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Design and Performance Evaluation of A Refrigeration System Utilizing The Peltier Cooling Effect

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Abstract

A domestic refrigerator with 5star rating and having capacity 180 Liters consumes 265 units per year. In India average cost of electricity consumption per unit for domestic usage up to 100 units is Rs 5.31per Unit and beyond 300 units it is Rs.8.95 and for industrial it may go beyond Rs 10.45/kWh. This scenario demands for alternative cooling technology that can replace totally VCR (vapour compression refrigeration) system. This thesis provides a better understanding of application of thermoelectric cooling technology in refrigerant subcooling. It investigates the methods to improvise the performance of the VCR system by using thermoelectric subcooling of the refrigerant. This technology can be utilized along with conventional refrigeration system to produce improvised hybrid cooling system. Therefore, the main objective of this thesis is to experimentally study the variation in performance parameters of the vapor compression refrigeration system when refrigerant is sub cooled by thermoelectric Peltier cooling module. Experiments are carried out on the freezer section of vapor compression refrigeration system by varying the load and performance is evaluated. The refrigerant is subcooled by thermoelectric cooling module after condenser to improve refrigerating effect subsequently COP. Performance parameters are measured & compared for with and without subcooling of the refrigerant. Coefficient of performance, power consumption per ton of refrigeration is determined for different loads on evaporator by considering the heat loss in the evaporator constant and neglecting it as the same evaporator is used for all experimentation. The effect of subcooling of refrigerant by Peltier cooling is also studied to optimize the use of subcooling for the refrigeration system. The consecutive experiments are carried about with improvisation to reach best results to know the working behaviour of TEC cooling modules.

Keywords: Vapor compression refrigeration, COP, thermocol, Peltier Coolers, TEC cooling modules.

INTRODUCTION

Refrigeration & air-conditioning eats nearly 20 percent of world's total energy demand of consumption of energy. Vapor compression refrigeration (VCR) is widely used in industrial & domestic applications. Higher price of electricity demands for performance improvement of system. A domestic refrigerator with 5star rating and having capacity 180 liters consumes *265 units per year*. In India average cost of electricity consumption per unit for domestic usage up to 100 units is Rs 5.31 per Unit and beyond 300 units it is Rs.8.95 and for industrial it may go beyond Rs 10.45/kWh. This scenario demands for alternative cooling technology that can replace totally VCR system. After so many efforts in different areas in cooling technology still no breakthrough is achieved. But if we refer Table 1 Thermo acoustic, Thermo tunneling, Magnetic refrigeration techniques are still in prototype or experimental phase and very

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Table 1. Comparison of cooling technology.

Name of technology	Maximum carnot efficiency %	Developmental state	Optimum carnot efficiency percent	Barriers in development	Eligibility to compete with VCR system
Magnetic	50-65	Prototype	25	Lowest	Better
Thermo tunneling	50-85	Only experimentation	No data	High	Medium
Thermo acoustic	65-90	Prototype	20	Higher	Better
Thermoelectric	28 -30	Available commercially	10-16	Higher	Good
Thermionic	20-30	Only experimentation	< 10	High	Poor
Vapor compression	70-80	Available commercially	65	Already developed	----

few players are in thermo tunneling area. Thermionic cooling technology is in experimental phase and development barriers are very high therefore these technologies cannot compete with VCR cooling technology. Thermoelectric cooling is having medium development barriers and Carnot efficiency is 10-15% this technology is commercially developed with so many players in R&D. Thermoelectric cooling technology has many advantages which are highlighted in next topic but it has disadvantage of very low figure of merit (FOM) & that's why it cannot replace completely VCR technology. Gurevich and Logvino [1] have explained the fundamentals of thermoelectric cooling, enveloping advanced thermoelectric materials with superior thermoelectric properties. Today's commercially available thermoelectric modules having ZT nearly equal to 1 are inefficient to compete with present vapor compression refrigeration systems.

Gao & Rowe [2] in their paper illustrated that the energy efficiency of thermoelectric coolers & refrigerators, made up from currently available materials and technology, is still lower than traditional vapor compression refrigeration technology. But Thermoelectric refrigerators are available in market with higher COP.

This may lead us to think about development of modified & more efficient vapor compression refrigeration system with lower consumption of electricity. The hybrid technology is the best option in which thermoelectric cooling module is used to sub cool refrigerant of VCR cooling system. Pottker and Hrnjak [3] investigated experimentally that the system COP of the VCR system can be increased up to 9% by subcooling R134a after condenser & 18% for R1234yf (2,3,3,3 – tetrafluoropropene)

Yang et al. [4] in his paper proposed a hybrid system which uses thermoelectric sub cooler to increase the subcooling temperature in a VCR system for lifting lower temperature. Thermoelectric COP is higher for 5^0C temperature lift.

