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EFFECT OF THERMOELECTRIC MODULE ON AIR TEMPERATURE: A EXPERIMENTAL STUDY

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ABSTRACT

A thermoelectric (TE) module, also called a thermoelectric cooler or Peltier cooler, is a semiconductor-based electronic component that functions as a small heat pump. By applying a low voltage DC power to a TE module, heat will be moved through the module from one side to the other. One module face, therefore, will be cooled while the opposite face is simultaneously heated. It is important to note that this phenomenon may be reversed whereby a change in the polarity (plus and minus) of the applied DC voltage will cause heat to be moved in the opposite direction. Consequently, a thermoelectric module may be used for both heating and cooling thereby making it highly suitable for precise temperature control applications. A thermoelectric module can also be used for power generation. In this mode, a temperature differential applied across the module will generate a current. The intake is heated using thermo electric module. Its purpose is to heat the air at most by using less energy. Different arrangements of modules will be made to check the effect at different positions. The inlet conditions like velocity and temperatures are measured and so the outlet. In this work it is proposed to analyze the effect of air velocity on temperature profile. The temperature is measured using thermocouple. A thermoelectric device for measuring temperature, consisting of two wires of different metals connected at two points, a voltage being developed between the two junctions in proportion to the temperature difference.

1. INTRODUCTION

Thermoelectric modules produce heat and cold at the same time while remain COP of thermoelectric higher than 1 in heating mode. This research will propose a novel thermoelectric air heater which is simple structure. A simulation model will be established to simulate the impact of operating voltage, indoor temperature, supply air temperature and thermal resistance of heat on the performance of warm air heater.

1.1 Thermoelectric Module

A standard module consists of any number of thermocouples connected in series and sandwiched between two ceramic plates. Figure 1-1 [2].

By applying a current to the module one ceramic plate is heated while the other is cooled. The direction of the current determines which plate is cooled. The number and size of the thermocouples as well as the materials used in the manufacturing determine the cooling capacity. Cooling capacity varies from fractions of Watts up to many hundreds. Different types of TEC modules are single stage, two stage, three stage, four stage, center hole modules etc.

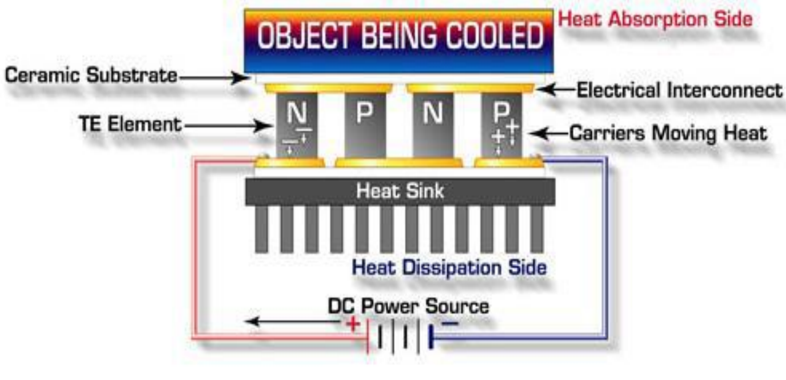


Figure 1-1 A Classic TE Module Assembly [3]

