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Experimental study of Effect of magnetic field on Refrigeration

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Abstract*— Magnetic cooling is a developing refrigeration innovation with potential to outperform the presentation of vapor compression device. It has been effectively connected in the cryogenic temperature ranges, where magnetic cooling gas liquefiers surpass the performance of conventional liquefaction system. Magnetic refrigeration innovation depends on the magneto caloric impact, a characteristics present in every single Magnetic material and alloys. In magnetic thermodynamic cycles, magnetization of a magneto caloric material is equivalent to the compression of a gas, while demagnetization is equivalent to expansion of a gas, while demagnetization is proportional to expansion of a gas, with a resulting lessening of the entropy. In these endeavor four arrangements of enduring magnet of 3000 Gauss field quality is presented at fixed detachment on the refrigerant liquid line (exit of condenser) of the VCC arrangement. Effect of with and without utilization of magnetic field on execution of system is observed. Experiment is done on R-134a refrigerant. The net results are resolved for the COP of the VCC and a while later the correlation is completed for the system it was found that the compressor power required to run the compressor is diminished as consistency of refrigerant is decreases and as such the COP of system increases.

***Keywords*— VCC, Magnetic field, Magneto caloric effect, COP, Refrigerator.**

I. INTRODUCTION

Emil Gabriel Warburg (1846-1931) was a German physicist who during his career was professor of physics at the Universities of Strassburg, Freiburg and Berlin. He carried out research in the areas of kinetic theory of gases, electrical conductivity, gas discharges, ferromagnetism and photo chemistry. In 1881 he discovered the magneto caloric effect in an iron sample, which heated a few Milli kelvins when moved into a magnetic field and cooled down again, when removed out of it. This technology was successfully applied in low temperature physics since the 1930's to cool down samples from a few Kelvin to a few hundred of a Kelvin above the absolute zero point (-273.15 K). But today, because of two important aspects, also applications for the refrigeration market seem feasible. The first one is the availability of magneto caloric materials with Curie temperatures at room temperature and above. Furthermore, by the "giant" magneto caloric effect new magneto caloric materials have become a factor two to three more performing [9].

Refrigeration is one of the most unavoidable advances of the modern world. From the ubiquitous refrigerator and cooling system to modern applications like the liquefaction of gases, this innovation is available in a wide assortment of fields. Conventional vapour compression systems are the foundation of most reasonable applications; yet these systems are no absolved of ecological and effectiveness concerns. The utilization of CFC's and different dangerous refrigerants, and the advantages of improving performance over the conventional vapour compression system, has driven the specialist network to create other elective refrigeration implies. Accordingly, innovations like thermo electric, thermo acustic, adsorption, absorption and magnetic cooling have been created. Magnetic cooling is one of the most encouraging. First created to achieve sub-kelvin temperatures, it has been effectively connected in some high-innovation establishments (for example CERN) to melt nitrogen and different gases. The achievement in these regions has energized researchers all around the globe to move in the direction of the objective of applying this innovation to room temperature devices. Magnetic refrigeration innovation depends on the magneto caloric impact (MCE), a trademark present in every single magnetic material and alloys. By varying the power of the magnetic field on the material, the MCE will show as a temperature change, which can be utilized to develop a heat pump.
The eventual fate of magnetic refrigeration looks bright. Much research is continuous in the field of magneto-caloric materials and magnetic refrigeration systems to locate an appropriate method to make a proficient machine. Despite the fact that noteworthy advances are accomplished in giant magneto - caloric materials around room temperature and the feasibility of magnetic cooling innovation has been shown through a few models, more work on both the central and viable plane is expected to ace this innovation and present it in modern and local applications. Magnetic refrigeration (MR) depends on the magneto-caloric impact (MCE), characterized as a natural property of some magnetic materials which react to an outside connected magnetic field by a variety in their temperature. The temperature increments when the magnetic field is connected (magnetization stage) and diminishes when the magnetic field is removed (demagnetization stage). This demonstrates the essential and significant job of the connected magnetic field. Along these

lines, the structure of the magnetic field source in MR system ought to be one of the principal issues that analysts should concentrate on. On the global level, numerous groups are taking a shot at new MR system structures. Specific endeavors have been done to increment attractive acceptance for all the more dominant MR frameworks. [1]

