PERFORMANCE IMPROVEMENT OF A REFRIGERATION SYSTEM WITH IMPLEMENTATION OF PCM

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ABSTRACT

The performance of a domestic refrigerator can be improved by incorporation of phase change material (PCM) with the evaporator. The features and properties of the refrigerant used in a refrigerator signify the heat storage and heat release rate. The utilization of PCM as the thermal storage will support in the advancement of coefficient of performance (COP) comprising the fresh cycle of refrigeration. The refrigerator or freezer is very important home appliances which consume a lot of energy. The biggest area of technical advancement is to incorporate electronic devices with better controls as well as insulation and can be used as replacement for refrigerators. However, environment friendly refrigerators for domestic purpose and energy efficient devices are cost effective, still upgradation in technology for instance labels of energy, standards comprising least efficiency and incentives among the industries are needed to improve the domestic refrigerators with innovative approach.

Keywords: refrigerator, cop, compressor,

INTRODUCTION

The sector of refrigeration industry has gradually enhanced as the illustration given from William Cullen, Scotland at the University of Glasgow by making the first man-made creating cooling effect on evaporating ether in 1748, to the development of exclusive machine for refrigeration based on vapor compression cycles by Jacob Perkins at London where he used ether as refrigerant in 1834. After the availability of electric energy on general basis, an automatic unit of electricity for a small size refrigerator was developed by William F. Singer in the year 1897 in New York.

With the introduction of electricity generating units the popularity of refrigerators increased and the homes were modified and wired accordingly. This led to the replacement of conventional iceboxes and window system used for cooling. The attention towards the domestic refrigerators and its increasing demand was helped by the design and improvement of fractional horsepower motors that were utilized on refrigerators. In the early 1920s the production of these units was started and proved to be essential for everyone.

The first unit that had successful air cooling system was the Isko. DOMELRE a hybrid and short form of Domestic Electric Refrigerator was marketed and designed by Fred W. Wolf. Nevertheless, the most significant associations were done by the Kelvinator and the General Electrics. The production of Audiffren machine by the General Electric was started in 1911 and in the year 1917, Kelvinator had sale of its first refrigerator. The most initial automatic control developed was a thermostatic switch which was established by Copeland for the Kelvinator. The unit of seal which removed the belt mechanism was incorporated by General Electric in year 1925.

In the present time refrigeration systems have become very essential in everyday life. The most important use of refrigerators is in the conservation of unpreserved food items and maintains the freshness of the food for long time. Undoubtedly, food is one of the vital aspects for any living being just like water and air. Additionally, refrigeration systems are utilized in generating thermal comfort and relaxation to people by the process of conditioning the air.

Refrigeration:

Refrigeration can be defined as the procedure of eliminating heat from a body or restricted space so as there is reduction of temperature first and then it is maintained low in comparison with the temperature of the surrounding. The device utilized to create the lowering of the temperature is known as refrigeration system.

Kinds of Refrigeration system

Refrigeration systems can be classified as:

There are two categories of refrigeration system

1. Systems comprising Vapour Compression Refrigeration (VCRS)

2. Systems comprising Vapour Absorption Refrigeration (VARS)

THERMAL ENERGY STORAGE

Thermal energy storages (TES) are essential for sound operation and improved performance of several processes carried out in industry comprising both cold and hot storages. The properties of any TES comprises of increased density storage with high energy in addition with high capacity in power related to discharging and charging. TES has emerged huge attention as it could be the most suitable method to justify the gap among the supply-demand chain. TES are categorized in three methods i.e. chemical storage of heat, latent heat storage and sensible storage of heat.