Riffat & Xiaoli Ma [5] illustrated the cooling potential of thermoelectric cooling technology as thermoelectric cooling modules are cooling device with no moving parts, solid state & low temperature working range it work effectively and can be used for subcooling the refrigerant. The life test has shown that, if thermoelectric coolers are operated at steady state it will work for more than 100000 hours.

Radermacher [6] in his paper illustrated that sub cooling can be obtained by using additional thermoelectric cooling system. Therefore these thermoelectric cooling modules are used to sub cool the refrigerant after condenser ultimately improving the actual COP. Subcooling of refrigerant is cooling the refrigerant under saturation temperature after condensation. Subcooling increases the refrigeration effect and COP.

Rosca et.al. [7] experimentally showed that as degree of sub cooling increases COP of the refrigeration system increases constantly. For thermoelectric sub cooling COP increases to its highest value 2.507 when degree of sub cooling is 5K. Bilal Qureshi et.al.[8] illustrated that degree of sub cooling is increases consistently with decrease in ambient temperature i.e. for lower ambient higher degree of sub cooling can be obtained. During day time approximately 5^0C to 8^0C degree of sub cooling is obtained, subsequently increases cooling capacity of evaporator. Substantial increase in COP can be produced by sub cooling of liquid refrigerant which minimizes throttling losses [9-40].

Basnsal et.al.[41] in his paper mentioned that the improvement in performance of thermoelectric module is only possible when electrical conductivity of the materials used should be high and difference between seebeck coefficient of the material should be high along with lower thermal conductivity and these conditions are highly difficult to achieve.

Peltier effect is used to sub cool the refrigerant and ultimately can improve coefficient of performance (COP). Thermoelectric devices works as thermal engines without moving parts. These devices are able to convert heat into electricity or work as heat pump, heat is pumped from cold to hot surface. Peltier Coolers are thermoelectric coolers made up from semiconducting materials are solid-state devices with no moving parts, reliable, compact & quiet. We can control the temperature ($< \pm 0.1$°C) with Peltier coolers. Available material of thermoelectricity is having very low figure of merit and cannot completely replace conventional refrigeration. By using thermoelectric cooling technology with conventional vapor compression refrigeration, we can achieve the lower consumption of electricity.

This dissertation aims to develop a hybrid system consisting of vapor compression refrigeration system with thermoelectric subcooling. In this system TEC cooler is used to sub cool the refrigerant and lower the electric consumption for the given refrigeration effect. The performance analysis of a system will definitely help to modify the conventional system using Peltier effect. The COP is increased but we have to select the perfect pair of thermo electric materials from thermoelectric series.

Design of Thermoelectric Cooling Device with Heat Pipe

For heat dissipation at hot side heat pipe technology will be used as performance of the TEC module depends upon how fast heat dissipates from hot end. By taking the reference of this development design of the subcooling device is to be finalized for the domestic VCR refrigerator

Experimentation of Hybrid System (VCR with TEC)

For the different types of load the experimentation is carried out with and without sub cooling the performance of the system will be measured. Comparative charts will be prepared. With an emphasis on the sub cooling of the refrigerant by TEC assembly we have to fabricate a separate system after the condenser to regulate the cooling effect for different environmental conditions. The consumption of electricity is analyzed and hybrid refrigeration system with reduced electricity consumption per tonne.

Scope of the Work

The scope of this work is to check the cooling potential of TEC module to sub cool the refrigerant. The selection of appropriate thermoelectric module to pump required heat along with the heat sink and fan. Experimental investigation is carried out with subcooling and without subcooling for different load & for different configurations of the TEC modules performance is tested. A hybrid system with TEC module with effective heat dissipating device is to be developed to increase the refrigerating effect.

The scope of the dissertation is to develop an effective thermoelectric device to subcool the refrigerant of VCR system & check the performance of the hybrid VCR system for following parameters (1) Refrigerating effect (2) Power Consumption/TR (3) Actual COP.

LITERATURE SURVEY

In this literature survey most papers are focusing on the effectiveness of the thermoelectric material in the cooling technology. The design & development of the device to sub cool the refrigerant is possible as the precise control of the current is possible in these TEC cooling modules. The selection of the proper thermoelectric cooling module is possible. Even the Figure of Merit of available TEC module is not more than 2. The thermoelectric technology cannot replace completely VCR technology but can be used in hybrid system to reduce the electrical consumption.

The extensive utilization of Thermoelectric cooling technology to improvise the performance of VCR system is still not in the industry this is gap. Little research has been done on this opportunity. One can improvise the working of VCR system by hybridizing this new technology as this technology cannot completely replace the he VCR system but this can be effectively used for the subcooling the refrigerant. This TEC cooling module along with heat dissipation assembly can give best results. The major focus of the research paper is still on improvement of ZT of thermoelectric material but available material with $ZT = 1$ can also be utilized for improvement in VCR system. The required subcooling in VCR system can be effectively achieved on account of low energy consumption which might reduce the size of the condenser in future therefore the proposed work is having great opportunity in commercial market as TEC modules are commercially available with a very high reliability and good compact structure.

