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# AN OVERVIEW OF EFFECT OF ELECTRO HYDRODYNAMIC ON PERFORMANCE OF REFRIGERATION SYSTEM WITH R-134A.

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## ABSTRACT
Heat transfer enhancement in refrigeration system is reviewed in this paper. Which explain EHD effect given and experimental results obtained are discussed. R-134a is common refrigerant for many application now so the experimental work has done using this refrigerant. Also basics of EHD are explained Electro hydro dynamic effect has impact on condensation heat transfer. The purpose of this Paper is to determine the possibility of using applied EHD on performance of refrigeration system with R-134a
**KEYWORDS**: Electro hydrodynamic, Condensation heat transfer.

## INTRODUCTION
The promotion of energy conservation and environment protection requires preparing the best utilization of energy sources. Enhancing of heat transfer coefficient has been an interesting area for research in recent years. There are various techniques for heat transfer enhancement that can be categorized in two groups of active and passive. The active techniques require external forces, e.g. electric field, acoustic or surface vibration and etc. while the passive techniques require fluid additives or special surface geometries.

Active control of heat transfer and fluid flow are very important in many engineering applications, such as refrigeration, air conditioning, energy, and heat recovery systems .Electro hydrodynamic (EHD) techniques have been introduced as one of the types of active heat transfer enhancement techniques which refer to the use of an electric field in a dielectric fluid medium. More recently, in systems with dielectric medium, based on media's characteristics, electrical field has been used to enhance heat transfer. EHD characterized by a high voltage and low current.[1]

The electric field induces an additional electrical body force on the flowing fluids.
The general expression of the electric body force is

$$f_e = \rho_e \overline{E} - \frac{1}{2}E^2\nabla\varepsilon + \frac{1}{2}\nabla\left[E^2\rho\left(\frac{\partial\varepsilon}{\partial\rho}\right)_T\right]$$

The first term on the RHS of the equation is the coulomb or electrophoretic force. This is due to existence of the net free charges within the fluid. The second and the third terms are, dielectrophoretic, and electrostrictive forces that contribute substantially in phase change processes such as boiling and condensation. The amounts of these terms are directly proportional to square power of the applied electric field. The value of the second term is a measure of the difference in permittivity of the fluid and gas phases,$\nabla\varepsilon$. Therefore, for higher density or permittivity difference between two phases, the effect of electric field is greater. The third term represents the acting force due to heterogeneity of the electric field within the fluid[3]
EHD is non-mechanical and a relatively robust technique that can be configured for a high degree of local control. Some of the main advantages of EHD are enumerated in following list
• Reduction on the size of heat transfer equipment.
• Rapid control of heat transfer coefficients by monitoring the electrical field strength.
• Suitable for application to special environments, such as zero gravity environments.
• Fluids with higher permittivity are more acceptable working fluids (at the present level of EHD technology).

• Simplified implementation, as it needs only a small transformer and electrode. Utilization of electrical field for enhancing condensation and vaporization heat transfer has significantly progressed in recent years. Condensation benefits of EHD, as an enhancement technique, are summarized as follows:

• Thinning of the condensate film by removing of condensate from the condensation surface using EHD extraction phenomena .

• Changing the mode of condensation from film condensation into pseudo-drop-wise condensation by further thinning of the condensate film.

• Condensate dispersion using electrostatic atomization.

• Disturbing and collapsing the accumulation of non-condensable gases at the liquid vapor interface. Thus, the overall mass transfer resistance is reduced to the vapor phase one and finally improves CHTC.

• Inducing perturbations and waviness into the condensate film results in increasing ofheat transfer.[2]

## RELEVANCE/MOTIVATION

Enhancing of heat transfer coefficient is an interesting area for both industry and academia. Achieving higher heat transfer rates through various enhancement techniques results in protection of our environment. This is done through substantial energy saving, due to both increasing of equipment performance, and designing of smaller systems to meet required loads. (EHD), as an active technique for enhancing heat and mass transfer, with a focus on industrial applications, especially for evaporators and condensers. As phase change phenomena of boiling and condensation are very important mode in heat transfer, improvement on enhancing heat transfer in both evaporators and condensers are highly required.