DOMESTIC REFRIGERATOR

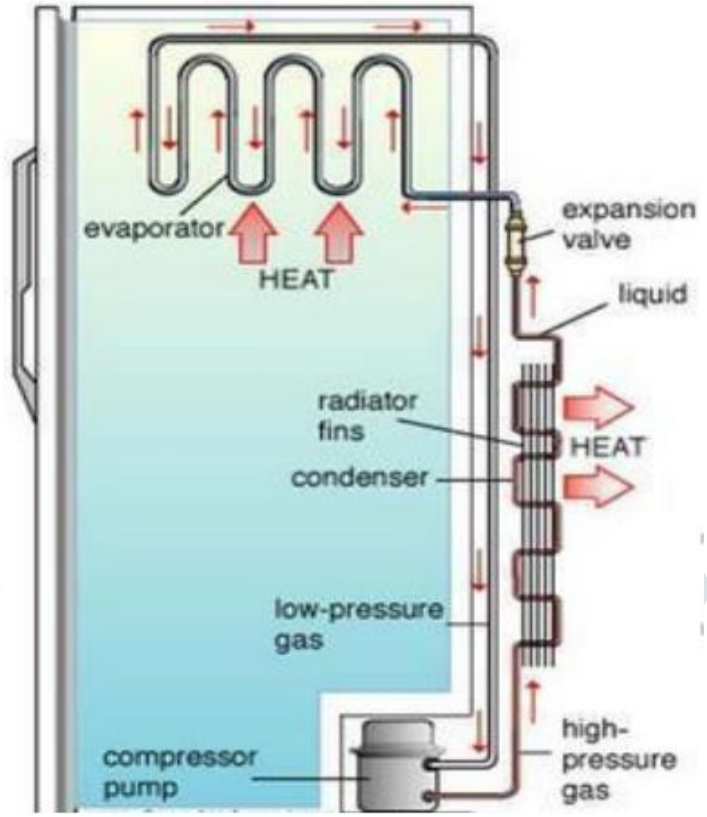

Figure.1 Domestic Refrigerator

Parts of the Domestic Refrigerator

The components within the refrigerator are responsible for the functioning of the refrigerator. a few of the components are fabricated at the backside of the refrigerator and few of them are fabricated in the main compartment of the machine.

Refrigerant: the operating material in the production of refrigeration is known as refrigerant. The refrigerant material is dispersed all over inside the refrigerator. The refrigerant material is responsible to create the cooling effect in the evaporator. The heat from the refrigerator body which supposed to be cooled within the freezer is absorbed by the refrigerant and is forced out in the environment with the help of condenser. The refrigerant material performs recalculations within the components inside the refrigerator operating in a cycle.

Compressor: The compressor is placed at the bottom of the refrigerator along the backside. The compressor intakes the refrigerant from the evaporator and releases it with high temperature as well as pressure. The compressor is operated by means of electric motor and it is a primary intense operating device in the refrigerator. Most of the time the closed compressors are used in the refrigerators.

Condenser: The condenser used in the refrigerator is air cooled since the manufacturing of thid type of condenser is simple. The structure of condenser is comprised of thin copper tubes located at the back of the refrigerator. The compressor comprising the refrigerant is passed through the condenser where it is cooled down by the means of surrounding air, hence releasing heat which is absorbed by the evaporator and the compressor. External fins are provided to the condenser in order to enhance the rate of heat transfer.

Expansion Valve or Capillary: the refrigerant leaving the condenser enters the expansion valve which is in form of a capillary tube in household refrigerators. It is coiled structure in circular form made of copper and comprises of number of turns. The pressure from the capillary tube degrades the temperature and simultaneously the refrigerant is passed through which is a process of constant enthalpy.

Evaporator or freezer: The refrigerant path its way to the evaporator at a very lower temperature as well as pressure. The evaporator is responsible for exchange of heat and it is made of number of turn of aluminium or copper tubes. The refrigerant is evaporated and on the other hand the heat is absorbed from the material which is further absorbed by the compressor. The cycle is complete and thus repeating.

Temperature control device or thermostat: Thermostat is the device which is a sensor interlinked with the evaporator and regulates the temperature. The compartment of a refrigerator comprises of a circular knob which controls the setting of the thermostat. When the temperature within the compartment reaches to the level of set temperature, the thermostat comes to hault and cut offs the power supply to the compressor. When the temperature of the compartment goes below the set temperature, the power supply is resumed.

