

Experimental Analysis of Thermoelectric Cooling System

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ABSTRACT -The main objective of our project is to Investigation of a Cooling system with the help of Thermoelectric Module which works on the principle of the Pettier effect. This will be a suitable and affordable system for the people living in remote part of India where load shading is a major problem. The major difference between the existing system and our system is that, our project works without use of mechanical device and without refrigerant too. As the module is compact in size one can design (i.e. shape, capacity) the system according to his requirement. In this project an attempt has been made to conduct an experimental study on small scale thermoelectric Cooling system.

KEY WORDS : Pettier Effect, Refrigeration, Thermoelectric Module, Reliability, Unconventional Cooling.

I. INTRODUCTION

1.1 REFRIGERATION

Refrigeration is a process of moving heat from one location to another in controlled conditions. The work of heat transport is traditionally driven by mechanical work, but can also be driven by heat, magnetism, electricity, laser, or other means. Refrigeration has many applications, including, not limited to: home refrigerators, industrial freezers, cryogenics, and air conditioning. Heat pumps may use the heat output of the refrigeration process, and also may be designed to be reversible, but are otherwise similar to air conditioning units. Refrigeration has had a large impact on industry, lifestyle, agriculture and settlement patterns. The idea of preserving food dates back to at least the ancient Roman and Chinese empires. However, mechanical refrigeration technology has rapidly evolved in the last century, from ice harvesting to temperature-controlled rail cars. The introduction of refrigerated rail cars contributed to the westward expansion of the United States, allowing settlement in areas that were not on main transport channels such as rivers, harbors, or valley trails. Settlements were also developing in infertile parts of the country, filled with new natural resources. These new settlement patterns sparked the building of large cities which are able to thrive in areas that were otherwise thought to be inhospitable, such as Houston, Texas and Las Vegas, Nevada. In most developed countries, cities are heavily dependent upon refrigeration in supermarkets, in order to obtain their food for daily consumption. The increase in food sources has led to a larger concentration of agricultural sales coming from a smaller percentage of existing farms. Farms today have a much larger output per person in comparison to the late 1800

This has resulted in new food sources available to entire populations, which has had a large impact on the nutrition of society.

II. METHODS OF REFRIGERATION

Methods of refrigeration can be classified as

3.1.1 non-cyclic,

3.1.2 cyclic,

3.1.3. Thermoelectric

3.1.4Magnetic.

3.1.1 NON-CYCLIC REFRIGERATION

This refrigeration method cools a contained area by melting ice, or by sublimating dryice. Perhaps the simplest example of this is a portable cooler, where items are put in it, then ice is poured over the top. Regular ice can maintain temperatures near, but not below the freezing point,unless salt is used to cool the ice down further (as in a traditional ice-cream maker). Dry ice can reliably bring the temperature well below freezing.

3.1.2 CYCLIC REFRIGERATION

This consists of a refrigeration cycle, where heat is removed from a low- temperature space or source and rejected to a high-temperature sink with the help of external work, and its inverse, the thermodynamic power cycle. In the power cycle, heat is supplied from a high-temperature source to the engine, part of the heat being used to produce work and the rest being rejected to a low- temperature sink. This satisfies the second law of thermodynamics.

A refrigeration cycle describes the changes that take place in the refrigerant as it alternately absorbs and rejects heat as it circulates through a refrigerator. It is also applied to heating, ventilation, and air conditioning HVACR work, when

Describing the "process" of refrigerant flow through an HVACR unit, whether it is a packaged or split system.

Heat naturally flows from hot to cold. Work is applied to cool a living space or storage volume by pumping heat from a lower temperature heat source into a higher temperature heat sink. Insulation is used to reduce the work and energy needed to achieve and maintain a lower temperature in the cooled space. The operating principle of the refrigeration cycle was described mathematically by Said Carnot in 1824 as a heat engine.

The most common types of refrigeration systems use the reverse- Rankin vapor-compression refrigeration cycle, although absorption heat pumps are used in a minority of applications.

Cyclic refrigeration can be classified as:

- Vapor cycle,
- Gas cycle

1. VAPOUR CYCLE

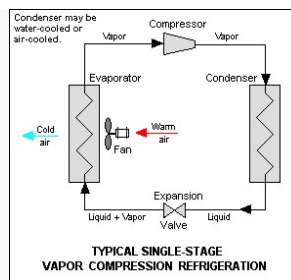
Vapor cycle refrigeration can further be classified as:

- Vapor-compressionrefrigeration
- Vapor-absorptionrefrigeration

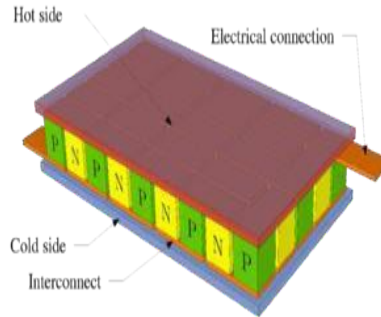
4.1 VAPOUR-COMPRESSION CYCLE

The vapor-compression cycle is used in most household refrigerators as well as in many large commercial and industrial refrigeration systems. Figure 1 provides a schematic diagram of the components of a typical vapor-compressionrefrigeration system.