The magneto caloric effect

The magneto caloric impact shows itself in the discharge or absorption of heat by a magnetic material under the activity of an magnetic field. Under adiabatic conditions, a magnetic field can create cooling or heating of the material because of variety of its inside vitality. Additionally, the expression "magneto caloric impact" can be viewed as more generally by its application not exclusively to the temperature variety of the material, yet in addition to the variety of the entropy of its magnetic subsystem under the impact of the magnetic field.

II. LITERATURE SURVEY

Priyanka A. Dangle, Dr. N. C. Ghuge [1]

This paper showed review of Effect of magnetic field on refrigeration. Magnetic field as source of energy shows influence on various materials and fluids which respond to the magnetic field. This study concluded that improvement in COP of refrigeration systems on application of magnetic field. The compressor power savings of vapor compression refrigeration system with the different refrigerants like R134a, R151a, R407a under the effect of magnetic field is studied.

Nagihan Bilir et. All [2]

The exhibition of a vapor compression cycle that uses an ejector as an extension gadget was explored. In the examination, a two-stage steady territory ejector stream model was utilized. R134a was chosen as the refrigerant. As indicated by the got outcomes, for any working temperature there are diverse ideal estimations of weight drop in the suction chamber, ejector region proportion, ejector outlet weight and cooling coefficient of performance. As the contrast among condenser and evaporator temperatures expands, the improvement proportion in COP rises while ejector region proportion drops. The base COP improvement proportion in the examined field was 10.1%, while its most extreme was 22.34%. Indeed, even on account of an off-structure task, the presentation of a system with ejector was higher than that of the fundamental system.

Dheeraj et. All [3]

This paper explored the effect of flash chamber on the performance of household refrigerator. In this novel flash chamber idea, the fluid and vapor is isolated before entering the evaporator which results in progress in the coefficient of performance of the system. In least development, support and running cost, this endeavor was very valuable for local reason. Since ecological contamination and energy expenses are on an ascent, in this manner, this idea is a path forward in understanding the financial just as natural requests. As it's intelligently stated, the vitality spared is the energy produced.

Mohan M. Taydeet. All [4]

Numerous electronic systems, parts, and processors make heat which must be successfully expelled so as to ensure lower temperatures. Old style refrigeration utilizing vapor compression has been generally connected in the course of the most recent decades to enormous scale mechanical systems. Presently, the smaller than usual scale refrigerator utilizing VCR is by all accounts an elective answer for the electronic cooling issue. Manufacture of extremely little gadgets is presently conceivable because of advances in innovation. In this examination a smaller than normal scale fridge of 300W cooling limits utilizing R-134a as refrigerant is planned, fabricated and tried. This test showed that the real COP of the created system is 1.6 and second law efficiency is 19%. The tests additionally demonstrated that the system had the option to disperse heat transitions of 48 W/cm2 and keep the intersection temperature underneath 82˚ C.

Samuel M. Samin and R. J. Kita [5]

The conduct of some new elective refrigerant blends, for example, R-410A, R-507, R-407C, and R-404A under different states of magnetic field are examined, investigated and exhibited. The impact of magnetic field on blend conduct fluctuates starting with one blend then onto the next relying on the blend's arrangement and its breaking point and therefore on the thermo-physical properties. Besides, the utilization of magnetic field seems to impact the heat limits of the condenser and the evaporator relying on the refrigerant blend's thermo-physical properties.

III. EXPERIMENTAL SETUP

Fig.1 Experimental setup

Here we used KONOR GQR80TG fridge compressor 200-220V/50Hz.220-230V/60Hz.
As in the existing refrigeration cycle, cycle begins from the evaporator inlet, the low-pressure liquid expands, absorbs heat, and evaporates, changing to a low-pressure gas at the evaporator outlet. After this compressor pumps this gas from the evaporator through the accumulator increases its pressure, and discharges the high-pressure gas to the condenser. In the condenser, heat is removed from the gas, which then condenses and becomes a high pressure liquid. At the end of compressor magnet is applied, it decreases viscosity of refrigerant therefore it reduces power required for compression. The magnets used in this experimental setup are of 3000, 6000,9000,12000 gauss.

