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Fabrication And Analysis Of Problems In Thermoelectric Refrigerator

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Abstract

It is based on the fabrication of the small refrigerator, which works on the principle of peltier effect. Refrigeration is the process of pumping heat energy out of an insulated chamber in order to reduce the temperature of the chamber below that of the surrounding air. Thermoelectric refrigeration uses a principle called the "PELTIER" effect to pump heat electronically. We has made the use of thermoelectric modules to lower the temperature of an insulated chamber. We have fabricate the thermoelectric refrigerator and taken out the performance parameters in order to analyze it.

INTRODUCTION

Introduction to Refrigerator

Refrigeration is a process in which work is done to move heat from one location to another. The work of heat transport is traditionally driven by mechanical work, but can also be driven by magnetism, laser or other means. Refrigeration has many applications, including, but not limited to: household refrigerators, industrial freezers, cryogenics, air conditioning, and heat pumps. Thus

A **refrigerator** (colloquially **fridge**) is a common household appliance that consists of a thermally insulated compartment and a heat pump (mechanical, electronic, or chemical) that transfers heat from the inside of the fridge to its external environment so that the inside of the fridge is cooled to a temperature below the ambient temperature of the room. Cooling is a popular food storage technique in developed countries and works by decreasing or even arresting the reproduction rate of bacteria. The device is thus used to reduce the rate of spoilage of foodstuffs. A refrigerator maintains a temperature a few degrees above the freezing point of water. Optimum temperature range for perishable food storage is 3 to 5 °C (37 to 41 °F). A similar device which maintains a temperature below the freezing point of water is called a **freezer**. A thermoelectric refrigerator in the same way is a refrigerator that uses the peltier effect to create a heat flux between the junction of two different types of materials.TEC also called as peltier cooler is a solid state heat pump which transfers heat from one side of the device to the other side against the temperature gradient (from cold to hot), with consumption of electrical energy.

A peltier cooler is neither a thermopile nor a thermocouple and it does not rely on the seebeck effect.

1.2 History of thermoelectric refrigerator

In 1821, Thomas Seebeck discovered that a continuously flowing current is created when two wires of different materials are joined together and heated at one end.This idea is known as the Seebeck Effect. The Seebeck effect has two main applications including temperature measurement and power generation. Thirteen years later Jean Charles Athanase reversed the flow of electrons in Seebeck.s circuit to create refrigeration. This effect is known as the Peltier Effect. This idea forms the basis for the

thermoelectric refrigerator.Scottish scientist WilliamThomson (later Lord Kelvin) discovered in 1854 that if a temperature difference exists between any two points of a current carrying conductor, heat is either evolved or absorbed depending upon the material.6 If such a circuit absorbs heat, thenheat may be evolved if the direction of the current or of the temperature gradient is reversed.[1]

1.3 Introduction to thermoelectric effect

The Seebeck, Peltier, and Thomson Effects, together with several other phenomena, form the basis of functional thermoelectric modules. Without going into too much detail, we will examine some of these fundamental thermoelectric effects.

SEEBECK EFFECT: The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit. The voltages produced by Seebeck effect are small, usually only a few microvolts (millionths of a volt) per kelvin of temperature difference at the junction. If the temperature difference is large enough, some Seebeck-effect devices can produce a few mill volts (thousandths of a volt). Numerous such devices can be connected in series to increase the output voltage or in parallel to increase the maximum deliverable current. Large arrays of Seebeck-effect devices can provide useful, small-scale electrical power if a large temperature difference is maintained across the junctions.

The Seebeck effect is responsible for the behaviour of thermocouples, which are used to approximately measure temperature differences or to actuate electronic switches that can turn large systems on and off. This capability is employed in thermoelectric cooling technology. Commonly used thermocouple metal combinations include constantan/copper,

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constantan/iron, constantan/chromel and constantan/alumel.

