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"A REVIEW ON THRMOELECTRIC REFRIGERATOR"

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Abstract ***– The global increasing demand for refrigeration in field of refrigeration and air-conditioning, food preservation, vaccine storages, medical services, and cooling of electronic devices, led to production of more electricity and consequently more release of CO_2 all over the world which it is contributing factor of global warming on climate change. Thermoelectric refrigeration is new alternative because it can convert waste electricity into useful cooling, is expected to play an important role in meeting todays energy challenges. Therefore, thermoelectric refrigeration is greatly needed, particularly for developing countries where long life and low maintenance are needed. Thermoelectric refrigeration is an eco-friendly (sustainable) technique used for producing refrigeration effect. Thermoelectric devices are developed based on Peltier, Seebeck and Thomson effect which has experienced major advancement and development in recent years. This review paper is based on thermoelectric refrigeration system, explored by the many researchers. This paper encapsulates the advancement in thermoelectric refrigeration with the help of solar panel, design methodologies, application in domestic appliances.***

INTRODUCTION

In many cases, people cannot afford a regular size of refrigerator due to economic problem. Available refrigerators in market consume more than 500W power which is quite difficult for the people living in remote areas. To reduce this type of problems thermoelectric refrigerator can be designed with easily available off-the-shelf component at very low costIt is using thermoelectric module, doesn't use any gas so it is an eco-friendly device. It is using heat sinker to absorb the heat dissipated. The overall size is small so it covers small space.[1] Thermoelectric refrigeration system is powered by SMPS (switch mode power supply). It is a power handling electronic component that converts electrical power conductively. On the other hand the power supply for thermoelectric refrigeration solar photo voltaic (PV) cell generated DC voltage is also suitable for Indian climatic conditions and applicable for rural health centers. Due to proper design of solar devices radiation in the climate will be reduced. In this type of devices energy losses is also there i.e. in the SMPS and power conditioning equipment and the losses also occurs due to mismatch of module in the solar panel.[2] A thermoelectric module thus uses a pair of fixed junctions into which electrical energy is applied causing one junction to become cold while the other becomes hot. Because thermoelectric cooling is a form of solid-state refrigeration, it has the advantage of being compact and long lasting. It uses no moving parts except for some fans, employs no fluids, and do not require bulky piping and mechanical compressors used in vapour-cycle cooling systems. Such sturdiness favour thermoelectric cooling over conventional refrigeration in certain situations. The compact size and weight requirements, as well as portability in the design, rule out the use of conventional refrigeration.[3]

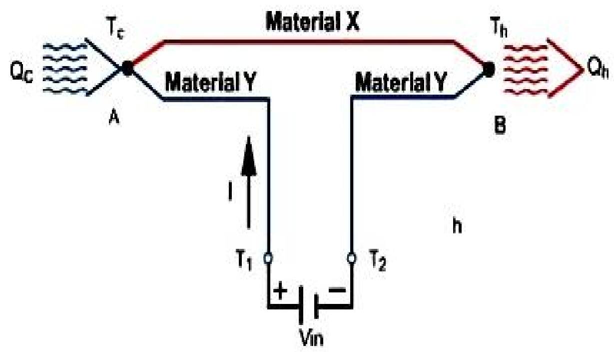

Fig. No. 1.1 Peltier Effect

I. LITERATURE REVIEW

Our Thermoelectric refrigeration is inspired by the following inventions as follows;

Thermoelectric cooling :-

In Thermo-electrical refrigeration system, the Peltier effect is the phenomenon of to create a heat flux between the junctions of two different types of materials. A Peltier heater, cooler or thermoelectric heat pump is a solidstate active heat pump, which convert heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC).Thermoelectric cooling uses the Peltier effect to create a heat flux between the junctions of two different types of materials. They can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools. This technology is far less commonly applied to refrigeration than vaporcompression refrigeration. The main advantages of a Peltier cooler are its lack of moving parts or circulating liquid, near-infinite life and potential to avoid leaks, and its small size and flexible shape. Its main disadvantage is high cost and poor power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient.[4]