Procedure carried out to check effect of magnetic field on refrigeration (Literature survey) Experimentation is carried out with and without the application of magnetic field. Following procedure is to be followed while carrying out experimentation [5].

- 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.

IV. RESULTS AND DISCUSSIONS

1. Refrigerating effect-
As power required to compressor reduces with increase in number of magnetic pairs in turns refrigerating effect increases up to 3rd magnetic pair after that it reduces. As low compressor power is required to pump same amount of refrigerant due to viscosity decrease. As number of magnetic pairs increases refrigerating effect increases because more amount of refrigerant is circulated per unit time due to decrease in specific volume of refrigerant which leads to improvement in heat transfer rate and refrigerating effect. The comparison of refrigerating effect obtained for various magnetic pairs in shown in figure 2. Refrigerating effect with application of magnetic pair is more as compare to refrigeration effect without magnetic pair. It is shown in figure 2.

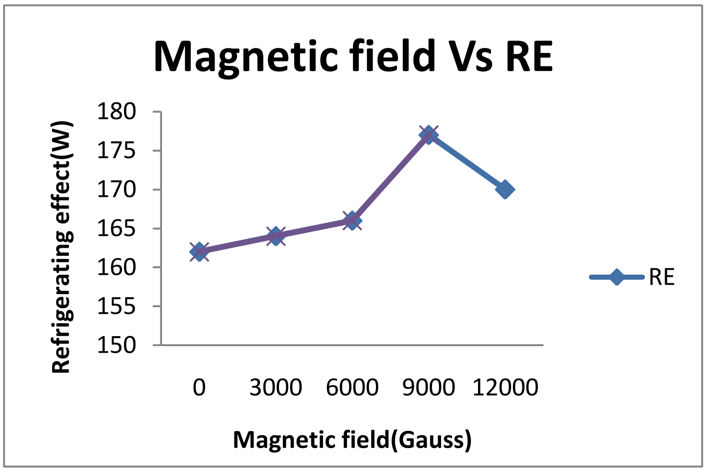

Fig.2 refrigerating effect vs Magnetic field

2. Compressor power-

Figure 3 shows graphical representation of magnetic field verses compressor power. It is observed that as magnetic field increases up to 9000 gauss compressor power required to refrigerator is reduced. Compressor power required is more without application of magnets as compare to with application of magnetic pairs. When we apply magnetic pair at the condenser exit it disrupt the intermolecular forces in working fluid and enhance the expansion of working fluid molecules, this reduces amount of liquid that is boil in compressor shell and lowering the power consumption of compressor.