Therefore the extensive research must be done on the application of thermoelectricity for improvisation of VCR system like Hybridization used in automotives to add electrical technology for part load. Similarly thermoelectric technology can be added to VCR system to take major responsibility to sub cool the refrigerant and improve the performance.

Final conclusion of this literature survey is design TEC cooling module apply it to VCR system analyze the results and improvise in consecutive experiment.

METHODOLOGY

Introduction to VCR and Sub Cooling

Vapor Compression Refrigeration

Vapour compression refrigeration system is most practical form of refrigeration and extensively used in domestic and industrial applications. The refrigerant alternatively condenses and boils on account of its latent heat without leaving the system. During evaporation it absorb heat from space to be cooled or object to be cooled and rejects heat to the medium colder that it usually air or water as a cooling medium. Refrigeration systems are nothing but latent heat pumps which pumps the latent heat from clod body to hot body. The input to the system is electrical energy supplied to the compressor to compress the refrigerant to pump the heat from cold to hot body.

Vapour compression refrigeration cycle is used in large industrial plants as well as small domestic refrigeration purposes. The working substance entering into the compressor is assumed to be a saturated vapour and compressed isentropic ally in the compressor this high pressure vapour refrigerant is condensed on account of its latent heat of condensation and it gets converted into liquid, this liquid is expended at constant enthalpy to lower pressure and lowest temperature, this lowest temperature liquid refrigerant enters into the evaporator and absorb surrounding heat by producing refrigerating effect.

Vapour Compression System Components

Compressor

Compressor works between two pressure low and high pressure. The low pressure and high temperature vapour enters from evaporator and it is compressed to high pressure and delivered to condenser.

Condenser

In condenser at high pressure refrigerant is cooled and condensed to low temperature on account of its latent heat. Vapour refrigerant rejects its latent heat to cooling medium and gets converted into liquid at high pressure.

Expansion Valve

The high pressure liquid refrigerant enters into expansion valve where it expands to lower pressure. It is assumed that enthalpy remains constant during this process. some of liquid refrigerant gets converted into vapour as the refrigerant is expended through small conduit with controlled rate of flow. The temperature of the refrigerant reduces considerably after expansion which is used for generation of refrigerating effect.

Evaporator

Very low temperature refrigerant enters into the evaporator where it absorbs latent heat from the space to be cooled or object to be cooled absorbing the heat equal to its latent heat of vaporization. The vapor at low pressure produced is supplied to compressor.

Working of Vapor Compression Refrigeration System

As shown in Figure 1 at point B the condition of refrigerant is low pressure vapor enters into the compressor. It is compressed into compressor and delivered at high pressure to condenser at point C .This high pressure refrigerant is condensed in to liquid and supplied to expansion valve at point D

Then it is expanded to lower pressure and finally producing the refrigerating effect on account of latent heat. The refrigerant undergoes phase change from liquid to vapor and vice versa and refrigerating effect is produced [42-44].

The exchange of energy is as follows:

1. The work required by the compressor is δw and supplied from surrounding to the system.
2. Heat δQ_1 is lost in the condenser which is equivalent of latent heat of condensation.
3. Heat δQ_2 is absorbed by refrigerant in evaporator which is equivalent to latent heat of vaporization.
4. Throttling process is carried out at constant enthalpy.

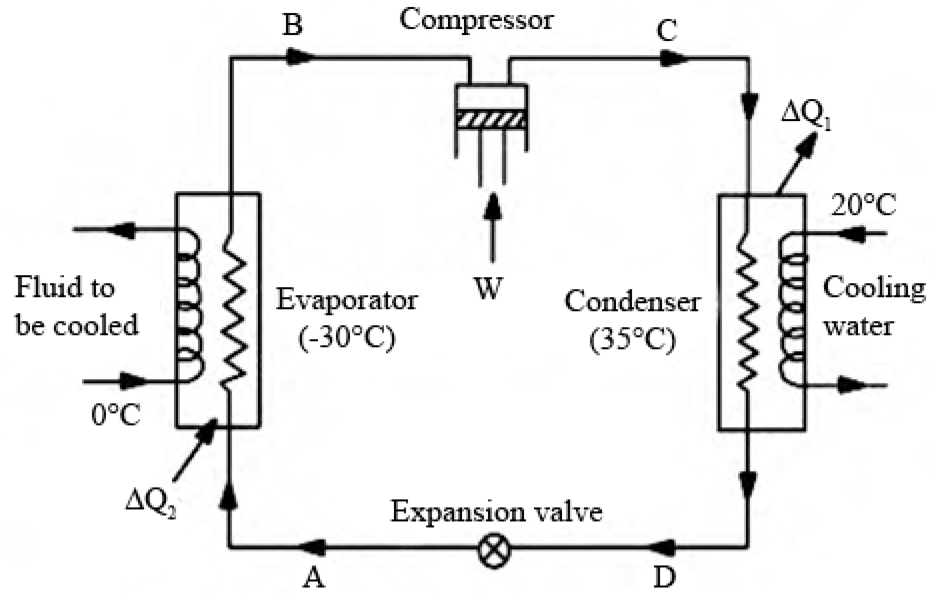

Figure 1. Vapour Compression Refrigeration Cycle.