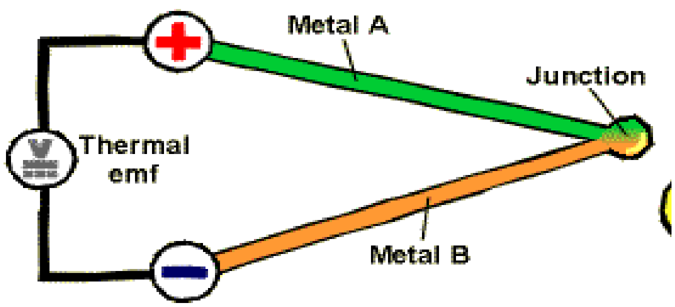
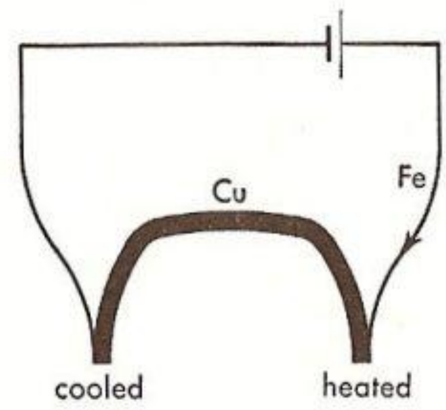


Fig 1.1

PELTIER EFFECT: The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material. This phenomenon can be useful when it is necessary to transfer heat from one medium to another on a small scale. The Peltier effect is one of three types of thermoelectric effect; the other two are theSeebeck effect and the Thomson effect. In a Peltier-effect device, the electrodes are typically made of a metal with excellent electrical conductivity. The semiconductor material between the electrodes creates two junctions between dissimilar materials, which, in turn, creates a pair of thermocouple voltage is applied to the electrodes to force electrical current through the semiconductor, thermal energy flows in the direction of the charge carriers.[2] Peltier-effect devices are used for thermoelectric cooling in electronic equipment and computers when more conventional cooling methods are impractical.



THOMSON EFFECT: In Thomson effect we deal with only metallic rod and not with thermocouple as in **Peltier effect** and **Seebeck effect.** (That's why sometimes it is known as homogeneous thermo electric effect. When a current flows through an unequally heated metal, there is an absorption or evolution of heat in the body of the metal. This is **Thomson effect.**

(i) Positive Thomson effect : In **positive Thomson effect** it is found that hot end is at high potential and cold end is at low potential. Heat is evolved when current is passed from hotter end to the colder end and heat is absorbed when current is passed from colder end to hotter end. The metals which shows positive Thomson's effect are Cu, Sn, Ag, Cd, Zn… etc.

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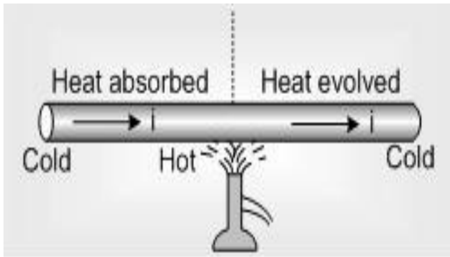
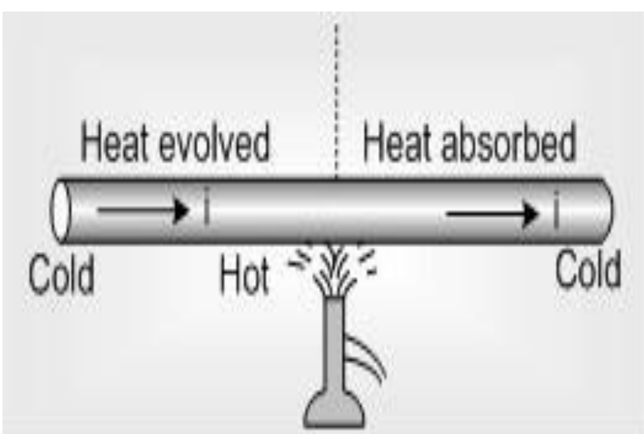


Fig 1.3

(ii) Negative Thomson effect : In the elements which show **Negative Thomson effect,** it is found that the hot end is at low potential and the cold end is at higher potential. Heat is evolved when current is passed from colder end to the hotter end and heat is absorbed when current flows from hotter end to colder end. The metals which show negative, Thomson's effect are Fe, Co, Bi, Pt, Hg… etc.