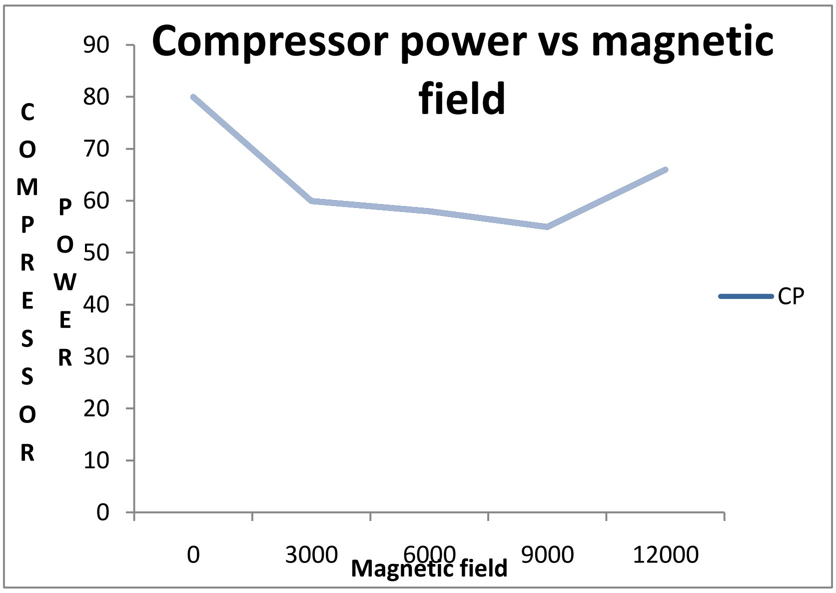

Fig.3 Magnetic field vs compressor power

3. COP

Figure 4 shows graphical representation of magnetic field verses COP. Application of magnetic field has a positive effect on cooling capacity which leads to improvement in coefficient of performance of system. Beyond 3rd pair evaporative capacity drops resulting in drop in COP of vapour compression cycle.

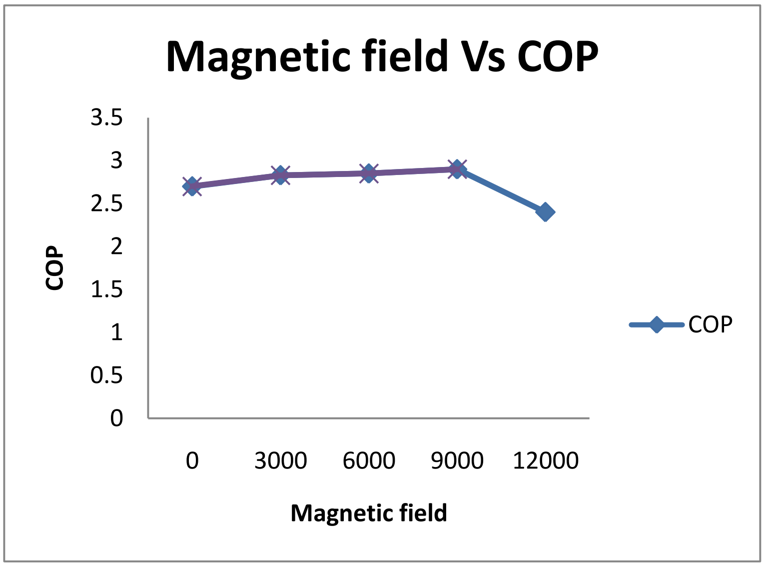

Fig.4 Magnetic field vs COP

4. Mass flow rates

Mass flow rate of refrigerant is increases with application of magnetic field it is mainly due to application of magnetic field to the end of condenser it reduces viscosity of refrigerant in turns it increases the mass flow rate of refrigerant. It can be measured with the help of rotameter. When magnetic field is applied to the liquid line of system (at condenser exit) molecules of refrigerant starts disrupting and expansion of fluid increases in turns mass flow rate of refrigerant increases.

5. Ozone depletion

In this experiment refrigerant used is R134a which is HFC refrigerant. When in refrigeration system uses Chloro fluro carbon refrigerant and HCFC it results in pollution of environment and it affects ozone layer depletion. Ozone depletion causes bad impact on human health and can lead to various skin diseases like skin cancer. R134 a is also known as tetrafluroethane from family of HFC refrigerant. With the discovery of the damaging effect of CFCs and HCFCs refrigerants to ozone layer the HFC family of refrigerant has been widely used as their replacement. That's why here HFC refrigerant is used which causes less pollution as compare to CFC and HCFC refrigerants. R134a has zero ODP (ozone depletion potential). It is now being used as a replacement for R12 CFC refrigerant in the area of centrifugal, rotary screw, scroll and reciprocating compressor. It is safe for normal handling as is non toxic, non flammable and non corrosive.

V. CONCLUSIONS

The experimental study is carried on vapour compression system and results are compared with magnet and without magnets. From this we it is found that,

- COP of system increase by 6.87% -7.1% due to application of magnetic pairs up to 3rd pair of magnet after that COP of system start to decrease.
- Refrigerating effect is increased by 3.8 % to 5% observed with application of magnetic field up to 3rd pair. It is due to reduction in power required to compressor
- Using magnetic field compressor power required is reduced by 16.28%.

VI. ACKNOWLEDMENTS

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