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Heat Transfer Enhancement Using Electrohydrodynamic and Magnetohydrodynamic Techniques: A Review

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***Abstract* - Increasing heat transfer from heat exchangers using different active and passive techniques is main focus of many researchers. Heat transfer enhancement saves energy and decreases the size of heat transfer equipments and as heat transfer equipments are used in many industries the effect of these new techniques can be implemented at number of applications. The heat transfer enhancement is mostly concentrated in the area of extended surfaces but many new and innovative techniques are also emerging in the research.**
Electrohydrodynamics and Magnetohydrodynamics are the newly developed techniques which can be used to enhance the heat transfer in many processes. This paper provides a review on the use of electrohydrodynamic and magnetohydrodynamic techniques in heat transfer enhancement with their different accepts.
***Keywords*: Heat transfer enhancement, Electrohydrodynamics (EHD), Magnetohydrodynamics (MHD), Active techniques**

I. INTRODUCTION

In thermal engineering, Heat transfer enhancement is a major research area in which different way to enhance heat transfer are studied, tested and analyzed. A lot of research in the area of heat transfer has already done and still in process by academic and industrial researchers. This topic of heat transfer has acquired position of special branch in thermal engineering.

These efforts of researchers to provide highly efficient heat exchanging devices are broadly classified into two branches first one is passive techniques. In passive techniques there is no requirement of external energy or power source to increase the heat transfer to or from the heat exchanging device. Some of the common heat transfer enhancement passive techniques are fins, inserts, perforations, extensions, surface roughening etc. And in the active techniques there is a requirement of external power or energy source to enhance heat transfer the common active techniques are forced convection, flow pulsations etc. It is observed that though passive techniques do not require any external power source they are not always effective or economical. In the situations where high and quick heat transfer enhancement is needed at such places use of active techniques is must.

The heat transfer in passive techniques is very less as compare to the active techniques. Hence active techniques will be preferred where high heat transfer enhancement is required and passive techniques are used where small amount of heat transfer is required, the passive techniques are also used where simplicity of the heat transfer equipment is to be maintained as providing passive heat transfer enhancement is less complex and simple like fins, surface roughening etc.

The electrohydrodynamic and magnetohydrodynamic techniques of heat transfer enhancement are active techniques but with the use of permanent magnets magnetohydrodynamic technique can be converted into passive technique [1]. These newly emerged techniques can be helpful to provide heat transfer enhancement in flexible and controllable manner. The electrohydrodynamic and magnetohydrodynamic techniques are proven by different researchers and also easy to implement.

II. ELECTROHYDRODYNAMICS (EHD)

Electrohydrodynamics deals with the study of effect of strong electric current on dielectric fluids. Electric field produces mechanical force on the dielectric fluid and as a result of which a flow is produced in the fluid [2]. If dielectric fluid medium is moving then this electric current generates a secondary flow within the main flow. In electrohydrodynamics force fluid movement is influenced by the electric current which causes the enhanced mass transfer of fluid. This phenomenon has drawn the attention of many researchers because mass transfer in fluid may also result in the other phenomenon which can act similar to forced convection mechanism.

Now-a-days many scientists are working in the field of electrohydrodynamics and most of their research is concentrated in the field of electrospray ionization, mixing of different fluid using EHD, electrostatic printing etc. But some researchers are also exploring the possibilities of the use of this phenomenon in heat transfer enhancement. Gharraei *et al.* [3] experimentally investigated electrohydrodynamic conduction pumping of various liquids films using flush electrodes. For liquids that negative ions mobility is higher than that of positive ions, pumping direction, with symmetric electrodes, is from the cathode toward the anode. With increasing the mobility difference pumping velocity and power increases. Also results show that, for present working fluids, the best range of operation for suitable flow rate and efficiency is 8-10 kV.

The another researcher Kumbhar *et al*. [2] has conducted an experimental investigation on Double pipe heat exchanger and studied the effect of electrohydrodynamic forces on heat transfer enhancement. It is found that as the Heat transfer rate increases; Overall heat transfer coefficient also increases for electrohydrodynamic (EHD) effect on the performance of double pipe heat exchanger as fluid flow rate of hot fluid and voltage increases. The heat transfer rates for EHD effect on the performance of double pipe heat exchanger were 30% (average) higher than the without EHD effect heat exchanger. In his research, from experimental comparative analysis it is found that as the voltage increases, the heat transfer rate as well as heat exchanger effectiveness in both parallel and counter flow arrangements.

These researchers shown that the use of EHD technique does have a positive effect on the heat transfer enhancement and can be implemented in heat exchanging devices to obtain higher heat transfer rates nut it is also observed that the electric current used for the EHD forces should be of a high voltage which might not be feasible and economical in some applications.

III. MAGNETOHYDRODYNAMICS (MHD)

The Magnetohydrodynamics is the branch of science which deals with the study of behavior of electrically conducting particle under the influence of strong magnetic field. The external magnetic field applied on a fluid will result into magneto-fluid-mechanical energy conversion process in which energy will first converted into magnetic energy to fluid energy which can be then easily converted into mechanical energy. The magnetic field also influences the fluid properties, and if this technique used properly it can also enhance the heat transfer from different heat exchangers. [4]

Mane et al. [5] provided the review on the work of different researchers worked in the field of Magnetohydrodynamics. He concluded that 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. He also concluded that the use of different working fluids in the heat exchangers has different effect on their performance under MHD forces. Also Shrotri et al. [6] presented the experimental investigation on the performance enhancement of Air conditioning systems using magnetohydrodynamic forces. He found out that the application of magnetic field have positive effect on the COP of split air conditioning system or one can say vapour compression cycle. It is also observed that with increasing intensity of magnetic field COP of system also increases as strong currents on refrigerant flow enhance the fluid flow properties which lead to more heat transfer enhancement. He also commented that the enhancement in the performance of Air conditioning system is a result of increased heat transfer in the condenser and evaporator of the air conditioning systems.

The magnetohydrodynamics has positive effect on the performance of the heat exchanger and hence it can be used to enhance heat transfer from the heat exchanging devices. The magnetohydrodynamics enhances the heat trnasfer by providing additional movement of fluid perticles under magnetic field, this phenomenon is vey useful in non conventional machining processes like ECDM. In ECDM magnetohydrodynamic force not only increases the heat dissipation but also it enhances the electrolyte circulation which leads to enhamcement in machining parameters and product quaity.[7]

IV. CONCLUSIONS

From the literature reviewed in this paper it can be concluded that the electrohydrodynamic and magnetohydrodynamic techniques are useful in heat transfer enhancement as well as they provide flexibility to the operation. The amount of heat transfer enhancement can be easily controlled as per the requirement of the user and these techniques are also easy to install on the current heat exchanging devices. But some more research is needed in this field so that more data and more analysis can be available for the commercial use of these techniques.

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