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Air Conditioner using Peltier Module

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Abstract: To achieve desired amount of cooling, an air conditioner using Peltier modules is designed. The appearance of this thermoelectric type of air conditioner is same as conventional window air conditioner. This brings the simplicity in construction. The air conditioner is intended to take up the cooling load in volume of space as in conventional automobiles like cars. If we use conventional vapour compression type of air conditioner which is currently used in vehicles is replaced with this one with an arrangement for its placement, it would reduce the total weight of vehicle which makes the fuel economical.
Keywords: Thermoelectric; Air conditioner; Peltier module; conceptual design

I. INTRODUCTION

Thermoelectric cooling uses the Peltier effect that produces a temperature difference between the junctions of electric conductors two different types of materials, when electricity is made to flow through the circuit. A Peltier cooler used in current work transfers heat from hot region to the comparatively cold region of space with the use of cluster of thermoelectric devices known as Peltier module, a semiconductor based refrigerator resembling flat square plate, where heat is absorbed from one side (cold side) and dissipated on the opposite side (hot side), with consumption of electricity. This cooling is a solid state method of heat transfer generated using P-type and N-type semiconductor, usually bismuth telluride.

Peltier module consists of a number of thermocouples sandwiched between two layers of ceramic substrates. Thermocouples (thermoelectric legs/pellets) are electrically connected in series but thermally in parallel. A single thermocouple consists of one n and one p- type semiconductor material and is known as a thermo-element. One Peltier module consists of number of such thermo elements.

II. STUDIES CARRIED OUT BY RESEARCHERS

For geometric optimization of thermo-elements in a thermoelectric cooler to achieve better cooling capacity and coefficient of performance numbers of investigation have been performed [1], [2], [3] and [4].

Tuning the operating current and voltage of a thermoelectric module by adjusting the cross- sectional area of pellets is described in [1].

In [2] it is shown that there is an optimum module thickness and an optimum operating current which depend on the overall heat dissipation and on the external thermal resistances.

In [3] A confined volume in which the TEC can be placed and the technological limitation in manufacturing a TEC leg were considered, and three parameters—leg length, leg area and the number of legs—were taken as the variables to be optimized.

In [4] it is mentioned that the maximum cooling capacity improves for an increment in the cross sectional area of the thermo-element or a decrement in the length. The maximum achievable coefficient of performance, irrelevant of the maximum cooling capacity, remains constant for any change in the area or the length of the thermo-element.

To develop better thermo-element materials to achieve a higher performance a study has been performed [5].

In [5] it is demonstrated that there is a doubling in the thermoelectric figure of merit (A measure of the suitability of a material for thermoelectric applications whose value has to be higher) for super-lattice materials.

III. CONSTRUCTIONAL FEATURES OF AIR CONDITIONER USING PELTIER MODULE PRESENTED IN THE PAPER

As shown in Fig. 1 air conditioner consists of a casing in the shape of rectangular box. Casing is of Aluminium. Casing contains container filled with water. Container has one outlet and one inlet. Container outlet connects to pump inlet. Pump outlet connects to inlet of cooling coils and cooling coils outlet is connected to inlet of container. The piping used in this connection is insulated. The cooling coils are made of copper and are arranged on half of one face of casing. Pump is of centrifugal type.

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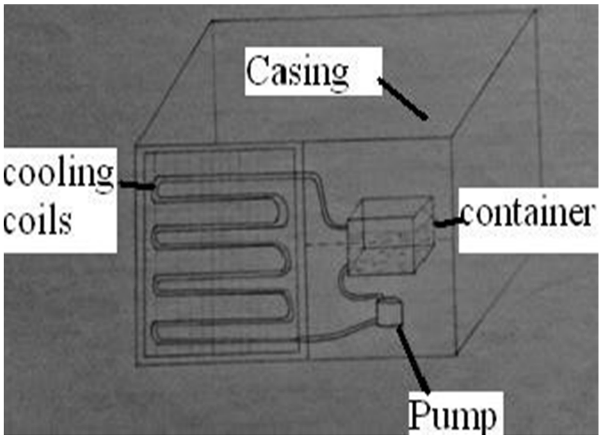