SEEBECK Effect:-

When the two junctions of a pair of dissimilar metals are maintained at different temperatures, there is the generation of emf (electromotive force).He conducted a series of tests by varying the temperatures of the junctions of various combinations of a set of materials. The emf output was found to be:

$\Delta E \ \alpha \ \Delta T$……………………………...(1)

Where ΔE and ΔT the emf output and the temperature difference of the junctions. The phenomenon of generation of emf is called Seebeck effect the proportionality constant of Eq.1is denoted by

$\alpha ab = \Delta E / \Delta T$…………………………(2)

and is called Seebeck coefficient or the thermo electric power. It is to be noted that αab(αa- αb) is the coefficient for a pair of different metals (A and B or P and N or p and n).[4]

Thermoelectric Effect:-

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates a voltage when there is a different temperature on each side. Conversely when a voltage is applied to it, it creates a temperature difference (known as the Peltier effect). At atomic scale (specifically, charge carriers), an applied temperature gradient causes charged carriers in the material, whether they are electrons or electron holes, to diffuse from the hot side to the cold side, similar to a classical gas that expands when heated; hence, the thermally induced current. This effect can be used to generate electricity, to measure temperature, to cool objects, or to heat them or cook them. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices make very convenient temperature controllers. Traditionally, the term thermoelectric effect or thermoelectricity encompasses three separately identified effects, the Seebeck effect, the Peltier effect, and the Thomson effect. In many textbooks, thermoelectric effect may also be called the Peltier–Seebeck effect. This separation derives from the independent discoveries of French physicist Jean Charles Athanase Peltier and Estonian-German physicist Thomas Johann Seebeck. Joule heating, the heat that is generated whenever a voltage is applied across a resistive material, is somewhat related, though it is not generally termed a thermoelectric effect (and it is usually regarded as being a loss mechanism due to non-ideality in thermoelectric devices). The Peltier–Seebeck and Thomson effects can in principle be thermodynamically reversible, whereas Joule heating is not. [5]

Spin Seebeck Effect and Magnetic Batteries:-

Physicists have recently discovered that heating one side of a magnetized nickel-iron rod causes electrons to rearrange themselves according to their spins. This so-called "spin Seebeck effect" could lead to batteries that generate magnetic currents, rather than electric currents. A source of magnetic currents could be especially useful for the development of spintronics devices, which use magnetic currents in order to reduce overheating in computer chips, since, unlike electric currents, steady magnetic currents do not generate heat.

Thermoelectric cooling uses the Peltier effect to create a heat flux between the junction of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active 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. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). Because heating can be achieved more easily and economically by many other methods, Peltier devices are mostly used for cooling. However, when a single device is to be used for both heating and cooling, a Peltier device may be desirable. Simply connecting it to a DC voltage will cause one side to cool, while the other side warms. The effectiveness of the pump at moving the heat away from the cold side is dependent upon the amount of current provided and how well the heat can be removed from the hot side.

Refrigeration

Peltier effect devices could reduce the emission of ozone-depleting refrigerants into the atmosphere. Hydrochlorofluorocarbons (HCFCs) and now-obsolete chlorofluorocarbons (CFCs) deplete the ozone layer. CFCs were replaced by HCFCs, however, the latter also impact the ozone and are being phased out. International legislation caps HCFC production and prohibits production after 2020 in developed countries and 2030 in developing countries. Thermoelectric refrigeration units could reduce the use of such harmful chemicals and reduce noise levels because they do not require compressors.) Common (vapor compression) refrigerators remain more efficient than peltier refrigerators, but they are larger and require more maintenance. A ZT>3 (about 20-30% Carnot efficiency) is required to replace traditional coolers.[5]

Solar Energy

Solar energy is one of the most well-known green sources of energy. Solar absorption refrigeration systems increasingly attract research interests. The performance of the refrigerator was simulated using Mat lab under varying operating conditions. The system consisted of the refrigeration chamber, thermoelectric modules, heat source and heat sink. When two conductors are placed in electric contact, electrons flow out of the one in which the electrons are less bound, into the one where the electrons are more bound. The performance of thermoelectric solar refrigerator was simulated using Mat lab under varying operating conditions. The system consisted of the thermoelectric solar refrigeration chamber, thermoelectric modules, heat source and heat sink. Results show that the coefficient of performance (C.O.P) which is a criterion of performance of such device is a function of the temperature between the source and sink.

