Effect of Magnetic field on Hydrocarbon refrigerant

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ABSTRACT

Performance test results of alternative refrigerant blendof R600A and R290 under various conditions of magnetic field are discussed, analysed and presented. The test results were obtained using a test setup of vapour compression cycle under various magnetic field conditions. Performance tests were conducted according to the ARI/ASHRAE Standards.Magnetic field being a source of energyshows influence on various materials and fluids which respond to the magnetic field. The vapour compression cycle is a well-established refrigeration technique used in most household refrigerators, air conditioners, and many large commercial and industrial refrigeration systems.
However, mankind is facing serious problems concerning the global environment, and the emissionsof conventional refrigerant fluids such as chlorofluorocarbon (CFC), hydrochlorofluorocarbon(HCFC) and hydrofluorocarbon(HFC) are responsible for ozone depletion or the greenhouse effect.The effect of magnetic field on mixture behaviour varies by using different permanent magnets of various gauss strength. Furthermore, the use of magnetic field appears to have a positive influence on the system COP as well as thermal capacities of condenser and evaporator.Most materials respond to an applied B-field by producing their own magnetization M and therefore their own B-field. Typically, the response is weak and exists only when the magnetic field is applied. The term magnetism describes how materials respond on the microscopic level to an applied magnetic field and is used to categorize the magnetic phase of a material.. Materials that can be magnetized and are also the ones attracted to a magnet are called ferromagnetic (or ferromagnetic). These include iron, nickel, cobalt, some alloys of rare-earth metals, and some naturally occurring minerals such as lodestone.

Keywords: *Permanent magnets, refrigerants, magnetic effect, vapour compression cycle.*

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1. INTRODUCTION

Vapour compression refrigeration systems are available to suit almost all applications with the refrigeration capacities ranging from few watts to few megawatts. A wide variety of refrigerants can be used in these systems to suit different applications, capacities etc. The actual vapour compression cycle is based on Evans-Perkins cycle, which is also called as Reverse Rankine cycle. Before the actual cycle is discussed and analysed, it is essential to find the upper limit of performance of vapour compression cycles. This limit is set by a completely reversible cycle.
A magnetic field is the magnetic effect of electric currents and magnetic materials. The magnetic field at any given point is specified by both direction and a magnitude (or strength); as such it is represented by a vector field.This magnetic field is invisible but is responsible for the most notable property of a magnet, a force that pulls on other ferromagnetic materials, such as iron, and attracts or repels other magnets. A permanent magnet is an object made from a material that is magnetized and creates its own persistent magnetic field. An everyday example is a refrigerator magnet used to hold notes on a refrigerator door.

2.LITERATURE REVIEW

In this experiment four pairs of permanent magnet of 3000 gauss field strength; are installed at fixed distance on the refrigerant liquid line (exit of condenser) of the VCC setup. The comparison of the set up performance is done with and without application of magnetic field to estimate the improvement in the VCC system. Experiments are carried out on hydrocarbon (R-404a) refrigerant. The test results mainly focus on the application of magnetic field which has a positive effect on the COP and power consumption of the system for the refrigerant. The net result is improvement in the COP of the VCC and reduction in the compressor power consumption.[1].