1.4 Introduction to thermoelectric module

The basic concept behind thermoelectric (TE) technology is the *Peltier effect*—a phenomenon first discovered in the early 19th century. The Peltier effect occurs whenever electrical current flows through two dissimilar conductors. Depending on the direction of current flow, the junction of the two conductors will either absorb or release heat. Explaining the Peltier effect and its operation in thermoelectric devices, is a very challenging proposition. It ultimately keys on some very complex physics at the sub-atomic level. Here we will attempt to approach it from a conceptual perspective with the goal of giving readers an intuitive grasp of this technology (i.e., without getting too bogged down in the minutia).

In the world of thermoelectric technology, semiconductors (usually Bismuth Telluride) are the material of choice for producing the Peltier effect—in part because they can be more easily optimized for pumping heat, but also because designers can control the type of *charge carrier* employed within the conductor (the importance of this will be explained later). Using this type of material, a *Peltier device* (i.e., thermoelectric module) can be constructed. In its simplest form, this may be done with a single semiconductor 'pellet' which is soldered to electrically-conductive material on each end (usually plated copper).[7] In this 'stripped-down' configuration (see *Figure*), the second dissimilar material required for the Peltier effect, is actually the copper connection paths to the power supply.

It is important to note that the heat will be moved (or 'pumped') in the direction of charge

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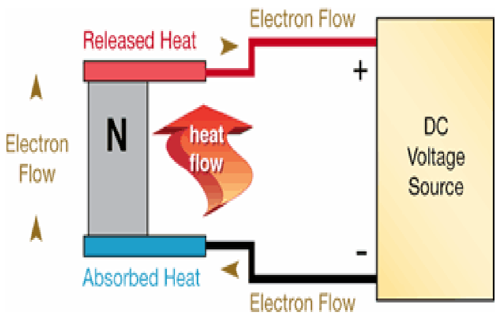
carrier flow throughout the circuit—actually, it is the charge carriers that transfer the heat.



In the thermoelectric industry, 'P-type' semiconductor pellets are also employed. P-type pellets are manufactured so that the charge carriers in the material are positive (known in electronics as 'holes'). These 'holes' are places where electrons can easily fit when a voltage is applied and they enhance the electrical conductivity of the P-type crystaline structure. Positive charge carriers are repelled by the positive pole of the DC supply and attracted to the negative pole; thus 'hole' current flows in a direction opposite to that of electron flow. Because it is the charge *carriers* inherent in the material which convey the heat through the conductor, use of the P-type material results in heat being drawn toward the negative pole of the power supply and away from the positive pole. This contrasting heat-pumping action of P and N-type materials is very important in the design of practical TE device. While the illustration here—for simplicity's sake—shows 'hole' flow through the connections to the power supply, in reality, electrons are the charge carriers through the copper pathways.

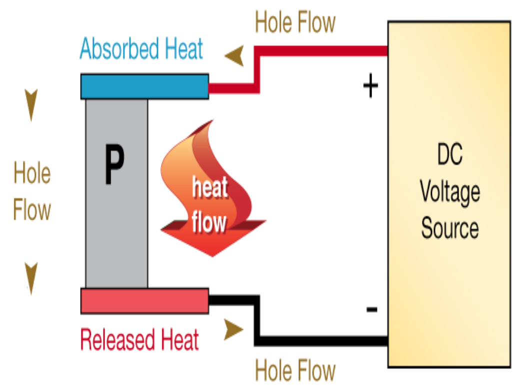


Fig 1.6

Unfortunately, while you can make a simple thermoelectric device with a single semiconductor pellet, you can't pump an appreciable amount of heat through it. In order to give a TE device greater heat-pumping capacity, multiple pellets are used together.