Defrost system: The defrost system in a refrigerator helps to remove the extra formation of ice over the evaporator. With the help of thermostat switch the defrost action can be manually operated or an automated system of electric based heater can be used.

METHODOLOGY

Selection of components

Initially, the space for storage and its capacity is designed which provides the quantity of refrigeration required in tones. Further, it becomes essential to set a specific target temperature which is the lowest temperature to be obtained in the complete system. As per the requirements, it is needed to choose such a compressor that can balance with the capacity and simplifies the whole system to obtain the required target temperature. Then after, once the compressor is selected, the remaining components are focused which are to be directly linked with compressor.

Fig.2 Evaporator

- Capacity of storage : 10.160 liters
- Refrigeration required: 0.01016 Tons
- Target temperature = -20 'C
- Required Compressor = 1/8 HP reciprocating type

Fig.3 Compressor

- Condenser =9*9*2 (cross flow type)

Fig.4 Condensor

- Throttling tube =1mm*12ft (maximum throttling tube length used with respect to compressor to gain target temperature)
- Copper tubing 4mm
- Temperature indicators (range -40 to 110 'C)

Fig.5 Temperature Indicator

- Pressure gauges (suction & delivery)

Fig.6 Pressure gauge

Fabrication

- Initially a frame was made on which all the parts were fabricated.
- Then a cabin was made in order to get the storage space, within which an evaporator was kept in square shape.

Fig.7 Storage cabin

- The cabin was mounted with the base and evaporator and solution of PCTR was used for adhesion
- The condenser along with compressor was mounted on the frame. The connection were made by gas welding. (oxy-acetylene)

Fig.8 fixing compressor

- The throttling was linked with evaporator and 95% of the throttle tube is placed between the insulation within the cabin in order to avoid loss of heat.

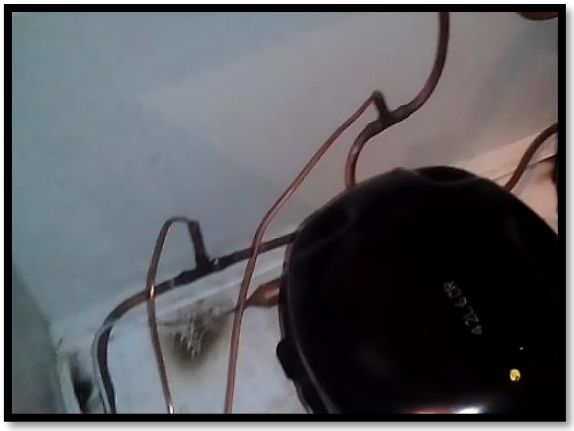

Fig.9 connecting tubes

Fig.10 Fixing Condensor on platform

- Now, the delivery tubes and the suction tubes were bypassed and linked with the pressure gauges.

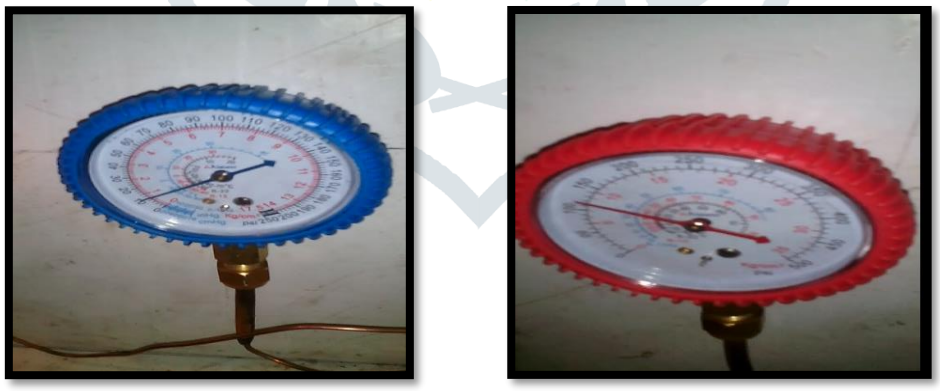

Fig.11 Attaching suction & delivery pressure gauges

- The temperature indicators were placed
- R134a refrigerant was incorporated by the help of compressor
- The compressor was sealed