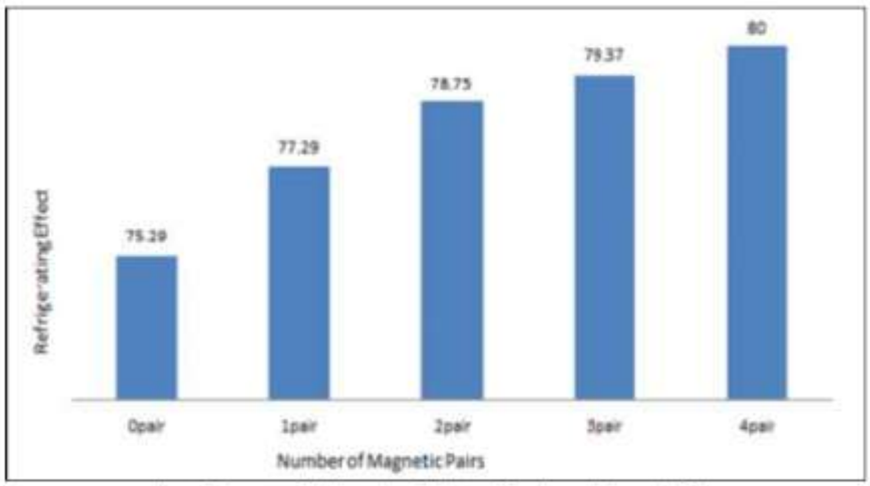

Fig-1 Variation of Refrigerating Effect VS No. of Magnet pairs

This paper presents an experimental study on the replacement of CFC12 and HFC 134a by the new R290/R600a refrigerant mixture as drop-in replacement refrigerant with and without the effect of magnetic field.The test results with no magnets showed that the refrigerant R290/R600a had 19.9-50.1% higher refrigerating capacity than R12 and 28.6-87.2% than R134a.[2].

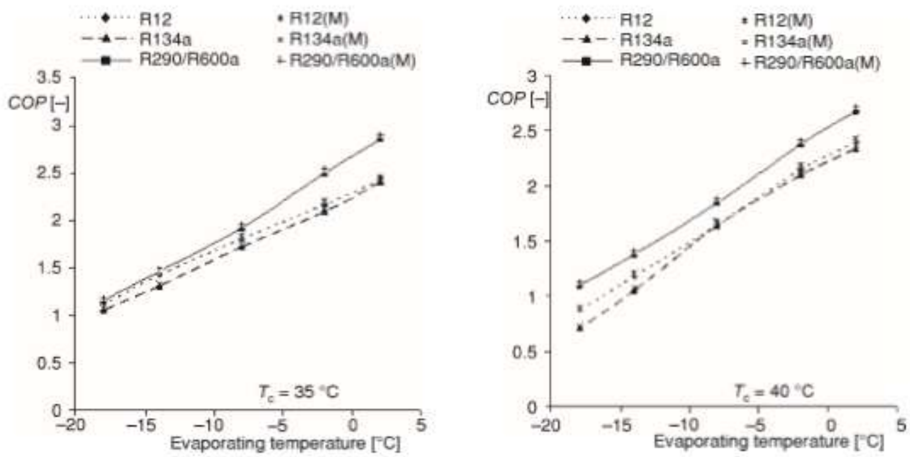

Fig-2COP vs T_e with and without magnetic field effect for T_c=35^{0}C, T_c=40^{0}C

The paper presents review of Effect of magnetic field on Hydrocarbon fluid flow (Refrigerant-R600). Published reports use of permanent magnets with different intensity (2000, 4000, 6000, 9000 Gauss) installed on the fuel line of the two-stroke engine, and study its wallop on fuel consumption, as well as emissions of exhaust gas and compared with performance without application of magnetic field to estimate the performance betterment.[3]

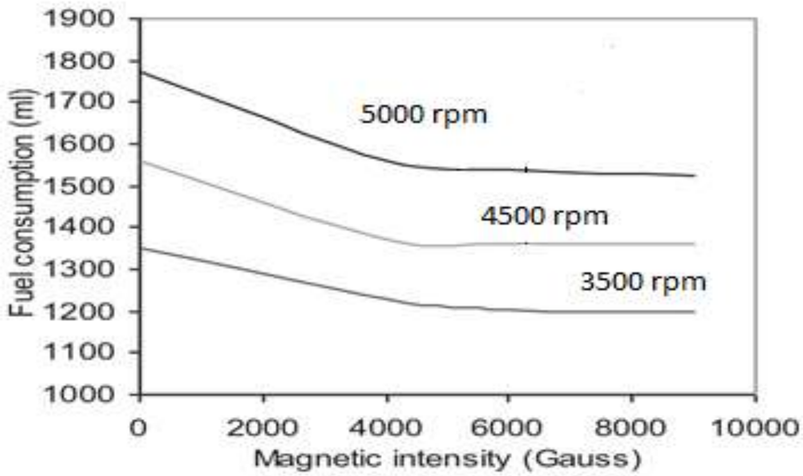

Fig-3 Reducing the amount of consumed fuel with increasing magnetic field intensity

3. TYPES OF MAGNETIC MATERIALS

A magnet is a material or object that produces a magnetic field. A permanent magnet is an object made from a material that is magnetized and creates its own persistent magnetic field.