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## LITERATURE REVIEW

1. **Hamid Omidvarborna.et.al[1]** they conducted experiments for condensing of a two-phase flow under influence of an applied electric field show that the EHD force is strong enough to extract sufficient liquid from condensing surface. The heat transfer resistance on the condensing side is increased by presence of air in condensing vapour. This is due to accumulation of the NC gas at condensing part which decreases the condensation rate of R-134a.Under the application of high voltage and high concentration of NC gas result shows that increase in the electric field has lower effect on enhancement of condensation heat transfer

2. **H. Omidvarborna,et.al[2]** has done experiment within an assembled experimental rig including a laboratory double pipe heat exchanger on in-tube condensation of R-134a under the effect of applied EHD, mass flux, electrode size, temperature difference, applied electric field, on the average CHTC in double pipe heat exchanger. Application of EHD has increased the averaged CHTC and ER. The ER is almost always higher than 1. Maximum magnitude of ER in vertical structure is equaled to around 14 and 31% for 4 and 6 mm electrode diameter

3. **Taveewat Suparos[3]** the experimental investigation has been carried of refrigeration system under effect of electric field. A high intensity de electric field was applied to the bank of tubes of condenser and evaporator. The electrode system carrying the high voltage comprised forty-five copper rods placed in between and around the tube of condenser and evaporator. Experiments were performed at cooling load values of 0.5, 0.75 and 1.0 ton of refrigeration (TR) and applied voltages of 0-25 kV.A significant enhancement was obtained with condensing and evaporating processes. An enhancement ratio of up to 1.98 at condensing process and 1.73 at evaporating process.

4. **H. Sadek,et.al[4]**an experimental investigation of electro hydrodynamic (EHD) augmentation of heat transfer for in-tube condensation of flowing refrigerant HFC-134a has been performed in a horizontal, single-pass, counter-current heat exchanger with a rod electrode placed in the centre of the tube. The effects of varying the mass flux (55 $kg/m^2$ s $\leq G \geq$ 263 $kg/m^2$ s), inlet quality and the level of applied voltage (0 kV $\leq$ V $\geq$ 8 kV) are examined. The heat transfer coefficient was enhanced by a factor up to 3.2 times for applied voltage of 8 kV. The pressure drop was increased by a factor 1.5 at the same conditions of the maximum heat transfer enhancement.

5. **Suriyan Laohalertdecha,et.al[5]** the report gives Effect of EHD on heat transfer enhancement during two-phase condensation of R-134a at high mass flux in a horizontal smooth tube. The test section is a 2.5 m long counter

flow double tube heat exchanger with refrigerant flowing in the inner tube and cooling water flowing in the annulus. The inner tube is made from smooth horizontal copper tubing of 9.52 mm outer diameter. The electrode is made from stainless steel wire of 1.47 mm diameter. The test runs are performed at average saturated temperatures ranging between 40 and 60°C, mass flux ranging between 200 and 600 kg/m$^2$ s, heat flux ranging between 10 and 20 kW/m$^2$ and applied voltage at 2.5 kV. For the presence of the electrode, the experimental results indicate that the maximum heat transfer enhancement ratio is around 30% while the maximum increase in pressure drop is about 25%.

6. **Somchai Wongwises,et.al[6]** through the tests on the condensation heat transfer coefficient and pressure drop in a 9.52 mm OD horizontal micro-fin tube, with and without EHD shows that The heat transfer enhancement increases with increasing heat flux but decreases with increasing mass flux, saturated temperature and inlet quality. The maximum heat transfer enhancement and pressure drop are about 1.15% and 50%, respectively

## CONCLUDING REMARK

Electro hydrodynamic (EHD) is one of the types of active heat transfer enhancement techniques. Many researches are conducted the experiments to know the effect of EHD on condensation of refrigerant vapors in the condenser.

1. EHD augmentation involves the application of an electric field which interacts with the dielectric fluid medium to induce secondary motions that destabilize the thermal boundary layer near the heat transfer surface creating increased turbulence. This can lead to heat transfer coefficients that are several times higher than those achieved by more conventional enhancement techniques.
2. The condensation process of refrigerant can be increased by use of EHD technique in refrigeration setup itself with some modifications in condenser section.
3. The dielectric fluid like transformer oil, water etc can be used to enhance the heat transfer with application of electric field in it.

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