Construction

Thermoelectric Refrigeration are constructed using two parts of semi-conductors, one n-type and other p-type , The flow of Direct current across the joint of the two semi-conductors creates a temperature difference. As a result of the many temperature difference, Peltier cooling causes heat to be absorbed from the cooling plate and to move to the end of the device.

The thermo electric heat is carried through the cooler by electron carriage and liberated on the in front of side as the electrons gate from a high to low energy state. When the two materials are connected to each other by an electrical conductor, a new equilibrium of free electrons is established.

A new dimension has been added to the cooling challenge by reduction of temperatures using thermoelectric solar refrigeration, with the regular demand for improved cooling technology to enhance performance, reliability and reduction in operating cost, a thermoelectric cooling may be considered a potential candidate.

Thermoelectric solar refrigeration technology has been used practically in wide areas recently. The thermoelectric solar refrigeration devices can act as coolers, power generators, or thermal energy sensors and are used in almost all the fields such as military, aerospace, instrument, biology, medicine and industrial or commercial products and use of rulers acres in easily. A temperature reduction of 12oC without any heat load and 10oC with 100 ml of water in refrigeration space at 24oC ambient temperature in first 30 minutes has been experimentally found at optimized operating conditions.

MATERIAL REVIEW

Thermoelectric module is made of two different semiconducting materials, which generate thermoelectric cooling effect (Peltier effect) when a voltage of similar polarity & in appropriate direction applied through the connected junction. Two heat sinks & fans are attached to hot and cold sides of thermoelectric module in order to enhance heat transfer and system performance.

There exists an optimum current & optimum voltage for maximum coefficient of performance (COP) for a specific module and fixed hot/cold side temperatures.

According to the primary criterion of figure of merit;

$$\left(Z = \frac{\alpha^2}{RK}\right).$$

a good thermoelectric material should have high Seebeck coefficient, high electrical conductivity, and low thermal conductivity. Commonly used thermoelectric materials are Bismuth Telluride (Bi2Te3), Lead Telluride (PbTe), Silicon Germanium (SiGe) and Cobalt Antimony (CoSb3), among which Bi2Te3 is the most commonly used one. These materials usually process a ZT value (figure of merit at temperature) less than one. From 1960s to 1990s, developments in materials in the view of increasing ZT value was modest, but after the mid-1990s, by using nano structural engineering thermoelectric material efficiency is greatly improved. Thermoelectric materials such as primary bulk thermoelectric materials like skutterudites, clathrates and half-Heusler alloys, which are principally produced through doping method are developed but not exploited for commercial use. The best commercial thermoelectric materials currently have ZT values around 1.0. The highest ZT value in research is about 3. Other best reported thermoelectric materials have figure-of-merit values of 1.2-2.2 at temperature range of 320-5200C. It is estimated that thermoelectric coolers with ZT value of 1.0 operate at only 10% of Carnot efficiency. Some 30% of Carnot efficiency could be reached by a device with a ZT value of 4. However, increasing ZT to 4 has remained a formidable challenge. Bell also mentioned that if the average ZT reaches 2, domestic and commercial solid-state heating, ventilating and air-cooling systems using thermoelectric material would become practical.[7]

Working :-

Thermoelectric coolers operate according to peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When current flows through junction of two conductors, heat removed at one junction and cooling occurs. Heat is deposited at other junction.

The main application of peltier effect is to generate cooling. However the peltier effect can also be used for heating or control of temperature. In every case, DC voltage is required.

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Fig No. 2 Experimental Setup

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