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REVIEW PAPER ON THERMOELECTRIC AIR-CONDITIONER USING PELTIER MODULES

BENZIGER B, ANU NAIR P & BALAKRISHNAN P

Department of Mechanical Engineering, Regional Centre Anna University: Tirunelveli Region

Tirunelveli, Tamil Nadu, India

ABSTRACT

The present air-conditioning system produces cooling effect by refrigerants like Freon, Ammonia, etc..Using these refrigerants can get maximum output but one of the major disadvantages is harmful gas emission and global warming. These problem can be overcome by using thermoelectric modules (Peltier effect) air-conditioner and their by protecting the environment.The present paper deals with the study of Thermoelectric air conditioner using different modules is discussed. Thermoelectric cooling systems have advantages over conventional cooling devices, such as compact in size, light in weight, high reliability, no mechanical moving parts and no working fluid .

KEYWORDS: Peltier Module, Thermoelectric Air Conditioner

INTRODUCTION

In thermoelectric materials, electrical energy can be directly converted into thermal energy and thermal energy into electrical energy. Direct conversion between electrical and thermal energy is possible because of two important thermoelectric effects: the Seebeck effect and the Peltier effect. The Seebeck effect refers to the existence of an electric potential across a thermoelectric material subject to a temperature gradient. The Peltier effect refers to the absorption of heat into one end of a thermoelectric material and the release of heat from the opposite end due to a current flow through the material.

Thermoelectric cooling, commonly referred to as 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 to two dissimilar conductors, a circuit can be created that allows for continuous heat transport between the conductors's junctions this is the principle of thermoelectric air-condition. Air conditioning is a process of removing heat from a room or other applications. Many ways of producing a cooling effect by like vapour compression and vapour absorption air condition. These air conditioners are producing cooling effect by using refrigerants like Freon and ammonia etc. It gives maximum output but, one of the disadvantage is producing harmful gases to the atmosphere. The harmful gases are cluro fluro carbon and some other gases are present.

These types of air conditioners have wide range of applications. An air conditioner is a major home appliance, system, or mechanism designed to change the air temperature and humidity within an area. The cooling is typically done using a simple refrigeration cycle, but sometimes evaporation is used, commonly for comfort cooling in buildings and motor vehicles. Normally we are used in the vapour compression air-condition system ,it has many moving parts and as well as produce harmful gases to the environment. By using thermoelectric modules air-conditioners we can overcome the existing air-conditioning system by modifying it to protect the environment.

A conventional cooling system contains three fundamental parts - the evaporator, compressor and condenser. The evaporator or cold section is the part where the pressurized refrigerant is allowed to expand, boil and evaporate. During this change of state from liquid to gas, energy (heat) is absorbed. The compressor acts as the refrigerant pump and recompresses the gas to a liquid. The condenser expels the heat absorbed in the evaporator plus the heat produced during compression, into the environment or ambient. A thermoelectric has analogous parts. At the cold junction, energy (heat) is absorbed by electrons 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. The power supply provides the energy to move the electrons through the system. At the hot junction, energy is expelled to a heat sink as electrons move from a high energy level element (n-type) to a lower energy level element (p-type).

LITERATURE REVIEW

Matthieu Cosnier et al[1] presented an experimental and numerical study of a thermoelectric air-cooling and air-heating system. They have reached a cooling power of 50W per module, with a COP between 1.5 and 2, by supplying an electrical intensity of 4A and maintaining the 5°C temperature difference between the hot and cold sides.

Suwit Jugsujinda et al[2] conducted a study on analyzing thermoelectric refrigerator performance. The refrigeration system of thermoelectric refrigerator (TER; 25 × 25 × 35 cm3) was fabricated by using a thermoelectric cooler (TEC; 4 × 4 cm2) and applied electrical power of 40 W. The TER was decreased from 30 ºC to 20 ºC for 1 hr and slowly decreasing temperature for 24 hrs. The maximum COP of TEC and TER were 3.0 and 0.65.