Fig. 1. Construction of air conditioner using Peltier Module showing water cooling circuit arrangement

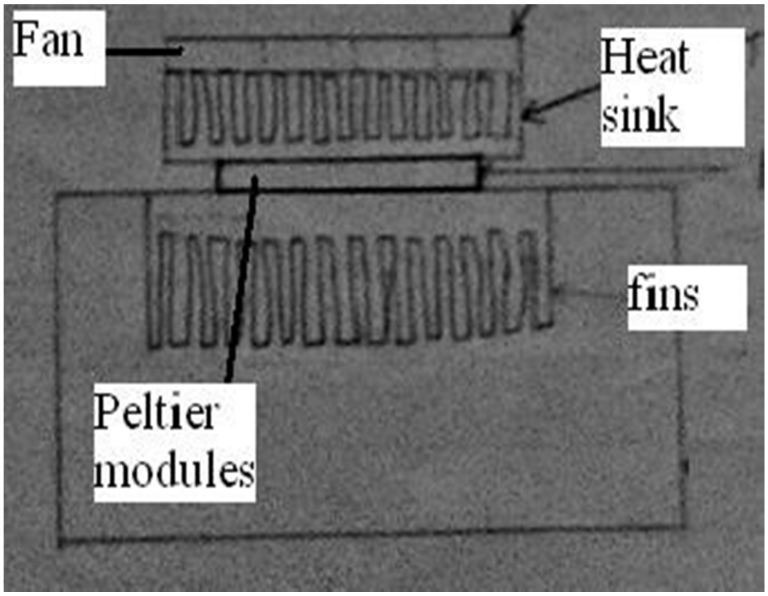

Fig. 2. Constructional details of water container

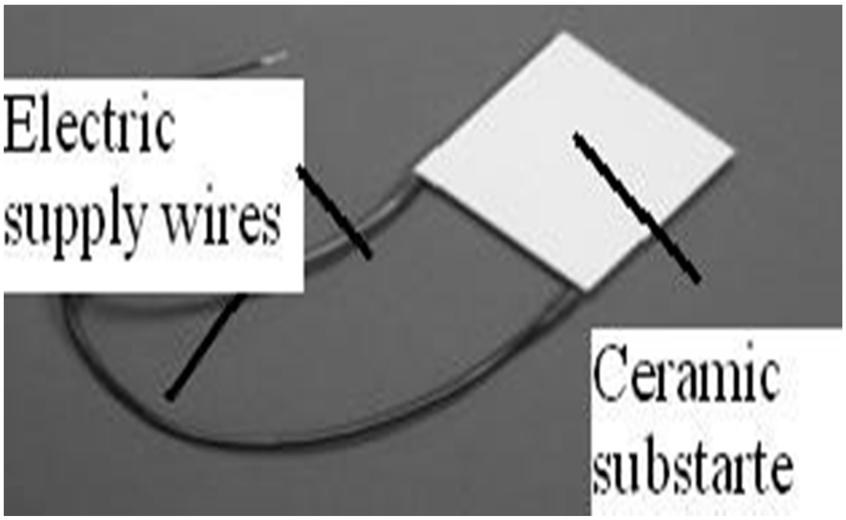

Fig.3. Peltier module

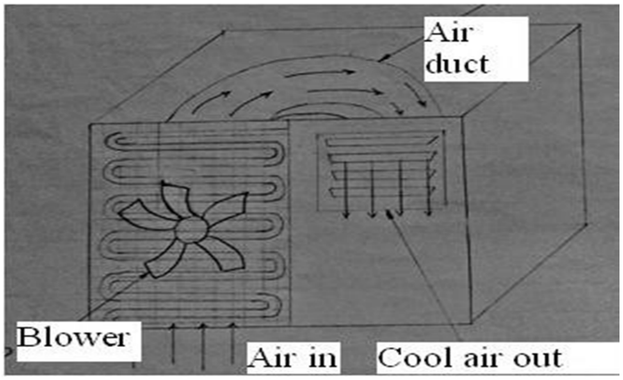

Fig. 4. Construction of air conditioner using Peltier Module showing air cooling circuit

For controlling the temperature inside the space to be cooled, there exists a thermostat. When the temperature inside the space reaches the required condition, the power supply to the Peltier modules will be stopped.