3.1 Paramagnetic Materials

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.

3.2 Diamagnetic Materials

If the electrons are already paired, the atoms resist the formation of a dipole and this resistance causes the atoms to move in the direction of decreasing magnetic field strength, known as diamagnetism.

3.3 Ferromagnetic Materials

Materials that can be magnetized and are also the ones attracted to a magnet are called ferromagnetic (or ferrimagnetic). These include iron, nickel, cobalt, some alloys of rare-earth metals, and some naturally occurring minerals such as lodestone

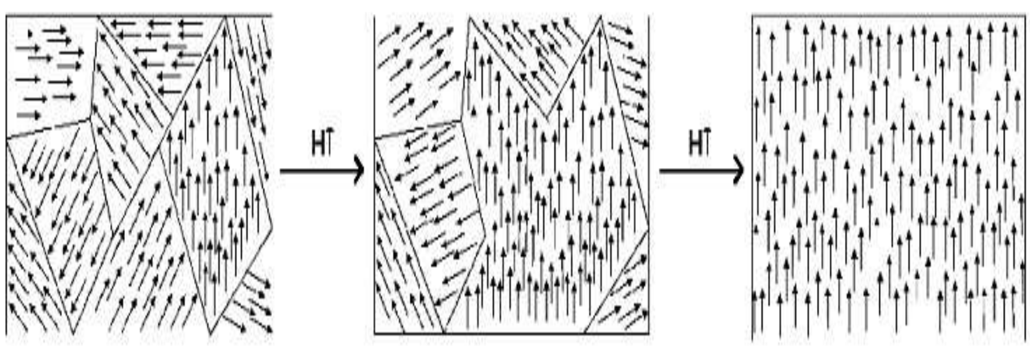

Fig-4: Comparison between diamagnetic, paramagnetic and ferromagnetic materials

The diagram above shows the reaction of molecules to paramagnetic, diamagnetic and ferromagnetic materials.
As shown in the figure as the field strength increases the molecules start to flow in a single direction.this one directional flow increases the velocity of flow.

4. HYDROCARBON REFRIGERANTS

4.1 R290/R600a (Propane + Isobutane)

It is an azeotropic mixture of propane (R290) & isobutane (R600a). It has properties very similar to R12 &R134a which are the commonly used refrigerant nowa days. It contains 60%propane+40%iso butane. It is named as mint gas because it has cooling property like mint. Moreover ithas zero ozone depletion potential and a reliable globalwarming potential (the two property due to which weneed to replace the CFC's).

This blend is used for domestic refrigerators because of
its following reasons-
1. Zero GWP
2. Compatible with mineral oil.
3. Pressure same as in R12 system. Almost like a dropin substitute.
4. Low discharge/winding temperatures.
5. Quantity of charge very small.
6. Easily available.

4.2 R-12 Dichlorodifluoromethane (CCL2F2)

R-12 is a very popular refrigerant. It is a colorless almost odorless liquid with boiling point of -29^{0}C atatmospheric pressure. It is non-toxic, non-corrosive, non-irritating and non-flammable. It has a relativelylow latent heat value which is an advantage in smallrefrigeration machines. R-12 has a pressure of 0.82 bar at -15^{0}C and a pressure of 6.4 bar at 30^{0}c. The latentheat of R-12 at -15^{0}Cis 159KJ/kg.