Experimental Description

The thermoelectric modules which we used in our experiment have the following

specifications:

• Place of origin:zhejiang china (mailnalnd)

• Model number:TES1-12703

• Couples:127

• Maximum voltage:15V

• Maximum current:3 I

• Maximum heat pumped:25.6WATT

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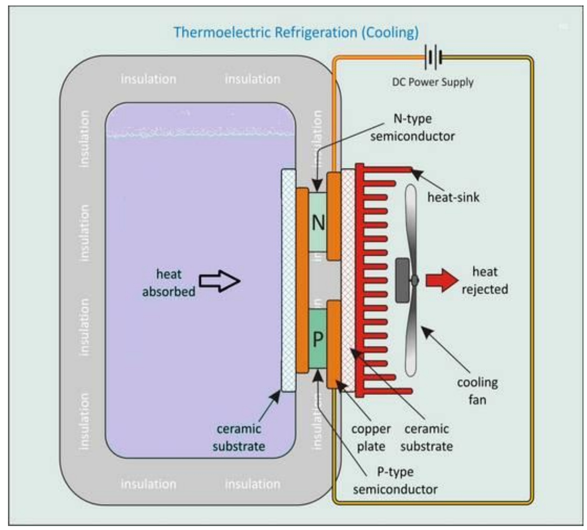
• Maximum temperature:67 degree centigrade

• Size :30x30x3.7

We use thermocol box as enclosure as it is easily available and good insulator. A

thermoelectric (TE) module, also called a thermoelectric cooler or Peltier cooler, is asemiconductor-based electronic component that functions as a small heat pump[5],is the thermoelectric device installed in the enclosure . In the fabricated model ,we use the power supply of rating12 V and 15A.Thermoelectric cooling devices utilize the Peltier effect, whereby the passage of a direct electric current through the junction of two dissimilar conducting materials causes the junction to either cool down (absorbing heat) or warm up (rejecting heat), depending on the direction of the current. Figure shows a pair of adjacent thermo-element legs joined at one end by a conducting metal strip forming a junction between the legs. Thus, the legs areconnected in series electrically but act in parallel thermally. This unit is referred to as a thermoelectric couple and is the basic building block of a thermoelectric (or Peltier) cooling module. The thermo-element materials are doped semiconductors, one n-type with a majority of negative charge carriers (electrons) and the other p-type with a majority of positive charge carriers (holes). The majority of commercially available thermoelectric cooling modules are assembled from n-type and p-type thermoelements cut from bismuth telluride (BiTe3) based bulk materials[7].



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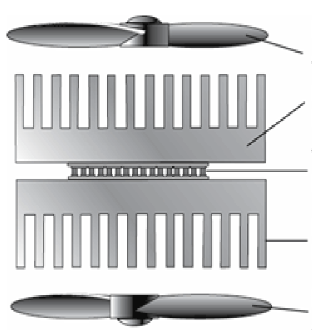
6.0 CONCLUSION AND FUTURE ENHANCEMENT

6.1Conclusion: We have found out that in the absence of cold plate,the convective heat transfer is very low even if we installed a fan ,only a temperature of 1 degree Celsius is obtained at middle portion of chamber and a difference of about 10 degree Celsius is obtained near the surface of the module,regardless of the time .Even we installed fans with a thought to increase the temperature difference in the middle portion also,not y helped for the same.In order to get an appreciable temperature difference in the middle portion also, the heat transfer from the surface of module should be done through conduction first, then through convection in the air.To overcome the earlier mentioned problem instead of direct convection through the surface we have to first install a cold plate(heat sink) on the surface of module for getting conduction and then convection in the air.



Solution of heat transfer problem[8]

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