A blower is attached facing towards cooling coils, an air circulation duct and a grid attached on the same face of casing where cooling coils are located. At inlet of air duct there lies a cooling coil with blower and at outlet grid is attached.

IV. WORKING OF AIR CONDITIONER USING PELTIER MODULE PRESENTED IN THE PAPER

There are two circuits; one circuit cools water directly through contact with Peltier plate and second circuit cools air to be circulated in the space to be conditioned.

The Peltier plates attached on water container box's one face absorbs the heat from water with consumption of electricity. This heat transfer is enhanced by the use of fins. Also the cold side of Peltier plate does not contact directly water. Cold side makes contact with thin highly conductive wall of container and on that wall fins are attached. On hot side of Peltier plate heat is rejected outside of the space to be cooled and again heat flow rate is enhanced by use of a fan (forced circulation) and highly conductive finned plate. Water after losing heat is sucked by pump. It forces water to move to inlet of cooling coil. To avoid heat gain during this journey piping and pump is kept thermally insulated.

Water becomes comparatively hot at outlet and goes again in to container for cooling completing the water circuit. The piping communicating outlet of cooling coil and inlet of container is again insulated to stop heat absorption from surrounding. This is done because the water after coming out of cooling coil may still be colder than surroundings and the unwanted increased load on Peltier modules can be avoided.

The blower forces air sucked from space to be cooled on cooling coil. Which gets cooled after flowing over coil (forced circulation for higher heat transfer rate). Air then flows through duct which is insulated to avoid heat absorption from surrounding before it goes to space where it is required. Cooled air comes out from grids attached on face of casing in the room to be cooled. Grids are made manually adjustable to control the direction of flow of air.

V. PROPOSED CALCULATIONS FOR DESIGN

To Calculate coefficient of performance of single Peltier module following procedure is adopted [7]. Some known amount of water is poured inside a beaker. Water initial temperature is measured. Then beaker is kept on cold side of Peltier plate. Now plate and fan is supplied safe amount of electricity its wattage is measured. Certain temperature difference is set and accordingly final temperature is measured with amount of time taken and above recorded data is substituted in following equations. The current Peltier module has following observed data.

Initial Temperature = 33^{O} C Final Temperature = 27^{O} C
Temperature Difference (dt)
= 6^{O}C Volume of water (m)
= 30ml = 0.03 litres Time (t)
= 5 minutes = 300 seconds
Power Utilized = Power utilized by heat sink fan
+ Power utilized by Peltier Module = (0.1 x 12) + (2 x 12) = 25.12
watts = 25.12 x 10^{-3} kW

Heat absorbed (Q) = m C_p dt = 0.03 x 4.18 x 6

=0.7524 kJ

Work consumed (W) = Power Utilized x Time Duration

= 25.12 x 10^{-3} x 300 = 7.536 kJ

COP = Heat absorbed / Work consumed = Q / W

= 0.7524

/ 7.536 = 0.1

Average refrigeration effect = Q/t =0.7524/300

=0.002508 kW= 2.5 W

Accordingly number of modules required for required refrigeration effect can be calculated considering some losses due to resistance of conduction (fined wall), resistance of convection from wall to water, water to cooling coil and cooling coil to air. Number of module determines container wall and the casing dimension by knowing module geometry and spacing between modules.

According to flow rate of air desired and refrigeration effect needed one can find flow rate of water required. By this blower and circulating pump could be selected.[8-10] However pressure drop considerations also will be important for selection of these two. Mass of water desired will also decide size of container. Blower area for air flow rate desired will also determine size of casing and grid sizing.

VI. CONCLUSION

Conceptual design and a different kind of construction of environment friendly, portable Peltier air conditioner are elaborated. An arrangement for fresh air entry could be made by providing another inlet communicating outside atmosphere to air duct with adjustable dampers to control required amount of fresh air. This whole unit with casing could be installed on a window with hot side facing outside of room for heat dissipation. This unit could be attached on a wall with some arrangement of heat dissipation to outside of room. This air conditioner could be coupled (provided the required electric power) with solar photoelectric panels, generating electricity from solar energy.

