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**MAGNETOHYDRODYNAMICS: A METHOD FOR PERFORMANCE
ENHANCEMENT IN AIR CONDITIONING AND REFRIGERATION**

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Abstract

The refrigeration and air conditioning system having low energy consumption and environment friendliness is the main focus of the research department Refrigeration and Air conditioning industry and technical institutes. Efficiency of the refrigeration or air conditioning system working on vapour compression refrigeration cycle can be increased by using the Magneto hydrodynamic principles. Many researchers indicated that the behavior of the refrigerant flowing through vapour compression cycle can be positively influenced by the application of the magnetic field. The eco friendliness and energy saving of the system can be also achieved by using this approach.

The aim of this paper is to provide a review on the methods used to apply Magneto hydrodynamic principles on the area of refrigeration.

KEYWORDS: Refrigeration, Magneto hydrodynamics, Magnetic field

Introduction

The term 'Refrigeration' is the process of removing heat from a substance under controlled conditions. There are many types of refrigeration systems used for producing low temperatures but Vapour compression system is widely used refrigeration system. A refrigeration system working on the vapour compression cycle consists of a heat carrying medium known as a refrigerant. This refrigerant undergoes different states like,

- High pressure and temperature vapour (After Compressor)
- High pressure liquid Vapour mixture (Condenser)
- Low pressure liquid Vapour mixture (After expansion valve)
- Low pressure vapour (After Evaporator)

Here it is seen that throughout the vapour compression cycle refrigerant changes to liquid from vapour and vice versa. The vapour compression system is major contributor in refrigeration hence by improving its efficiency overall energy consumption can be reduced.

MAGNETOHYDRODYNAMIC EFFECT

When moving conducting fluids interact with magnetic field it causes a phenomenon associated with magneto-fluid-mechanical energy conversion. This effect of magnetic field on a moving fluid is commonly known as "Magneto hydrodynamics" or simply MHD. This phenomenon may observe with liquids, gases, two phase mixtures or plasmas.

This effect can be used for many exciting scientific and real life applications like enhanced cooling and heating of fluids, to enhance heat exchanging process, to create power from two phase mixtures, in aerospace engineering to modify aerodynamic forces, purification of molten metals, pumping of liquids etc. [1]

As there is a wide area available for the application of Magneto hydrodynamics, the objective of this study is to review the literature on application of Magneto hydrodynamic principles on the area of refrigeration.

LITERATURE REVIEW

Many industrial and academic researchers worked in the field of magnetohydrodynamics and they made following conclusions from their observations;

Northrup et al. [1] described effect of magnetic force on fluid, which have potential to develop motion in fluid. He also shows that this effect can be used for applications like purification of molten metal, pumping of liquids etc.

Zimm et al. [2] described the several magnetic refrigeration devices under development by Astronautics using convection NbTi magnets. The system advantages of incorporating high temperature superconducting magnets in designs also have been discussed in this work. He concluded that the magnetic refrigeration is potentially a highly efficient and high power density technology because the magnetization process on which it is based is essentially reversible and the volumetric heat capacity of the refrigerant is very high. Large magnetic fields produced by superconducting magnets are needed to most effectively couple to the magnetic entropy. Thus magnetic refrigeration is both a promising technology for cooling superconducting magnetic systems and a promising application of superconducting magnets.

Foldeaki et al. [3] reported the magnetic measurements to evaluate the thermodynamic behavior of magnetic material. Depending on the thermodynamic cycle selected, the isothermal magnetic entropy temperature change or the adiabatic temperature change upon the field application should be preselected as a function of temperature. This presented classical magnetic measurements, when evaluated within the framework of the Landau theory.

Muraki et al. [4] demonstrated the magnetic field and its capabilities as well as its impact on the thermodynamic characteristics. However, as the EHD technique has shown an improvement of the heat transfer on refrigerant side, it is believed that magnetic field could have an enhancement effect on heat transfer properties.

Andrew et al. [5] have conducted experiments using an active magnetic regenerator (AMR) cycle near room temperature have produced significant temperature spans with relatively low applied fields. An overview of the magnetocaloric effect, AMR cycle, test apparatus, and experimental results are provided with a focus on multi-material, layered

regenerators using magnetic fields of 2T and cycle frequencies of 0.65 Hz are reported. His results show that the use of magnetic regenerator provides tremendous advantage.

Mani et al. [6] have conducted an experimental study on the replacement of CFC12 and HFC134a by the new R290/R600a refrigerant mixture as drop-in replacement refrigerant with and without the effect of magnetic field. The effect of magnetic field force reduced the compressor energy consumption by 1.5-2.5% than with no magnets. The coefficient of performance of the system was higher in the range 1.5-2.4% with the effect of magnetic field force. The R290/600a (68/32 by wt. %) mixture can be considered as an excellent alternative refrigerant for CFC12 and HFC134a systems.

Cookey et al. [7] investigates the problem of MHD free convection and oscillatory flow of an optically thin fluid bounded by two horizontal porous parallel walls under the influence of an external imposed transverse magnetic field in a porous medium. By taking the radiative heat flux in the differential form and imposing an oscillatory time-dependent perturbation the coupled nonlinear problem is solved for the velocity and temperature profiles. The results show that the fluid velocity increased with increase in the magnetic field, M , Grashof number, Gr , and the porosity, χ parameters; whereas the fluid velocity is decreased with increase in the radiation parameter, F . Equally, the skin friction decreased with increases in magnetic and porosity parameters for $Gr = 2$ and increased for $Gr = 5$, while the reverse is the case with increase in radiation. Finally, the rate of heat transfer is increased with increases in the radiation parameter.

Krishnan et al. [8] have discussed process involved in MHD power generation and in this work high temperature gaseous conductor at high velocity is passed through a powerful magnetic field and a current is generated and extracted by placing electrodes at suitable position in the gas stream, and hence the thermal energy of gas is directly converted in to electrical energy. He concluded that by using magnetohydrodynamic generator efficiency of the energy conversion process increases. And by using magnetohydrodynamic generator power generation system the plant efficiency can be increased by increasing the working temperature.

Zaman et al. [9] studied the effects of hall current on MHD boundary layer second-order viscoelastic fluid

flow induced by a continuous surface with heat transfer. Effects of Hall current on heat transfer and magnetohydrodynamic (MHD) boundary layer flow induced by a continuous surface in a parallel free stream of a second-order viscoelastic fluid are studied for uniform suction/injection by taking viscous dissipation into account. Complex nonsimilar solutions to the stream function and temperature are developed by means of an elegant technique, known as homotopy analysis method (HAM). Convergence of the solutions is ensured with the help of h -curves. Graphical and tabular results for the effects of Hall current reveal that it has a significant influence on: complex velocity, complex temperature, magnitude of the shear stress at the surface, magnitude of the rate of heat transfer at the surface and on boundary layer thickness.

Conclusions

From above literature review it can be concluded that many attempts were made to apply magneto-hydrodynamics principles in the refrigeration to improve its performance. In these attempts magnetic force is used on the different combinations of refrigerants and it is observed that in all above cases the COP of the particular system was increased hence it can be concluded that magnetic force causes the positive changes in the refrigeration without causing any additional impact on the environment.



In future use of magneto-hydrodynamics in refrigeration will have great scope as in future there will be great demand for the energy efficient systems with more COP and less environmental impact and this is possible by making some improvements in refrigeration systems.

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