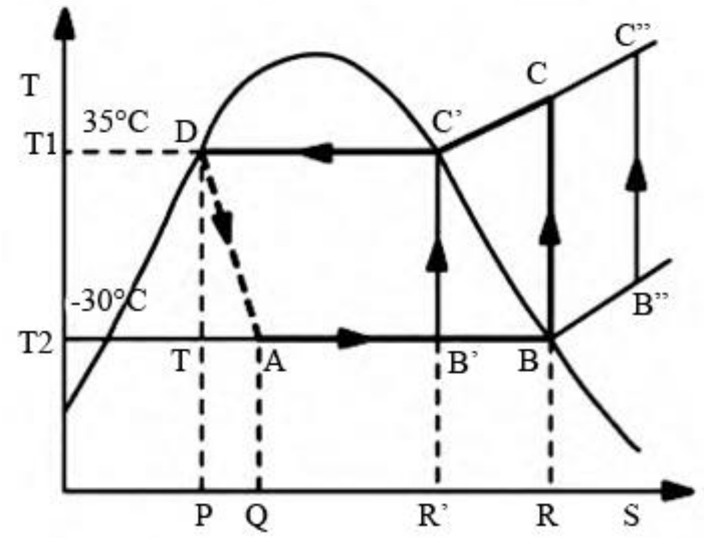

Figure 2. T-S diagram.

Figure 2 shows a simple vapor compression refrigeration cycle on T-s diagram for different compression processes. Cycle works between condensing temperature T_1 and evaporating temperature T_2 respectively. The various process of the cycle A-B-C-D (A- B'-C'-D and A-B"-C"-D) are as given below:

1. *Process B-C (B'-C' or B"-C"):* The process B-C is isentropic compression where the state of refrigerant is saturated and B' to C' is wet compression & B''-C'' is superheated compression.
2. *Process C-D :* constant pressure heat rejection in condenser
3. *Process D-A:* Isenthalpic expansion process. It is practically irreversible process.
   i. *Process A-B:* isobaric heat absorption.
   ii. *COP of vapor compression cycle:*

$$C.O.P. = \frac{Heat\ absorbed\ at\ evaporator}{Work\ input} = \frac{h_b - h_a}{h_b - h_c}$$

Subcooling

The refrigerating effect can be increased and compressor power can be reduced by subcooling the refrigerant. For 1% reduction in operating cost 2^0C subcooling is required. In Figure 3 T-H diagram shown two different cycles one represent VCR cycle with subcooling and another is without subcooling. The decrease in temperature of refrigerant below saturation temperature is known as subcooling which subsequently increases the refrigerating effect and increases the COP Effect of condenser subcooling on the performance of vapor compression system is a theoretical and experimental study about the

1. As condenser subcooling increases, COP increases & condensing pressure increases and subsequently specific compression work also increases. Therefore there is tradeoff between these two things. The reduction of the air-refrigerant temperature difference increases the condensing pressure & is associated with the refrigerant-side heat transfer coefficient. The maximum COP increases with condenser subcooling due to thermodynamic properties related to increase in refrigerating effect like liquid specific heat & latent heat of vaporization.
2. R-134a is highly benefitted by subcooling.
3. This subcooling is achieved by thermoelectric cooling module

Introduction to Thermoelectric Cooling

The seebeck effect is discovered by Thomas seebeck in 1821. The peltier effect is discovered by jean peltier in 1834. Now a day's thermoelectric modules use modern semiconductor technology.TEC (Thermoelectric cooling module) is a semiconductor based electronic component that work as heat pump. When DC Power supply is applied across TEC module heat is transferred from one surface to

