Experimental Investigation and Performance Improvisation Methods of Domestic Refrigerator

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ABSTRACT

Refrigerator is a device used for chilling of food products for the both commercial and domestic appliances utilizing mechanical vapour compression cycle in its process. Optimization for the better performance of the system becomes main issue and many researches are still on going to improve efficiency of the system. The main objective of this work is to enhance the performance of the domestic refrigerator by flooding the evaporator with liquid refrigerant. To attain this objective, the magnetic field is installed on the refrigerator line (exit of condenser). The performance of refrigerator is evaluated with and without magnetic field. Also analysis is carried using mixture of refrigerant (R600a/290). From the results it is found that COP, refrigeration effect of the system improves with the installation of magnetic field. Also the system gets benefited in the form of decrease in compressor work with the installation of magnetic field. Literature has reported improvement in performance on application of magnetic field on account of decrease in the viscosity of the fluid, enhancing the flow rates and in turn cooling capacity simultaneously reducing the compressor power.

Keywords: ***Magnetic field, Hydrocarbon, Magneto-caloric effect, Compressor power consumption.***

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1. INTRODUCTION

Vapour compression cycle is the most frequently used refrigeration cycle. Several studies have reported the use of magnetic elements for the improvement in the vapour compression cycle. The study of magnetic refrigeration was started with the discovery of magneto caloric effect. Warburg first discovered the thermal effect of metal iron when applying it in a varying magnetic field in 1881. Magnetic refrigeration is a cooling technology based on the magneto caloric effect (MCE).This magnetic field is invisible but is responsible for the most notable property of a magnet, a force that pulls other ferromagnetic materials, such as iron, and attracts or repels other magnets. A magnet produces a vector field, the magnetic field, at all points in the space around it.

1.1 Types of Magnetic Material

1.1.1 Diamagnetic

Materials called diamagnetic are those that on- physicists generally think of as non-magnetic, and include water, wood, most organic compounds such as petroleum and some plastics, and many metals including copper, particularly the heavy ones with many core electrons, such as mercury, gold and bismuth. Diamagnetic materials are repelled by magnetic fields.

1.1.2 Paramagnetic

It is a result of unpaired electrons within an atom that can cause a magnetic dipole to form in the presence of a magnetic field and, as a result, in the presence of a magnetic field this effect causes the fluid to be drawn in the direction of increasing magnetic field strength.

1.1.3 Ferromagnetic

These materials are the only ones that can retain magnetization and become magnets; a common example is a traditional magnet Sami et al.[1] have presented the test results of the performance of new alternative refrigerants such as R410A, R507, R407C, and R404A under various conditions of magnetic field. The test results reported that the increase in magnetic field force, increases compressor head pressure and discharge temperature slightly as well as less liquid refrigerant was boiling in the

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compressor shell. Gschneidddner and Pecharsky[1] in 1999 discussed about the research on magnetic calorific effect and its application regarding the cooling near room temperature. The study they conducted included the relationship between the nature of magnetic transformation and the temperature dependence of the magnetic calorific effect and the entropy utilized in the magneto-caloric. Richardson et al have investigated the performance of HC 290/HC 600a mixture in a vapour compression refrigeration system. It was shown that propane and propane/isobutene mixtures may be used in an unmodified R12 system and give better coefficients of performance (COP) than R12 under the same operating conditions.

2. WORKING PRINCIPAL

The working fluid was R134a.Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapour and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapour is then in the thermodynamic state known as a superheated vapour and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapour is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the air.

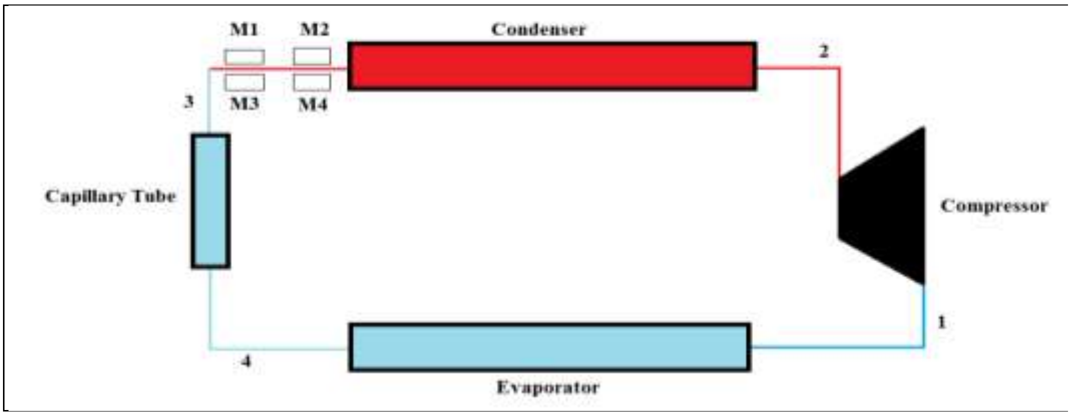

Fig-1: Working Principal of vapour compression refrigeration system with magnetic field