4.3 R-134a Tetraflouroethane (C2H2F4)

The preferred replacements of R-12 can be the HFC refrigerants R-134a. This has a boiling point of -26.2^{0}C which bears reasonable comparison with the boiling point of R-12 (-29.8^{0}C). R-134 is a not a drop in replacement of R-12 because the refrigerating effect is slightly different. This would appear to be non-flammable and non toxic substitute for R-12 at extreme pressure ratios.

4.4 Refrigerant Selection:

The refrigerant selected for the experiment is the blend of (R290+R600a) i.e. Propane + Isobutane.

5.EXPERIMENTAL PROCEDURE

Experimentation is carried out with and without the application of magnetic field. Following procedure is to be followed while carrying out experimentation:

- Plug in and switch on the setup
- Ensure that the suction and discharge pressure is constant.
- Connect all the thermocouples to the points specified.
- Switch the thermocouple setting to Kelvin.
- Take the first reading of the temperatures after starting the setup
- Repeat the above point after the interval of 20 to 30 min.
- Repeat it until the compressor stops working and note down the temperature.
- Now use permanent magnets of different strengths at condenser exit and repeat the whole procedure.

6. EXPERIMENTAL SETUP

Fig-5 Actual Test Setup

Components of the test setup:
1: Compressor
2: Condenser
3: Evaporator and Storage tank
4: Capillary tube
5: Pressure gauge
6: Thermocouple
7: Permanent Magnets
Refrigerant used in the setup: (R290:R600a) = (60%:40%)
Magnets used in the setup: Permanent magnets of 3000 Gauss strength

7. RESULT AND DISCUSSION

A) Variation of water temperature VS time for (R290/R600a):

Case 1: Variation of temperature without magnet
Case 2: Variation of temperature with a pair of N52 grade magnet
Case 3: Variation of temperature with a pair of N35 grade magnet
Case 4: Variation of temperature with one N50 and N35 grade magnet