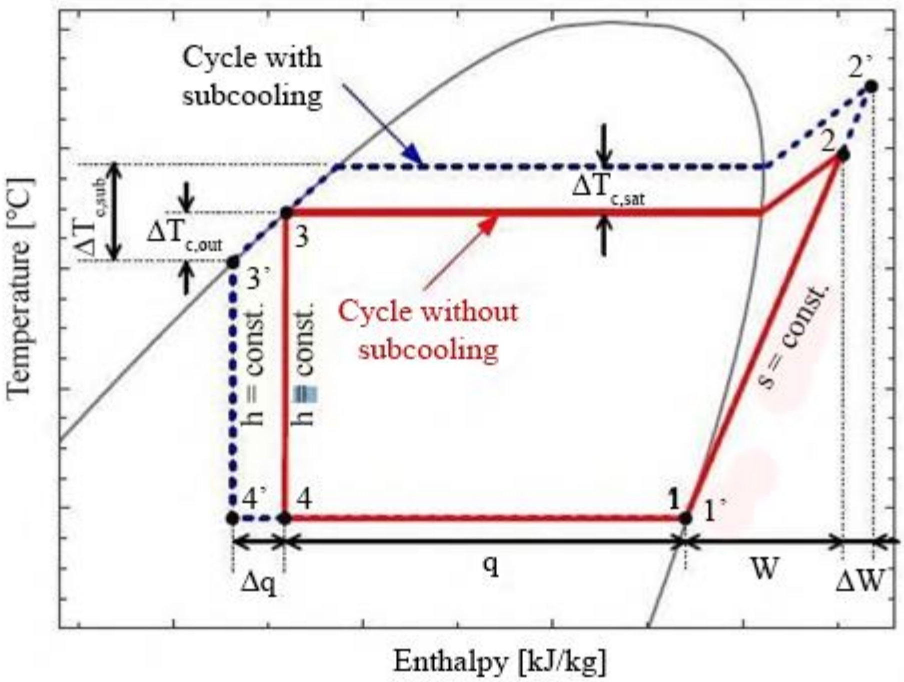

Figure 3. T-H diagram

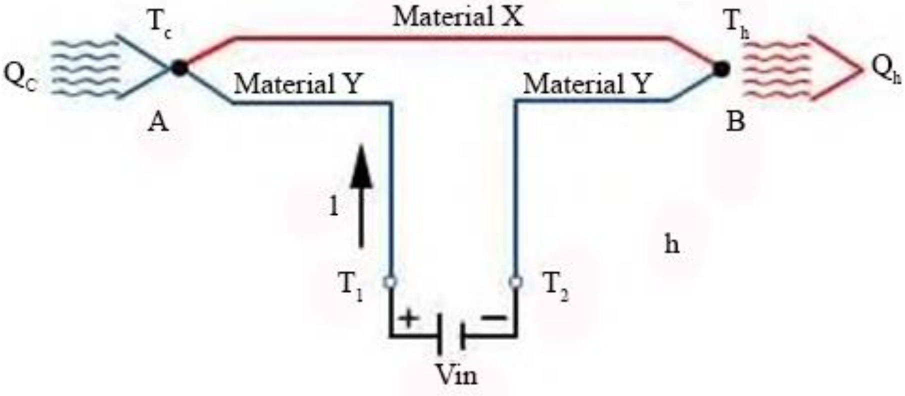

Figure 4. Peltier Effect schematic diagram.

another surface. Heat transfer is proportionate to current supplied so one surface becomes HOT and one becomes COOL. This phenomenon can be reversed by changing the polarity of connections. It can be used for applications where precise control is required. The thermoelectric module with heat sink at room temperature, when DC power supply is given to module cold side temperature reduces but at one point module stops pumping heat i.e. module reached its maximum rated DELTA T (DT). If heat was added to the module's cold side, the cold side temperature would increase progressively until it eventually equaled the heat sink temperature. At this point the TE cooler would have attained its maximum rated "heat pumping capacity" (Q_{max}).The electrons to move through the semiconductor material when DC current is supplied. Heat is absorbed by electrons at cold and rejected at hot end.

Peltier Effect

When two dissimilar metals are attached to each other forming two junctions as shown in the Figure 4 one junction becomes hot and other becomes cold, when DC Voltage is applied across these junctions. Heat produced or rejected at each junction is given by the formula.

$$q = (\alpha_A - \ ) \times \mathrm{I} \times \mathrm{T}$$

Where T is the absolute temperature of the junction, I is the current supplied α is the property of the material known as seebeck coefficient. It may be positive or negative. The α is much higher for semiconducting materials compared to 50µV/K for metals. The highest α can be achieved by best doping between suitable alloys of semiconductor to produce n-type semiconductor & p-type semiconductor.