Wei He et al[3] Conducted did Numerical study of Theoretical and experimental investigation of a thermoelectric cooling and heating system driven by solar. In summer, the thermoelectric device works as a Peltier cooler when electrical power supplied by PV/T modules is applied on it. The minimum temperature 17 degree C is achieved, with COP of the thermoelectric device higher than 0.45.Then comparing simulation result and experimental data.

Riff and Guoquan [4]Conducted an experimental study of comparative investigation of thermoelectric air conditioners versus vapour compression and absorption air conditioners. Three types of domestic air conditioners are compared and compact air conditioner was fabricated.

Riffat and Qiu[5] compared performances of thermoelectric and conventional vapor compression air-conditioners. Results show that the actual COPs of vapor compression and thermoelectric air-conditioners are in the range of 2.6-3.0 and 0.38-0.45, respectively. However, thermoelectric air conditioners have several advantageous features compared to their vapor-compression counterparts.

Astrain, Vian & Domınguez[6] conducted an experimental investigation of the COP in the thermoelectric refrigeration by the optimization of heat dissipation. In thermoelectric refrigeration based on the principle of a thermo syphon with phase change is presented. In the experimental optimization phase, a prototype of thermo syphon with a thermal resistance of 0.110 K/W has been developed ,dissipating the heat of a Peltier pellet with the size of 40*40*3.9 cm , Experimentally proved that the use of thermo syphon with phase change increases the coefficient of performance up to 32%.

Shen, Xiao et al[7] investigated a novel thermoelectric radiant air-conditioning system (TE-RAC). The system employs thermoelectric modules as radiant panels for indoor cooling, as well as for space heating by easily reversing the input current. Based on the analysis of a commercial thermoelectric module they have obtained a maximum cooling COP of 1.77 when applying an electric current of 1.2 A and maintaining cold side temperature at 20°C.

Virjoghe, Diana et al[8] conducted an numerical investigation of thermoelectric System. The thermoelectric systems have attracted renewed interest as concerns with the efficient use of energy resources, and the minimization of environmental damage, have become important current issues. This paper presents of numerical simulation for several the thermoelectric materials. Numerical simulation is carried out by using a finite element package ANSYS.

Maneewan et al[9] conducted an experimental investigation of thermal comfort study of compact thermoelectric air conditioner. In this paper analyse the cooling performance of compact thermoelectric air-conditioner. TEC1-12708 type thermoelectric modules used for heating and cooling application. The compact TE air conditioners COP was calculated to its optimum parameters. Then analyse the cop with respect to time and calculated cop at various considerations.

Manoj and Walke[10]conducted an experimental study of thermoelectric air cooling for cars. They are trying to overcome these demerits by replacing the existing HVAC system with newly emerging thermoelectric couple or cooler which works on peltier and seebeck effect.

Yadav and Mehta[11] presented combined experimental and theoretical study of thermoelectric materials and application. The present study develops an optimization design method for thermoelectric refrigerator. This device is fabricated by combining the standard n- and p-channel solid-state thermoelectric cooler with a two-element device inserted into each of the two channels to eliminate the solid-state thermal conductivity

Manoj Kumar et al [12] presented an experimental study of noval potential green refrigeration and air-conditioning technology. They are analysing the cause and effect of an existing air-condition system. Thermoelectric cooling provides a promising alternative R&AC technology due to their distinct advantages. The available literature shows that thermoelectric cooling systems are generally only around 5–15% as efficient compared to 40–60% achieved by the conventional compression cooling system.