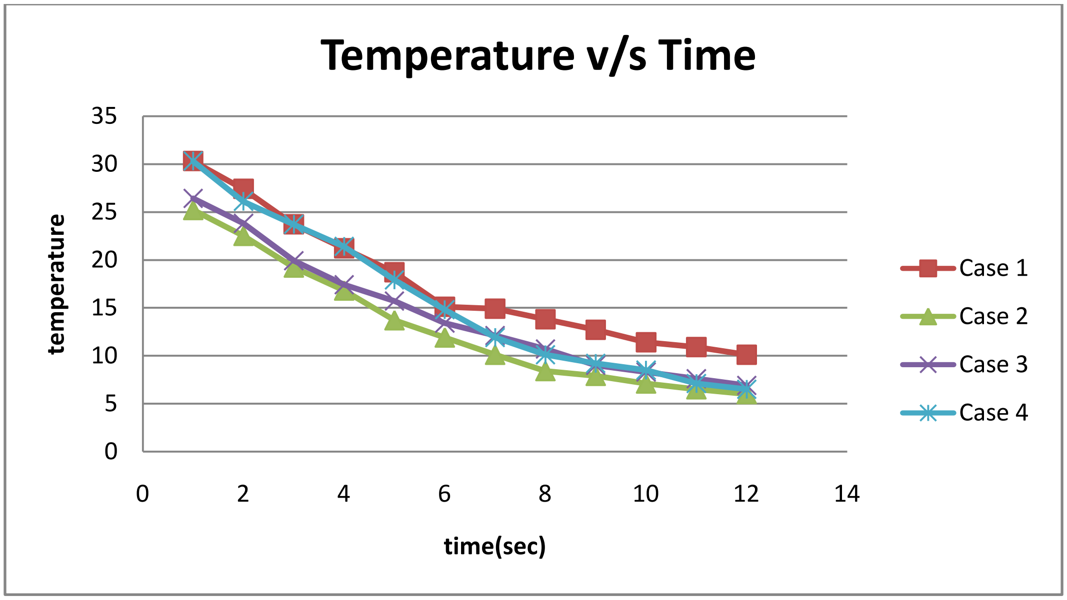

Chart-1 Output Temperature vs Time

The above graph shows the variation of temperature of water in the storage tank with time. The graph is plotted with increasing number of magnetic pairs with magnetic field strength of 2000 gauss respectively and without any magnetic pair. The readings are considered with respect to the water temperature in the range of 30°C-6°C. It is found that after the application of magnetic field, time required to cool the water up to 6°C is reduced. When one magnetic pair is used of N35 grade, the time required for the refrigerant to cool the water temperature up to 6°C is reduced by 4% with respect to no magnetic pair applied. When further magnetic pair of N52 grade is used, the time reduction is by 16%. For the magnetic pair of one N52 and one N35grade, 8% time is reduced. The maximum time saved is found in case of N50 magnetic pair. The reduction in time is obtained because of the increase in the specific heat of the refrigerant due to the magnetic field.

B) Variation of Compressor Power with number of magnets:

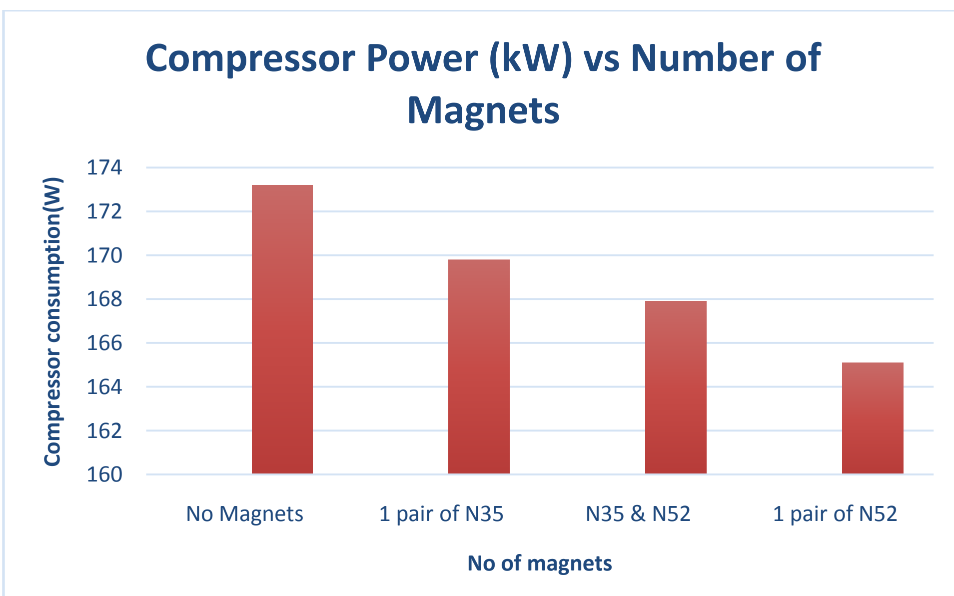

Chart-2 Compressor Power VS No. of Magnets

When the magnetic field is applied because of the magnetic dipole moment various thermodynamic properties of refrigerant changes such as increase in specific heat of the refrigerant. As the specific heat of the refrigerant increases the evaporating effect increases because of which evaporation of refrigerant increases. As a result of above effects the compressor power reduces. Fromabove graph it can be concluded that maximum compressor power is saved when N52 grade magnetic pair is used. Thus, due to application of magnetic field compressor power reduces by 12%.

3. CONCLUSION

The test results shows application of magnetic field has positive effect on the COP of the system for Hydrocarbon refrigerant.Thus this study has been able to validate the reported phenomena of improvement in COP refrigerant systems on application ofmagnetic field between condenser outlet and TXV. By application of magnetic field to vapour line (i.e. compressor inlet) there is no change in refrigeration capacity or compressor power consumption. Performance defoliates after certain magnetic field strength
COP = Mwater*CPw*(Tinitial –Tfinal) / Compressor power Mwater = 20 kg, Cpw = 4187.23 J/kg-K
Improvement in COP = (COP with application of magnetic field/ COP without application of magnetic field) * 100.
15% COP improvement is experimentally observed with application of the magnetic field on R600a/R290.

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