Figure 1-2 Thermoelectric Module

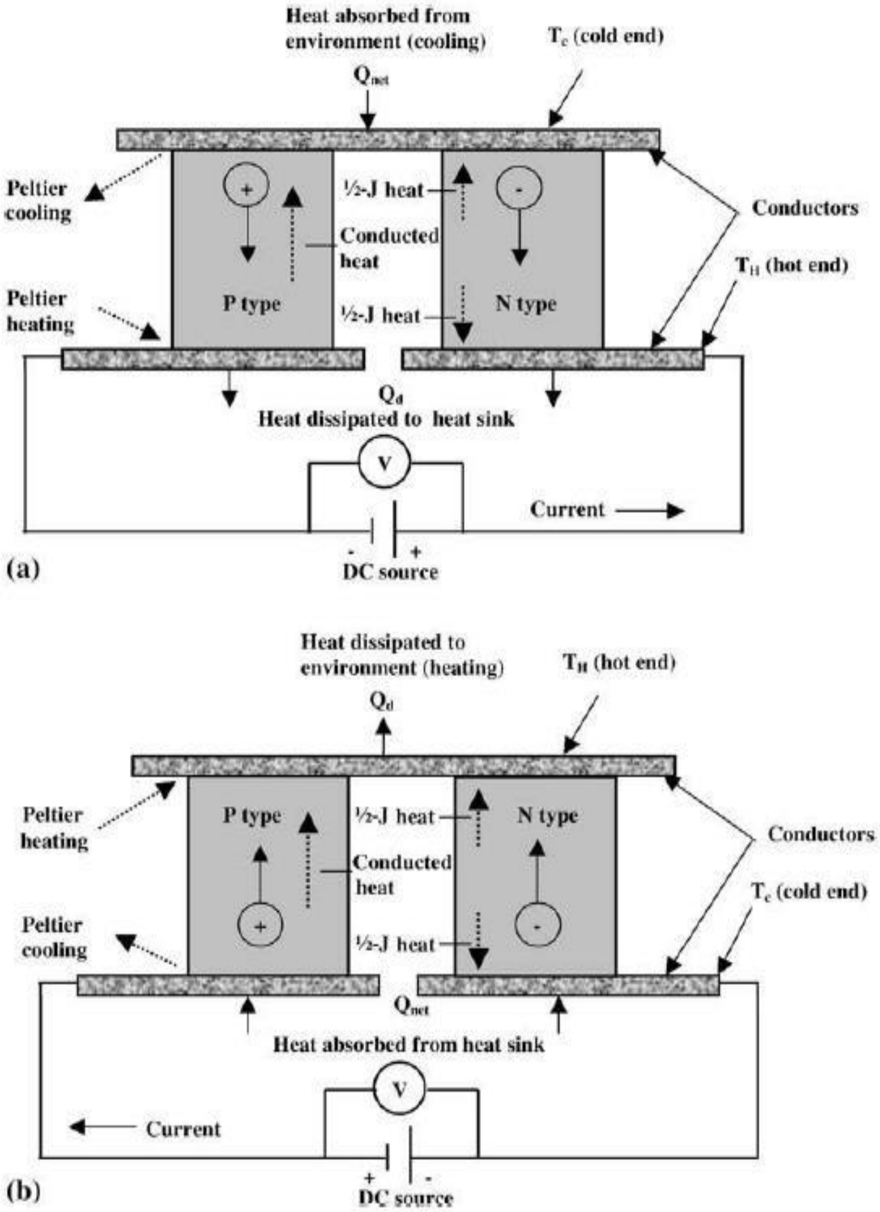


Figure 1-3 Schematic of thermoelectric module operation (a) cooling mode (b) heating mode [2]

2. MATERIAL SELECTION AND DESIGN OF COMPONENTS

2.1 Thermoelectric Air Heating/Cooling for Wooden Duct

The thermoelectric cooling fan design will be performed on the basis of certain mechanical and electrical calculations. The prototype assembly starts with a main fan which is used to blow the ambient air through a wooden duct. The duct is attached to the blower fan and leads towards a group of four heat sinks. The air which is passed through the duct goes into the cluster of four/five heat sinks which are united together. These heat sinks acts as a channel for the air to pass through. There are four/five TECs which are placed in the partition provided.

Figure 2-1 Wooden Duct

The material used for making the duct is wood (i.e. plywood). As the only manufacturing part is duct so the material selection criteria was minimized.

2.2 Design of Duct

Calculation of duct size
Given:
N= 1425 rpm
Q= 600 cfm
a= 5.5” b=7”

Q = 600×(0.3048)360 ……………………………………………………………………… 3.1
Q= 0.2832 $m3s/$
D = 2×5.5×75.5+7 ……………………………………………………………………………………3.2
D= 6.16” = 0.1565 m
V = $\pi \times D \times N60$ ……………………………………………………………………………… 3.3
V= π×0.1565×142560 = 11.6769 $ms/$
Q=A×V
A=QV **…………………………………………………………………………………………… 3.4**
A = 0.283211.6769 = 0.02425 $m2$
If we consider rectangular duct,
One side = 7” = 17.78 cm
Other side = 0.024250.1778 =13.6389 cm
= 5.369” ≈ 6”
Size of duct = 6” × 7”
Calculation of entrance length for duct
Given:
Kinematic viscosity = 17.48 X 10^-6 m^2 /s
Velocity of air in duct (v) = 15 m/s
Diameter of duct (D) = 0.1565 m

1. Reynolds number (Re) = $v.D\vartheta$ ……………………………………………………… 3.5

Re = **1.156517.48 *X* 10−6**
Re= 134296.3387
Here Re > 2300, hence flow is turbulent.

2. Entrance length (Le)

For turbulent flow, *LeD* = 4.4 X ***Re*16** **………………………………………………… 3.6**
Le = 0.1565 X 4.4 X 134296.3387**16**
Le= 4.9277 m

Entry length is much shorter in turbulent flow, entrance effect become insignificant beyond duct length of 10 diameter. [12]
Le= 10 X diameter
Le= 10 X 0.1565
Le= 1.565 m

From the calculation we got Le=1.565 m which is < 4.9277 m, hence we will get fully developed flow beyond length of 1.565 m. [12]
Hence we considered entry length as **Le= 2 m** (approx...)