Huang. B et al[13] conducted an experimental study of design method of thermoelectric cooler. They are fabricated the thermoelectric cooler and analyse various considerations. The system simulation shows that there exists a cheapest heat sink for the design of a thermoelectric cooler. It is also shown that the system simulation coincides with experimental data of a thermoelectric cooler

MATHEMATICAL MODELLING

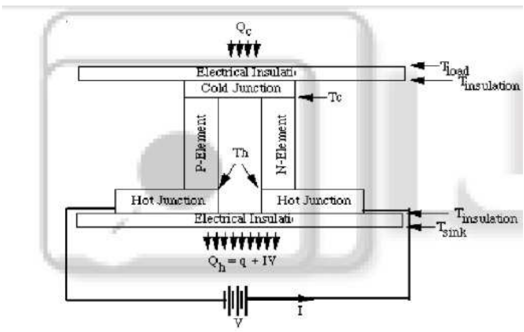

Figure 1: Thermal Network Model of TER

Assumptions

- No heat loss takes place from or to the system.
- Thermo physical properties such as Resistivity, conductivity etc do not change with temperature.
- Heat transfer takes place only through the P type and N type semiconductor.

When current is passed through the dissimilar material, heat is absorbed or liberated at the junction. This phenomenon is known as Peltier Effect. Thermal network model of TER is given in Figure 1. The various equations used for calculating the parameters under the study are given below.

Cooling and heating due to the thermoelectric effect is given by (peltier effect)

$$Qc = \alpha I T_c$$

$$Qc = \alpha I T_h$$

For the cold junction

$$Q_c + 0.5\, I^2 R + U\ \ (T_h - T_C) = \ \alpha I T_C$$

For the hot junction

$$Qh + U(T_h - T_c) = \alpha I T_h + 0.5 I^2 R$$

Thus the thermoelectric Cooling is

Q_c=α IT_c-0.5I^2R-K(T_h-T_c)

And heating is

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

Now energy input to the system from outside, as per first law of thermodynamics, is given by

$\oint \quad \delta Q = Qnet = -Q_h - Q_c$

$$= \alpha I(T_h - Tc) + I^2 R$$

Negative sign indicates that energy has to be supplied to the system.

Now, $(COP)_C = Q_c / Energysupplied$

Q_c=α IT_c-0.5I^2R-U(T_h-T_c)

$$P = \alpha I(T_h - Tc) + I^2 R$$

Similarly $(COP)_h = Q_h / Energysupplied$

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

$$P = \alpha I(T_h - Tc) + I^2 R$$

THERMOELECRIC MATERIAL

The common Thermoelctric Material used in Different applications are Bismuth sulfide(Bi_2S_3), Lead Telluride(PbTe), Antimony Telluride(Sb_2Te_3), Cesium Sulfide(CeS), Bismuth telluride(Bi_2Te_3), and Germanium Telluride(GeTe). The seeback coefficient for different material are given in table 1.

Table 1: Seeback Coefficient for Different Material

Material	$\alpha(K^{-1})$
Germanium Telluride	1.5×10^{-3}
Cesium Sulfide	1×10^{-3}
Bismuth Telluride	41×0^{-8}
Lead Telluride	1.5×10^{-3}

PROPOSED WORK

The aim of the project is to investigate experimentally and Numerically the COP of the thermo electric air conditioner using Peltier Modules. The details of the experimental set up are as follows

S. No	Description	Dimension/Range
1	Peltier Module	40×40×40 mm
2	Aluminum Block	320×6.5×3.8 cm
4	Rectangular Fin	68×35 cm
5	Fiber Sheet	470×36 cm
6	K-Type Thermocouple with Indicator	$0\text{-}1000^0c$
7	Multimeter	350V ac
8	Variable Speed Transformer	230 Dc

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

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, heat power (W)
COP	coefficient of performance
I	electric current (A)

Q_h Peltier pellet hot side heat flow (W)

Q_c Peltier pellet cold side heat flow (W)

P electric power supplied

R thermal resistance (K/W)

V voltage to the thermoelectric module (volt)

α Seeback coefficient (v^0c^{-1})

ΔT temperature difference of cold and hot side T_h hot side temperature (K)

T_c cold side temperature(K)

T_a ambient temperature (K)

K total thermal conductance (w^oc^{-1})

COP_c coefficient of performance of thermoelectric cooling system

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