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A Review on Thermoelectric Refrigeration System using Peltier Effect

Akash G. Bhongade[1], Aakash D. Ravekar[2], Pratik V. Wankhade[3], Rushikesh K. Dongre[4], Chetan H. Katyrmal[5], Chaityana G. Deshmukh[6]

[1,2,3,4,5]Student, Dept. of Mechanical Engineering, DES'S COET, Dhamangaon Rly
[6]Professor, Dept. of Mechanical Engineering, DES'S COET, Dhamangaon Rly

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Abstract - *The increase awareness towards environmental degradation due to the production, use and disposal of ChloroFluoro Carbons (CFCs) and Hydro Chlorofluorocarbons (HCFCs) as heat carrier fluids in conventional refrigeration and air conditioning systems has become a subject of great concern and resulted in extensive research into development of novel refrigeration and space conditioning technologies. The performance of the system depends on incoming solar insolation and the temperature difference between the hot and cold sides for thermoelectric cooler module. Under these circumstances ODP of solar driven vapour absorption system is zero. This gives us tremendous environmental benefits a refrigerants. Also global warming & Carbon dioxide emission are producing very big environmental hazards. Using solar energy instead of fossil fuels in case of vapour absorption system provides with big environmental benefits in terms of the above mentioned effects Looking at the advantages of solar driven vapour absorption system(VAS) in modern day environment ,we are motivated to work towards the system because a large part of solar driven VAS remains unexplored which has tremendous potential in the future of Refrigeration & Air-conditioning using peltier effect .*

Key Words: Solar energy, solar panel, refrigeration system, generator, battery, peltier effect.

1. INTRODUCTION

Refrigeration is defined as any process of heat removal from a place for preserving foods and medicines by enhancing their shelf life . Immunization prevents illness, disability and death from vaccine preventable diseases including diphtheria, measles, pertussis, pneumonia, polio, rotavirus diarrhea, rubella and tetanus. Immunization currently averts an estimated 2 to 3 million deaths every year but an estimated scrap water dispenser. 22 million people from remote area of developing country worldwide are still missing out their routine vaccination programs due to the lack in availability of the safe vaccine. According to WHO guidelines, vaccine should be kept in the temperature range of 0-8 o C. For the storage of life saving drugs or vaccines in the innumerable area of the developing country where the power supply is still irregular renewable has to be a central part of energy solution. Out of the various renewable sources of energy, solar energy proves to the best candidate for cooling because of the coincidence of the maximum cooling load with the period of greatest solar radiation input.

The variety of TE products is quite large and is ever increasing with the imaginations of design engineers for heating and cooling applications. However, TE cooling is specifically the abstraction of heat from electronic components. Over the past four decades, improvement in the conversion efficiency has been marginal. The challenge has been the improvement in the performance of the thermocouple materials, which could lead to a breakthrough in terms of the efficiency of the TE device. TE cooling is specifically the abstraction of heat from electronic components. Over the past four decades, improvement in the conversion efficiency has been marginal. The challenge has been the improvement in the performance of the thermocouple materials, which could lead to a breakthrough in terms of the efficiency of the TE device.

The first important discovery relating to thermoelectricity occurred in 1823 when a German scientist, Thomas Seebeck, found that an electric current would flow continuously in a closed circuit made up of two dissimilar metals provided that the junctions of the metals were maintained at two different temperatures. Some 12 years later French watchmaker, Jean Charles Athanase Peltier, discovered thermoelectric cooling effect, also known as Peltier cooling effect, Peltier discovered that the passage of a current through a junction formed by two dissimilar conductors caused a temperature change. The true nature of Peltier effect was made clear by Emil Lenz in 1838, Lenz demonstrated that water could be frozen when placed on a bismuth-antimony junction by passage of an electric current through the junction.

An increasing surge in the demand of refrigeration has been noticed e.g. air-conditioning, food preservation, vaccine storages, medical services, and cooling of electronic devices, led to an 12 increase in the consumption of electricity which is a contributing factor for global warming and climate change. TE refrigeration is a beneficial alternative as it can use waste electricity for further cooling applications and meeting our present energy challenges. Further, these are entirely solid-state devices and absence of moving parts makes them rugged, reliable, and quiet. In addition to this, these use no ozone depleting chlorofluorocarbons, potentially offering a more environmental friendly alternative to conventional refrigeration.

2. RELATED WORK

When outside air temperatures reach uncomfortable levels, the coolest temperature we can hope to maintain within our homes is the same, despite any amount of ventilation through the use of conventional fans. In reality, our homes become even warmer than the outside air temperature, through solar gains and additional heat-loads from within. With air-conditioning equipment installed, we can quickly reduce the temperature within any of the rooms within the home to a comfortable level, whilst at the same time reducing the humidity to eliminate the 'stickiness' associated with summers. Doors and windows can be kept closed improving the security of your home, whilst at the same time keeping out nuisance insects and any external noise pollution. The air within the room is re-circulated through filters to trap dust and pollens, in turn benefiting people suffering from allergies and respiratory problems.

Since the last century it has been known that when a closed circuit of two dissimilar metals and two junctions is formed, a current will flow between the junctions. This happens when there is a temperature difference between the junctions or when the metals have different temperatures. The phenomenon is known as the Seebeck effect, and is the fundamental principal behind the thermocouple. Generally speaking, the greater the temperature differences, the higher the current Also, the combination of metals that are used will affect the current flow. Using different metals produced cooling devices that had very poor coefficient of performances (COP). This was because materials with high temperature conduction co-efficient were used partly because of excessive temperature conduction between the hot side and the cold side of the thermo-electric heat exchanger. Since the discovery of semiconductors, the co-efficient of performance of the TEC was drastically improved since materials could be used with low temperature conduction co-efficient but by doping it, the semiconductor could be made to conduct, exerting electrical conduction properties found in metals Thermoelectric modules have no moving parts and do not require the use of chlorofluorocarbons.