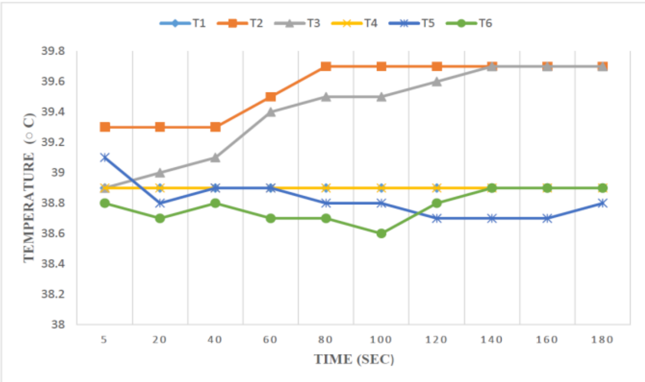
The total length of the duct is 3 meter, which includes a duct as entry duct of length 2 meter and 1 main duct which is having partition of length 1meter.
As said earlier the thermocol insulation will be provided for accompanying the heat losses.

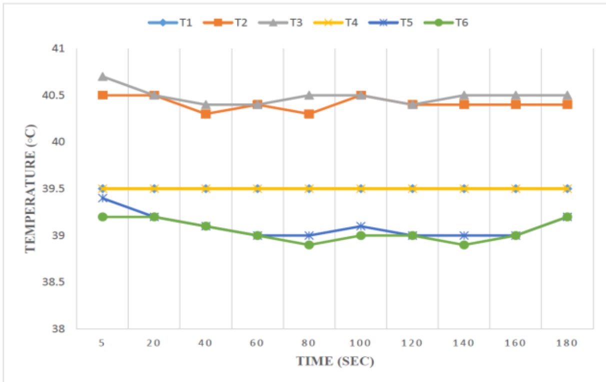
3. MANUFACTURING/ASSEMBLY

The assembly will consist of the Blower whose output is the inlet of duct. For measuring the temperature at different position thermocouple is used. The partition which is there in the duct is for module attachment. The portable plate (acrylic) is inserted in the space (partition) with module fixed in it.

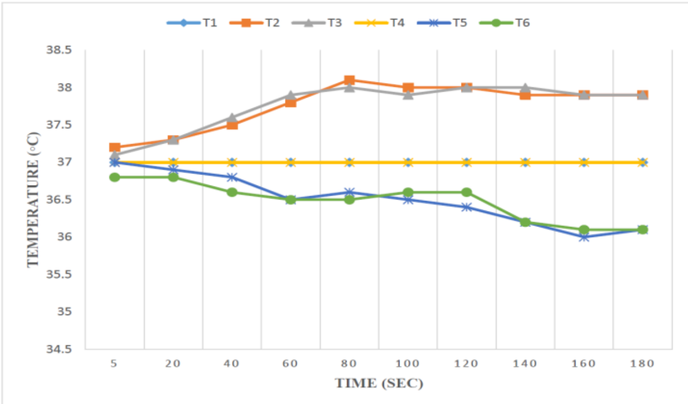
Figure 3-1 Main Assembly

4. RESULTS AND DISCUSSION





a **b**



c

Graph a Temperature Vs Time (One Module Arrangement)
Graph b Temperature Vs Time (Three Module Arrangement)
Graph c Temperature Vs Time(Three Module Diagonal Arrangement)

The above Graph c is showing significant variation for heating and cooling.

- There is gradual increase in temperature T3 and T2 on hot side up to 80 sec and thereafter remains constant with respect to time.
- The temperature T5 keeps on dropping gradually till the end with some slight fluctuation.
- The temperature T6 also decreases like T5 up till 80 sec, after which there is slight rise up till 120 sec and then again decreases.
- Similar to three module straight arrangement, it also gives better heating and cooling effect than single module arrangement.

5. CONCLUSION

This report presents the experiment conducted on different arrangements of thermoelectric modules to find the optimum arrangement. The power input and velocity were kept constant while performing the experiment. After analyzing the obtained data the following conclusions were made:

- Single module arrangement does not give significant heating and cooling effect, hence this arrangement is not recommended.
- Three module diagonal arrangement is recommended over three module straight line arrangement due to following reasons:
  1. Heating effect obtained in diagonal arrangement is better than in straight line arrangement.
  2. Gradual cooling is obtained in diagonal arrangement.
- Maximum heating obtained is by 2 degree Celsius.
- Maximum cooling obtained is by 1.2 degree Celsius.
- The optimum velocity for this setup is 8-12 m/s.

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