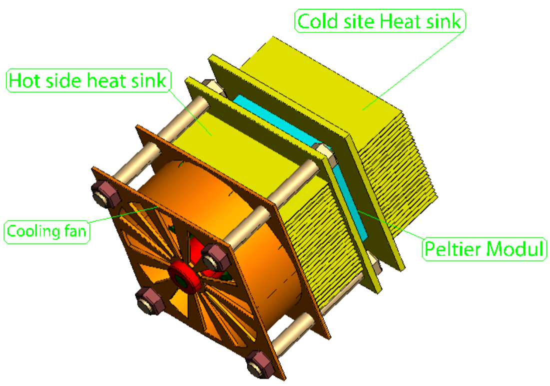


Fig 7 Peltier module kit

Mathematical Module of Peltier module –
Assumptions:
1. No energy (heat) loss takes place from or to the system.
2. Thermo physical properties such as Resistivity, conductivity etcdo not change with temperature.
3. Heat transfer takes place only through the P type and N type semiconductor.
4. When current is passed through the dissimilar material, heat is absorbed or liberated at the junction. This phenomenon is known as Peltier Effect.

The various equations are used for calculate the parameters under the study are as given below.

Coolingandheatingduetothethermoelectriceffect (peltier effect) isgivenby

$$Qc=\alpha IT_c$$
$$Qc=\alpha IT_h$$

Forthecoldjunction:
Q_c+ 0.5 I^2R+ $(T_h-T_C)=\alpha IT_C$
Forthehotjunction:
$Qh+(T_h-T_c)=\alpha IT_h+0.5I^2R$

ThusthethermoelectricCoolingis
$Q_c= \alpha IT_c - 0.5I^2R - K(T_h-T_c)$

Andheatingis
$Q_h=\alpha IT_h+0.5I^2R-(T_h-T_c)$

Nowenergyinputtosystemfromoutside area, asperfirstlawofthermodynamics,is givenby
$\oint \eth Q=Qnet=-Q_h-Q_c$
$=(T_h-Tc)+I^2R$
Negativesignindicatesthatenergysuppliedtosystem.

Now,$(COP)=Q_c$/Energy Supplied

$Q_c= \alpha IT_c- 0.5I^2R- U(T_h-T_c)$
$P=(T_h-Tc)+I^2R$

Similarly$(COP)_h=Q_h$/ Energy Supplied

$Q_h=\alpha IT_h+0.5I^2R-(T_h-T_c)$
$P=(T_h-Tc)+I^2R$

THERMOELECRIC MATERIAL

Common Thermoelctric Material is used in different applications are Bismuth sulphide (Bi2S3), LeadTelluride(PbTe), Antimony Telluride(Sb2Te3), Germanium Telluride(GeTe), CesiumSulfide (CeS), Bismuth Telluride(Bi2Te3), and The seeback coefficient for different materials are given in table 1.

Table1:SeebackCoefficientfor Different Material

Material	$\alpha(K^{-1})$
GermaniumTelluride	1.5×10^{-3}
CesiumSulfide	1×10^{-3}
BismuthTelluride	41×0^{-8}
LeadTelluride	1.5×10^{-3}

PROPOSED WORK

The aim of project is to investigate experimentally and numerically for the COP of the “thermoelectric airconditioner usingPeltierModule”. Thedetailsofthe experimentsetupareasbelow.

S.No	Description	Dimension/Range
1	PeltierModule	40×40×40mm
2	AluminumBlock	320×6.5×3.8cm
4	RectangularFin	68×35 cm
5	FiberSheet	470×36cm
6	K-TypeThermocouplewithIndicator	0-1000^{0}c
7	Multimeter	350V ac
8	VariableSpeedTransformer	230 Dc

The Parameter varied during the Experimentation are Voltage and Current. The temperatures at various locationsof the Modules are measured with the help of calibrated K Type thermocouples. Heat input is supplied by the use ofdimmer stat.

II. Conclusions

The literature regarding the investigation of Thermoelectric air conditioner using different modules has been thoroughly reviewed .From the review of the pertinent literature presented above, it can be inferred that thermoelectric technology using different modules used for cooling as well as heating application has considerable attention. Many researchers try to improve the COP of the thermoelectric air-conditioner using different material. Thermoelectric coolers to be practical and competitive with more traditional forms of technology, the thermoelectric devices must reach a comparable level of efficiency at converting between thermal and electric energy.

NOMENCLATURE

Q Heat flow per unit time(T), heat power W.
COP Coefficientofperformance
I Electriccurrent(A)
QhPeltier pellet hot side heat flow (W)
QC Peltier pellet cold side heat flow (W)
P Electric power supplied
R Thermalresistance(K/W)
V Voltage to the thermoelectric module (volt)
αSeeback coefficient (v^0 c-^{1})
ΔT Temperature difference of cold and the hot side T_h Hot side temperature (K)
T_CCold side temperature(K)
T_SAmbienttemperature(K)
K Totalthermalconductance(w^o c^{-1})

COPcCoeff.ofperformanceofThermoelectriccoolingsystem

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