With referring the Figure 4 if voltage V is applied across the junctions maintained at temperatures T_1 & T_2 heat is pumped from junction A to B. Junction A becomes cold & Junction B becomes hot. The Peltier effect can be expressed mathematically as:

$$Qc\ or\ Qh = p_{xy}\ x\ \mathrm{I}$$

P_{xy} is Peltier coefficient and I is current. The peltier coefficient is different for two junctions. It depends upon seebeck coefficient. This peltier effect can be reversed after by changing the polarity of DC current and it can be controlled precisely. This advantage can be utilized in precise measurement of different quantities. Thermoelectric peltier cooling effect can be used for subcooling when directly applied at the condenser side. Joules heating and conductive heat transfer reduces the cooling effect due to peltier. To obtain highest COP cold side temperature should be low and hot side temperature should be as high as possible is figure of merit as high as possible and is a function of temperature. The material with larger difference in their α values, high electrical conductivity, low thermal conductivity is required for highest COP. Commercially available thermoelectric are having ZT=1 at present and is not sufficient to compete with VCR cycle. The best ZT materials are found in heavily doped semi-conductors. Bi_2Te_3 (p-type)/Sb_2Te_3 (n-type) super lattices are reported to have ZT of 2.5 around room temperature. To produce energy efficient cooling units ZT should be 9.

The best ZT materials are found in heavily doped semi-conductors. BiTe3 (p- type)/Sb2Te3 (n-type) super lattices are reported to have ZT of _2.5 around room temperature.

Figure 5 shows simple TEC device consist of N-Type & P-Type semiconductor hooked up electrically in series and thermally in parallel. The current *I* is injected at bottom of N-leg semiconductor, current flows in upward direction & electrons are flowing in downward direction, as electrons are negatively charged these electrons are carrying heat from top to bottom generating peltier cooling effect at upper copper plate and dissipating heat to the bottom copper plate. The current then flows through the P- type leg and holes goes down carrying heat from top to bottom finally peltier effect is obtained at upper plate. The electrons flow at Fermi level or nearer to Fermi level in metals, but in semiconductors it flows above the Fermi level in conduction bands (N- type semiconductor) & below the Fermi level in valance band(P-Type semiconductor).

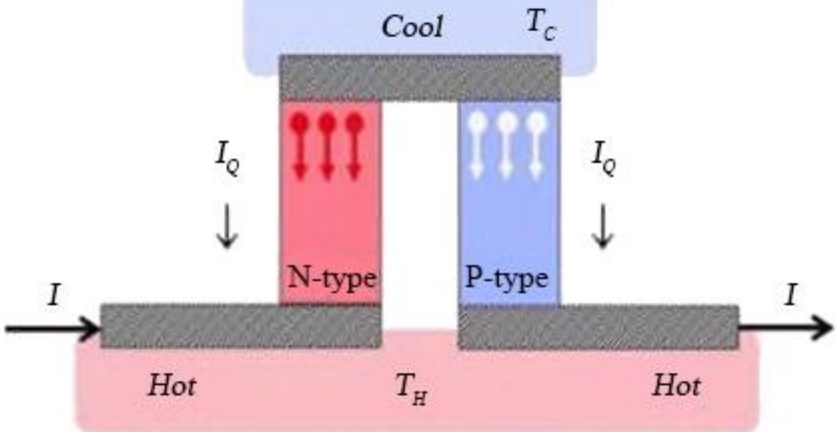

Figure 5. Path of Current flow in TEC Module.

RESEARCH METHODOLOGY

In this paper methodology of the said dissertation is illustrated. The dissertation emphasizes on development of hybrid system consisting TEC cooling module along with VCR system. This can be achieved by subcooling the refrigerant by Thermoelectric cooling module .In VCR system for required pressure difference initially compressor is selected; the capillary (expansion device) which match with the compressor is selected. The selection of condenser and evaporator depends upon pressure difference of the VCR system and capacity of the condenser and evaporator, this capacity is determined based upon the compressor and the expansion device and then suitable condenser and evaporator are selected for VCR system used for experimentation. Thermoelectric cooling modules are available in the market. Some manufacturers are Marlow industries, Komatsu, Ferrotec, kryotherm. So many manufacturers are involved in manufacturing with research and development work of the thermoelectric cooling & heat genaration devices. A simple procedure to select the module is calculate the active and passive load generated by the device to be cooled and determine the ratio between DT & DT_{max} plotting the points on the performance curves initially generated by the manufacturer . The intersection between I/I_{max} line and DT/DT_{max} gives the required voltage for TEC. The following activities are carried out during PhD research.

1. The literature survey has been carried out to study the work done on this topic.
2. Existing Practices in various industries have and relevant data regarding the topic is collected.
3. Methodology to conduct experiment and process of measurement of performance parameters is defined.
4. Experiments are carried out on basis of above parameters. Experimental results are formulated and analysis is performed.
5. Conclusions and documentation of dissertation work.