The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through a capillary tube where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic evaporation of a part of the liquid refrigerant. 2 pairs of magnetic elements with a Gauss level of 2000 each were employed in this study. These magnets were placed on the refrigerant full liquid line at condenser outlet. Two pressure gauges are placed in the system to note down the compressor inlet (suction) and compressor outlet (discharge) pressures. Temperatures at various points in the system were noted. The cold mixture is then routed through the coil or tubes in the evaporator. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapour from the evaporator is again a saturated vapour and is routed back into the compressor. For minimizing the heat loss, the outer tube was well insulated. The refrigerant (in gaseous form) is then passed into the compressor.

3. EXPERIMENTAL SETUP AND TEST PROCEDURE

Fig-2: Experimental setup

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1) Compressor
2) Perforated condenser
3) Capillary tube
4) Evaporator
5) Magnets
6) Charging unit
7) Pressure gauge
8) Drier
9) Digital temperature indicators

3.1 Refrigerant Used In Experiment

R134a – Tetrfluroethane (hydro fluorocarbon or HFC compound)

3.2 Properties of Refrigerant – R134a

No ozone depletion potential, ODP = 0 and GWP = 1200, Boiling point = −26.1°C (−14.9°F), Density and phase 0.00425g/cm^3, Solubility in water = at 25^0C, Non Flammable, Nontoxic, Energy saving up to 20% due to lower molecular mass and vapor pressure.

3.3 Permanent Magnets:

For the experiment we have used 4 permanent magnets of field strength 2000 gauss each. We have applied magnetic field with help of permanent magnets at exit of condenser (liquid line).