Fig.12 Sealing Compressor

Fig.13 Completely Fabricated system

- The fabrication process was completed
- The setup was started and minimum temperature was ensured to obtain in the storage space
- The readings were noted down with load n and later with and without PCM

RESULT

(C.O.P.)with PCM >(C.O.P.)without PCM

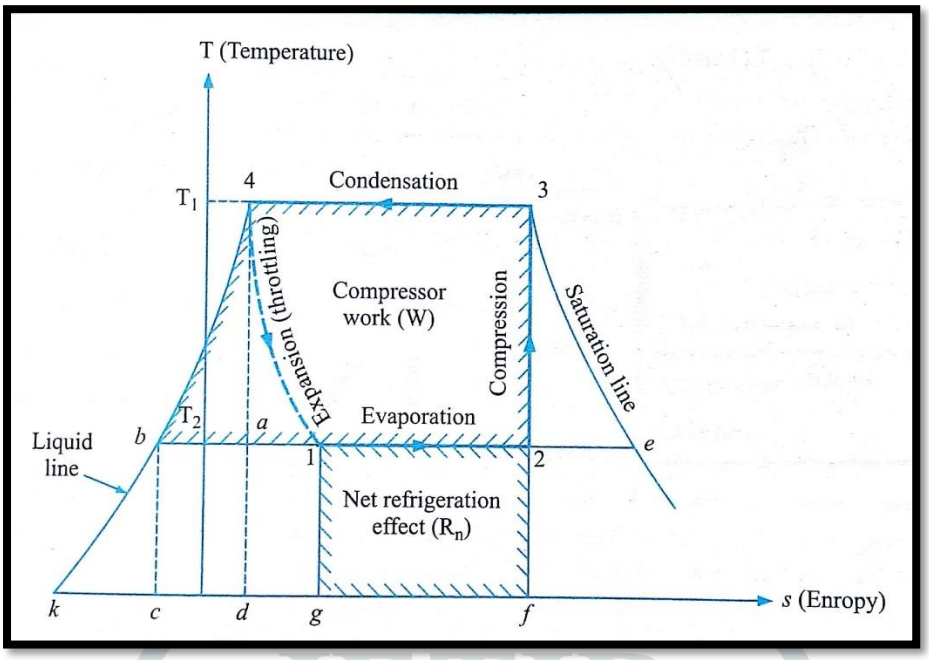

Fig.14 T-S diagram

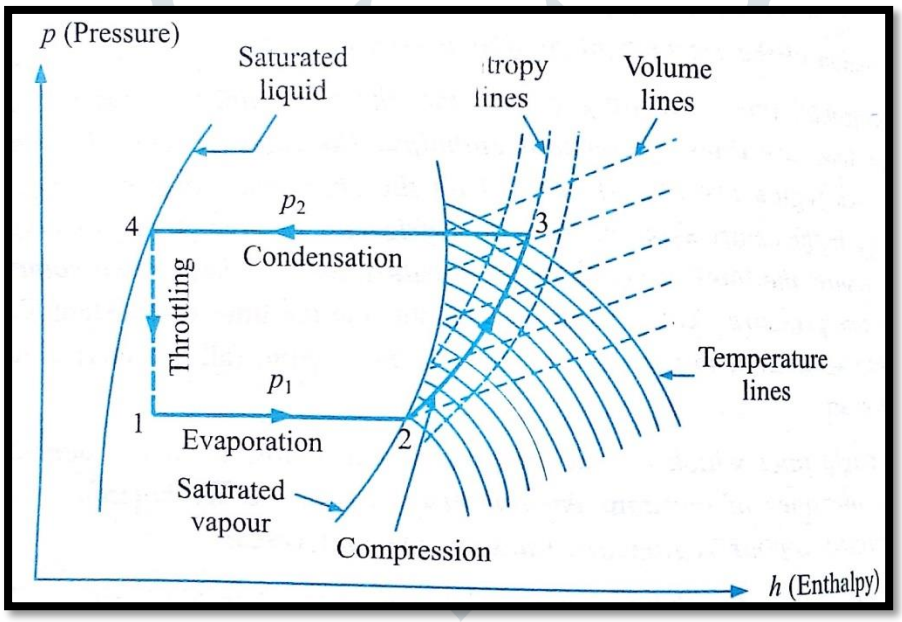

Fig.15 p-H diagram

Comparison with the help of actual p-h diagram of the system

Gray color - Without PCM

Red color - With PCM

X axis- h (kJ/kg)

Y axis - p (psi)

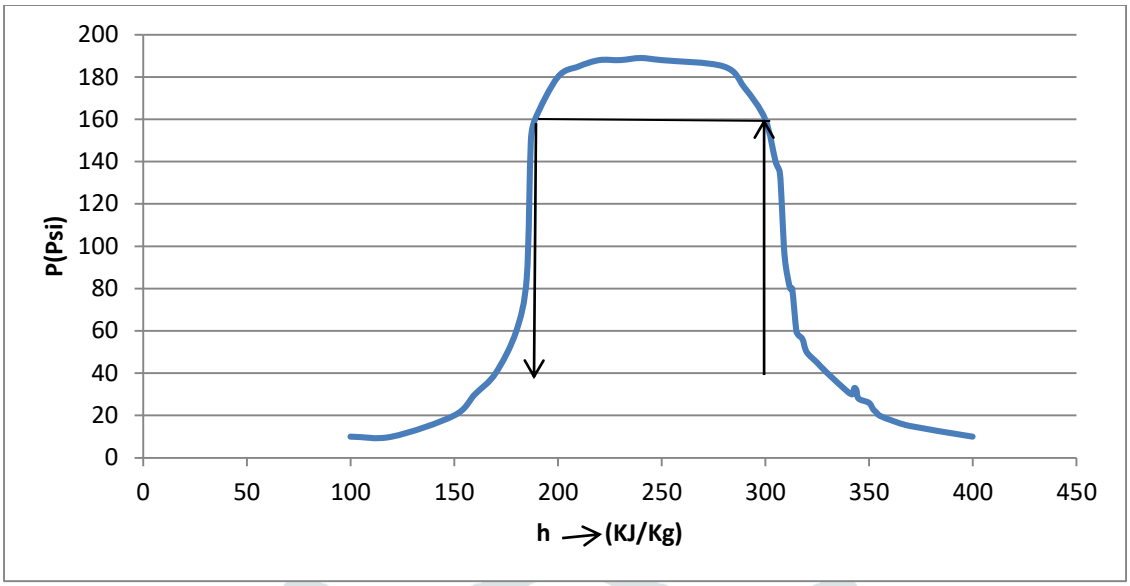

Fig.16 Actual p-H diagram of the system

- The graph shows that there is decline in process 1-2 which means the work of compressor is reduced.
- Process 1-4 is increased which means refrigeration effect is elevated in small amount.
- Point 2 is at the bottom position in the cycle along with PCM which signifies that temperature at the exit of the compressor will be lower i.e. heat is liberated to the atmosphere.

CONCLUSION

The present research work comprises of the enhancement of the performance of a household refrigerator by means of two phase change materials at varied amounts and loads.

- The work of compressor is declined and the effect of refrigeration is increased by utilizing PCM.
- When the power supply is off the PCM helps to keep the temperature down for longer time. the observations show that cooling effect with PCM is longer than compared to without PCM with respect to time.
- The outlet temperature of compressor is low due to the reduction in the work of the compressor. Hence it liberates less heat in the atmosphere.
- Domestic refrigerators along with PCM can be beneficial in fluctuating load situations and in underdeveloped areas since the PCM can retain low temperature for higher duration of time.

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