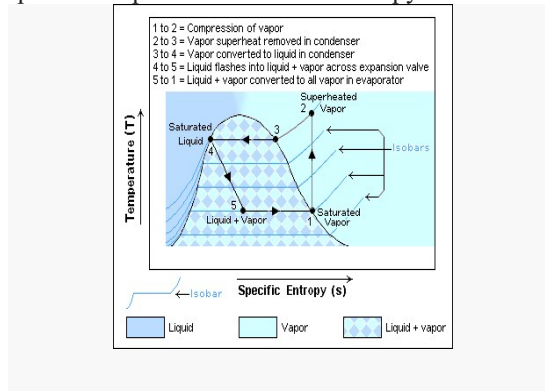
refrigerated) being blown by a fan across the evaporator coil or tubes. The resulting refrigerant vapor returns to the compressor inlet at point 1 to complete the thermodynamic cycle.



The thermodynamics of the cycle can be analyzed on a diagram as shown in Figure. In this cycle, a circulating refrigerant such as Freon enters the compressor as a vapor.



From point 1 to point 2, the vapor is compressed at constant entropy and exits the compressor as a vapor at a



The above discussion is based on the ideal vapor-compression refrigeration cycle, and does not take into account real-world effects.

2. OPERATING PRINCIPLE

Thermoelectric coolers operate by the **pettier effect** (which also goes by the more general name **thermoelectric effect**). The device has two sides, and when a **DC** electric current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter. The "hot" side is attached to a heat sink so that it remains at ambient temperature, while the cool side goes below room temperature. In some applications, multiple coolers can be cascaded together for lower temperature.

A portable Cooling system was fabricated using thermoelectric module & electric control unit and tested for the cooling and heating purpose. The system used in isolated & a remote part of the country where load-shading is a major problem. The important aspect to be noted is that it is a one-time investment & is free from maintenance. The cooling rates for different modes of heat transfer (conduction & convection) for water; is analyzed. The analysis indicates that

- a. Cooling rate for conduction of water is higher compared with convection of water.

b. The heating rate of water is higher than cooling rate.

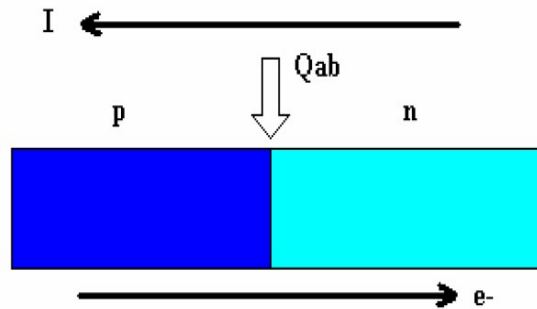
Further improvement in the efficiency of the system may be possible through improving module contact-resistance & thermal interfaces. This could be achieved by installing more modules in order to cover a greater surface area of the system

III. PELTIER EFFECTS

Thermal energy is usually a byproduct of other forms of energy such as chemical energy, mechanical energy, and electrical energy. The process in which electrical energy is transformed into thermal energy is called Joule heating. This is what causes wires to heat up when current runs through them, and is the basis for electric stoves, toasters, etc.

Heating and cooling at electrical carrying junction of two different conductor is known as Peltier effect. This effect was discovered by scientist named Jean Charles A. B. Peltier in 1834. When current is flowed through two conductor then heat may be generated or removed. The Peltier coefficient is heat carried per unit charge. The current must be continuous across the junction and the heat flow will develop a discontinuity at the junction. This can be considered as the reverse effect to the Seebeck effect. If a simple TE circuit is closed then the Seebeck effect

will allow a current, which in turn with the help of the Peltier effect. Transfer of heat is from the hot to the cold junction. There is a close relationship between Peltier effect and Seebeck effect. The Peltier effect is used in refrigeration purpose in many places.



The relationship between the amount of current and heat absorbed/released at the junction of the two dissimilar semiconductors is given by the Peltier coefficient

$$\pi_{ab}(T) = \frac{\Delta Q_{ab}}{I}$$

III. APPLICATIONS

Commercial devices based on thermoelectric materials have come up in a big way recently. In addition to the benefits thermoelectric offer over the conventional devices, commercial factors like decrease in production costs and significant opening of consumer markets have helped it in a big way and the use of T.E. devices is increasing day by day.

1. Can be used for remote places where electric supply is not available,
2. Medical and pharmaceutical equipment,
3. Military applications

IV. CONCLUSION

A portable Cooling system was fabricated using thermoelectric module & electric control unit and tested for the cooling and heating purpose. The system used in isolated & a remote part of the country where load-shading is a major problem. The important aspect to be noted is that it is a one-time investment & is free from maintenance. The cooling rates for different modes of heat transfer (conduction & convection) for water; is analyzed. The analysis indicates that

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