4. EXPERIMENTAL ANALYSIS

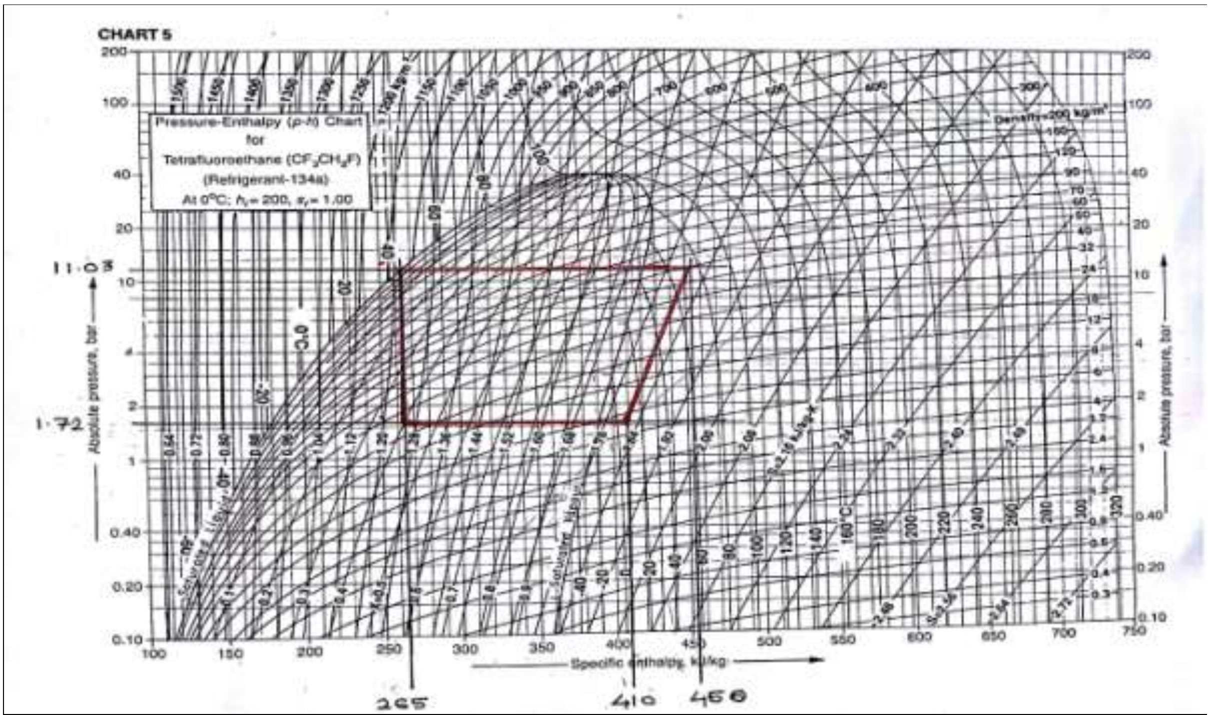

Fig-3: When magnetic field is not applied to liquid line

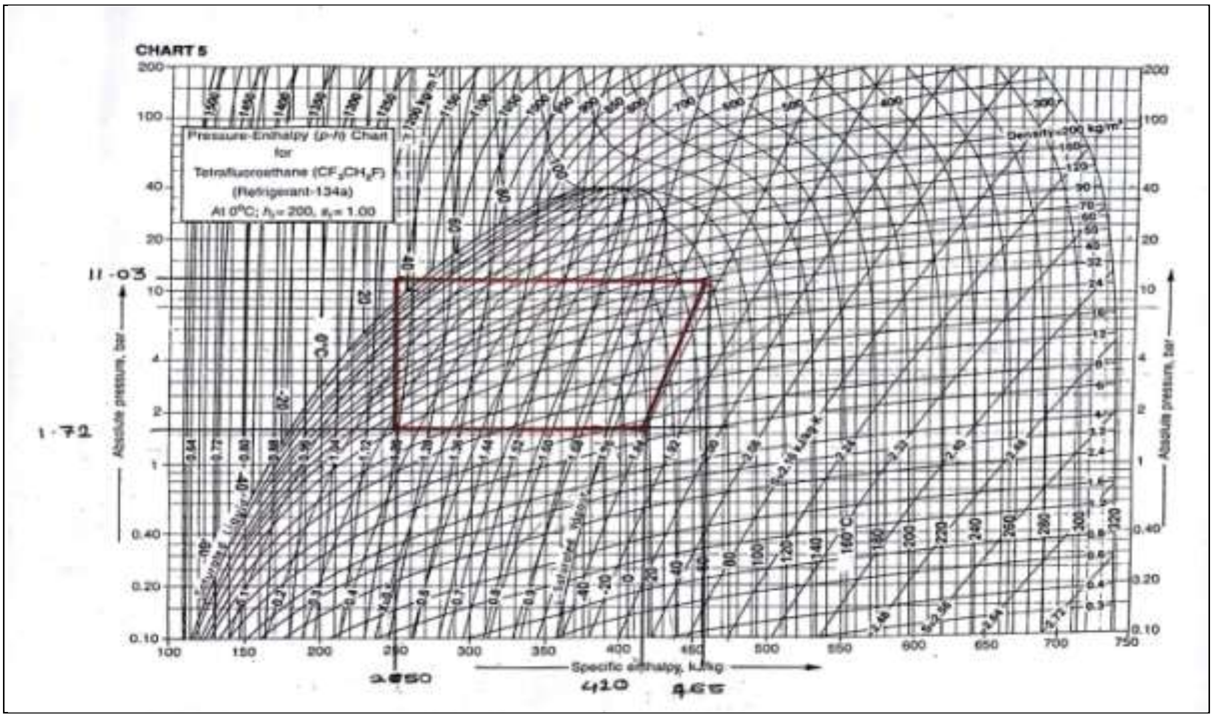

Fig-4: When magnetic field is applied to liquid line

From figure 2 and 3 show the p-h charts i.e. pressure-enthalpy plots for vapour compression refrigeration cycle without and with magnetic field. It shows that the vapour compression refrigeration cycle with magnetic field has increased refrigeration effect than the cycle without magnetic field. The refrigerating effect (h_1-h_4) of the cycle without magnetic field is less by25 KJ/Kg than that of cycle with magnetic field.

5. CONCLUSION

The test results show application of magnetic field has positive effect on the COP of the system for Hydrocarbon refrigerant as R134a (Tetrfluroethane) is used in this system.
Thus this study has been able to validate the reported phenomena of improvement in COP refrigerant systems on application of magnetic field between condenser outlet and capillary tube. By application of magnetic field to vapour line (i.e. compressor inlet) there is no change in refrigeration effect or consumption compressor power. The COP of vapour compression cycle without magnetic field is 2.9 and of cycle with magnetic field is 3.22 which is more than 32% of the COP of refrigeration without magnetic field.
Improvement is experimentally observed with application of the magnetic field on R134a.
For more refrigerating effect permanent magnets of more gauss strength can be implemented.

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