Following are the steps

i. Study of working of the Peltier effect & TEC module
ii. Study of Effect of subcooling On VCR system
iii. Selection of appropriate TEC Module for required heat load.
iv. Selection & fabrication of the TEC module with Heat sink & fan assembly (TEC assembly)
v. Checking cooling potential of the TEC assembly.
vi. Experimentation on cooling of aluminium plate in confined space & analysis of cooling potential in different ambient temperature.
vii. Experimentation to sub cool the refrigerant R-134a in VCR system for different loads.
viii. Different configurations of the refrigerant pipe are also utilized to increase the surface area of for thermoelectric subcooling of the refrigerant.
ix. Results & analysis of experimentation towards capability of the TEC subcooling.
x. Conclusion towards design of the TEC cooling Device for final experimentation.
xi. Implementation of heat pipe for heat dissipation on hot side of the TEC module
xii. Comparison & analysis of data obtained during experimentation for two different cases with subcooling & without subcooling.
xiii. Final conclusion about utilization of TEC module for subcooling.

EXPERIMENTAL ANALYSIS

As per methodology experiments are structured and conducted. There are five different experiments carried out. After each experiment the result is analyzed and improvisation is implemented in to the next consecutive experiment. Last experiment is sixth experiment in which heat pipe is used along with TEC cooling module.

Experiment on Surface Cooling of Aluminium Plate by TEC Assembly in Confined Space

Aim

To determine lowest average temperature of aluminum plate and the cooling effect obtained in the confined space when the plate is cooled by TEC cooling modules (Table 2).

Apparatus

Table 2. Apparatus.

S.N.	Particulars	Numbers	Specification
1	TEC cooling Modules	04	40mm x 40mm
2	Heat sink	04	120mm X 110mm
3	Variable DC power supply	01	12 volts 15 amp
4	Aluminum Plate	01	56cm x 45 cmx1mm
5	Fans	08	12volts & 0.18amps

Theory and Procedure

The experimentation is carried out to check the ability of TEC module to cool the aluminum plate and the cooling effect obtained in the confined space & to study the effect of heat dissipation through heat sink.

1. The cooling ability of TEC module is utilized to cool the aluminum plate and confined space. Four TEC modules with heat sink & fan are applied on the surface of the aluminum plate & cooling at four different points on the one side, another side is confined space in which available air is cooled and refrigerating effect is calculated. Temperature of the plate & air temperature is recorded. 250 ml of water is placed in the confined space to reduce the temperature using cooling effect generated by cooling the plate with TEC cooling module initial temperature of water is recoded and the test is carried for specified time. A 15amp current is supplied by using variable power supply to four cooling modules and fans on the heat sinks to dissipate the heat.
2. The aluminum plate is cooled at four different locations and the area covered by the Thermoelectric cooling module of the aluminium plate is (6400mm^2) for cooling purpose, the cooling effect is uniformly distributed to aluminum plate and the air inside the confined space is cooled
3. As the temperature inside the confined space reduces this can be utilized to cool the fruits and water and other food products
4. Confined space will work as freezer
5. Data logger and the printer is used to record the temperature reduction of the aluminum plate.

Experimental Setup

The aluminum plate is placed in the confined space made up of plywood along with thermocol for insulation. Four TEC1-12715 are placed on the surface of the aluminum plate which is surrounded by the plywood box having dimensions (540×440×392mm).Size of the confined box was chosen on higher side because large amount of air should be trapped inside the box we can calculate the cooling effect (Figures 6 and 7).

Construction of Inner Box

- Initially the plywood marked with required dimensions of inner box (540×440×392mm) and cut.
- blocks of 40×40mm were marked on the back plate of 540×440mm dimension and cut by means of cutter.
- The aluminum sheet having 560×450mm dimension with 12mm thickness was fixed on one side of the back plate with the help of nails.
- The back plate with aluminum sheet on one side is inner side of the box.
- All side of box was fixed together by means of nails
- The thermocol was cut as per the dimension of inner box in size of 654×554×461mm.
- Side which is used to insulate back plate was marked with 4 blocks of heat sink size (150×120mm) and cut.
- The 4 side of thermocol is then fixed to inner box by means of fevicol.