Therefore they are safe for the environment, inherently reliable, and virtually maintenance free. They can be operated in any orientation and are ideal for cooling devices that might be sensitive to mechanical vibration. Their compact size also makes them ideal for applications that are size or weight limited where even the smallest compressor would have excess capacity. Their ability to heat and cool by a simple reversal of current flow is useful for applications where both heating and cooling is necessary or where precise temperature control is critical.

2.1 Comparison of thermoelectric refrigeration and other methods of refrigeration

- **Thermoelectric**: Cooling is achieved electronically using the "Peltier" effect heat is pumped with electrical energy.
- **Compressor**: Cooling is achieved by vaporizing a refrigerant (such as freon) inside the refrigerator heat is absorbed by the refrigerant through the principle of the "latent heat of vaporization" and released outside the refrigerator where the vapour is condensed and compressed into a liquid again. Uses mechanical energy.
- **Absorption**: Cooling is achieved by vaporising a refrigerant (ammonia gas) inside the refrigerator by "boiling" it out of a water ammonia solution with a heat source (electric or propane). Uses the principle of "latent heat of vaporisation". The vapour is condensed and reabsorbed by the ammonia solution outside the refrigerator. Uses heat energy.

3. METHODOLOGY

3.1 Solar Cooling Options

The conventional refrigeration and space conditioning devices are based on vapour compression machines and need electrical energy and/or fossil fuels for their operation. With the advent energy crisis and the realization the depleting nature of the fossil fuels, the search for the use of alternative energy sources become an essentiality. Solar energy has a very high potential amongst renewable sources of energy since it is abundantly available and is an inexhaustible global source of energy having no pollution hazards associated with it.

3.2 Circuit Description

When a heat exchanger operates, a liquid or a gas acts as the cooling medium, carrying the heat from the cold side to the hot side of the heat exchanger. The liquid or gas acts as the heat carrier. In a thermo-electric heat exchanger the electrons acts as the heat carrier. The heat pumping action is therefore a function of the quantity of electrons crossing over the p-n junction. Since the amount of current in a conductor represents the quantity of electrons flowing in a conductor, it can therefore be said that the cooling effect in a thermo-electric heat pump is directly proportional to the current flowing through the device.

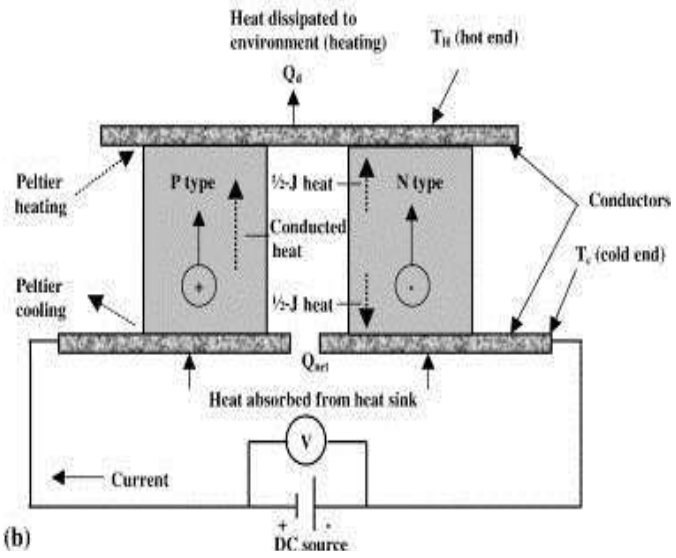

Fig.3.1: Circuit Diagram

The TEC consists of a p-n material junction. The operation can also be explained using the p-n junction theory usedin diodes – the most simple semiconductor device. If a LED (light emitting diode) is analyzed, it can be seen that the light that is produced by LED, follows the same principle as thermoelectric cooling. In p-material, the charge carriers are holes and in n-material the charge carriers are electrons. The free electrons in the material move in the conduction band, and movement will only take place under the influence of an applied voltage. This is known as electron motion. The hole transfer in p-material is a process in which energy levels in the valence band are not occupied by an electron. Holes, as with electrons, move in the valence band, but in the opposite direction. In any p-n junction where a voltage is applied, the holes and the electrons continually recombine (when current flows from the n-material to the p-material). In the case of the LED, electron flow is from the p-material to the n-material. The electrons move from the conduction energy level (n-material) to the valence band (p-material).

The change energy level from a higher energy level to a lower energy level causes the electron to give off energy and this energy is given off in the form of visible light the same principle can be applied to thermo-electric cooling. As the electron moves from the higher energy state in the n-material to a lower energy state in the p-material energy is released (heating effect). If the electron moves from the p-material to the n material, energy is absorbed because the electron moves from a lower energy level to a higher energy level, needing additional energy to cross the junction, which in the case of thermo-electric cooling, is obtained in the form of heat.

A thermo-electric cooler can be constructed by connecting many p-n junctions in series. Consider a pn-p junction in a thermo-electric cooler; when the electron moves across the p-n junction, heat is absorbed due to the change from a lower energy level to a higher energy level, causing a cooling effect As the electron moves across the n-p junction, the electron moves from a higher energy level to a lower energy level, causing the electron to give off energy, causing a heating effect A heat pump is then formed, pumping heat (energy) from the cold side to the hot side. If the current is reversed, the cold side will change into the hot side and the heat will be pumped into the opposite direction.

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