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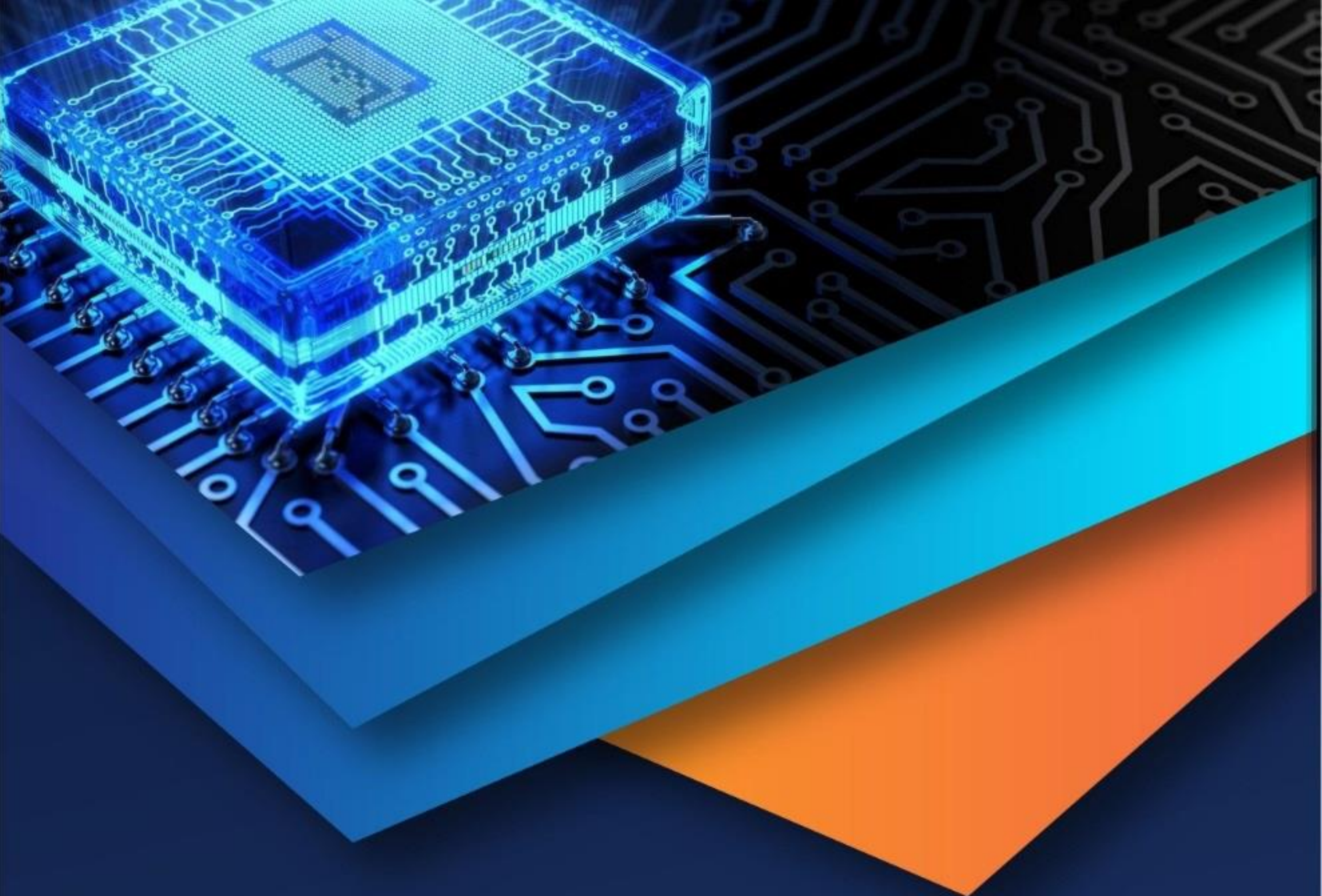

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