Figure 6. Inner Box

Figure 7. Back plate of inner box

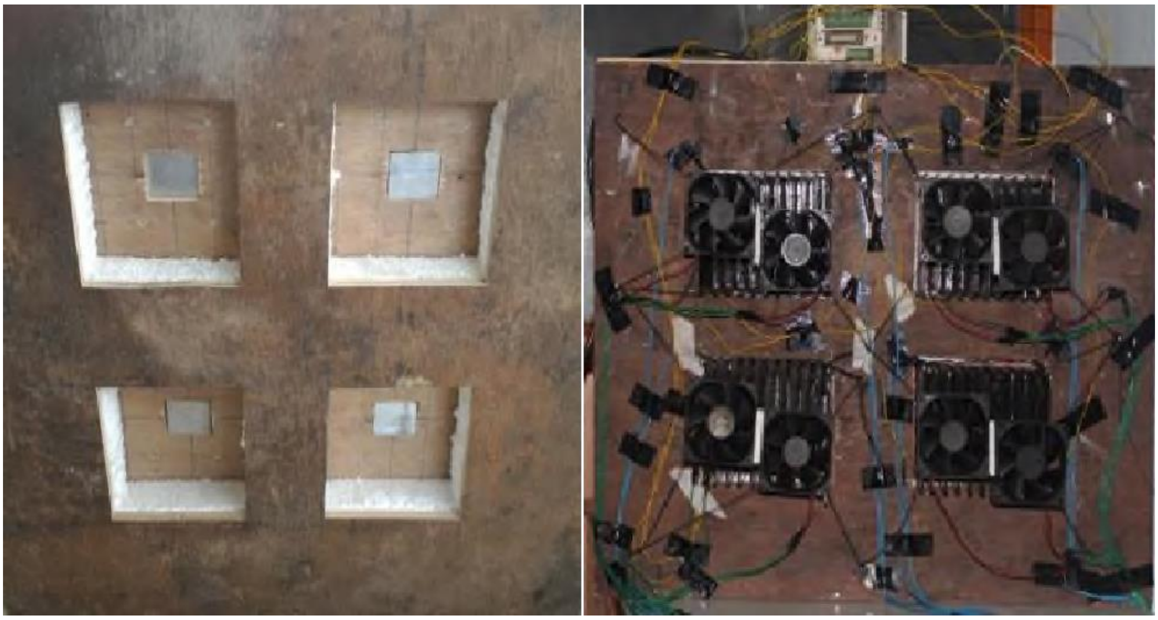

Figure 8. Experimental Setup

Manufacturing and Mounting of Outer Box

- Plywood was marked and cut by considering size of insulation for preparation of outer box.
- Dimension of outer box is
- blocks with heat sink dimension 150×120mm were marked and cut with the help of cutter similar to that of thermocol.
- The sides of outer box fixed with each other with the help of nails.
- The inner and outer box is fixed with the help of nails (Figure 8).

Selection of Module

The object to be cooled to 10 to 15°C, the amount of heat removed from the cold object is 120 watts. The ambient temperature 35^{0}C. The space to be cooled is 56cm x 45 cm. the power available to each TEC is 12VDC.The approximate temperature of the heat sink 50°C.

The Second TEC is Selected TEC1-12715

Figure 9 shows a TEC module having 127 couples size single module which is made of high performance 127 couples, size single module which is made of high performance in got achieve superior cooling performance and larger DT_{max}, is designed for superior cooling max current is 15amp.

Figure 9. Thermoelectric cooling module

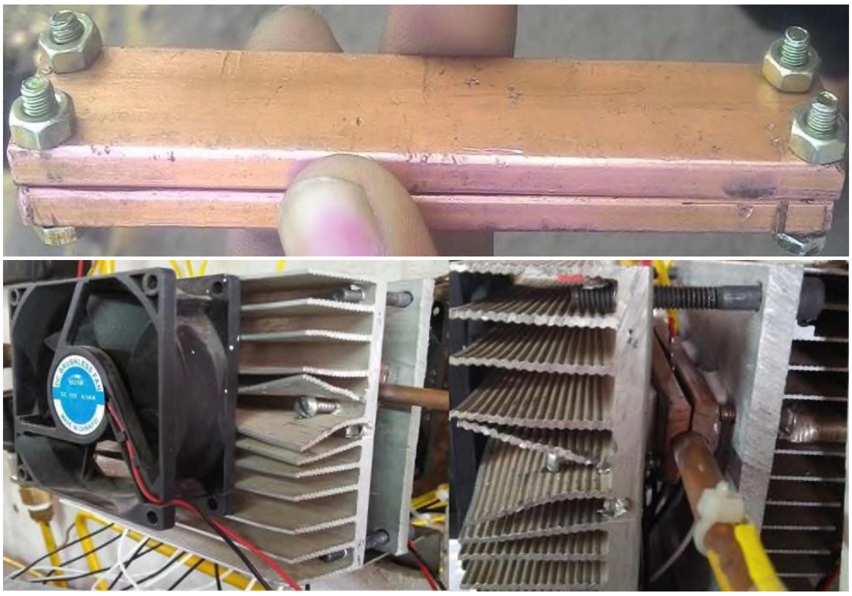

Figure 10. Overall assembly with Fan & Fastening of the heat sink.

WORKING

That assembly of the Copper block is placed in between condenser and expansion valve, when we required subcooling process the refrigerant will flow through this device, and supply is given to the pellets through the SMPS after getting supply the working of pellet starts which results in one side is get cold and other become hot. As refrigerant pipe is in contact with the bottom surface of copper block, and that surface is in contact with cold surface of pellets, when the DC power supply is given to the pellets one side is get cold which is cool the copper block and that block cools the refrigerant pipe which helps to lower down the refrigerant temperature, which is termed as subcooling (Figure 10).

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