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EXTERNAL ELECTRIC FIELD AS THE FACTOR OF HEAT TRANSFER ENHANCEMENT IN THE SYSTEM WITH REFRIGERATOR AGENT R-134A

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The way of enhancement of heat transfer is to control the process of film formation and film thickness on the surface of electrodes. The film can be formed by:

- condensation of R-134a on the lateral surface of the tubes,
- sedimentation of R-134a droplets on the tube surface,
- by evaporation of liquid from the surface of the tubes under the EHD effects (spraying of liquid, increasing of liquid film turbulence and surface, etc.).

The most important role in all of these cases plays the formation of liquid phase and it's behavior control.

To control charged aerosol behavior it is necessary to know how geometrical, physical and electro-physical parameters of charged droplets change with changing of the parameters of gas phase [1].

Test calculations were carried out for water droplets. Calculations of physical parameters of a water droplet show, that with increasing of liquid temperature liquid density and viscosity remain practically unchangeable and only surface tension a little bit decreases (Fig.1).

As the physical parameters of a water droplet are not so sensitive for temperature, the geometrical parameters of the droplet (radius, surface and volume, and also their relative values) do not changes considerable with liquid temperature increasing (Fig.2).

Electro-physical parameters of a charged droplet: surface charge density, maximum droplet charged, critical charge-to-mass ration, energy of a charged droplet, were also calculated [2].

With increasing of liquid temperature the surface charge density decreases, as the surface of the droplet increases (Fig.3) [1]. The energy of surface tension decreases, but the energy of electric field remain practically stable (Fig.4). This means, that the value of critical charge-to-mass ratio of a charged water droplet decreases with increasing of liquid temperature. So at high temperatures the EHD disintegrations of a charged droplet can take place, in spite of the fact, at the lower temperatures this droplet was electrostatically stable. Calculations are in a good agreement with data from another references (Fig.5) [3].

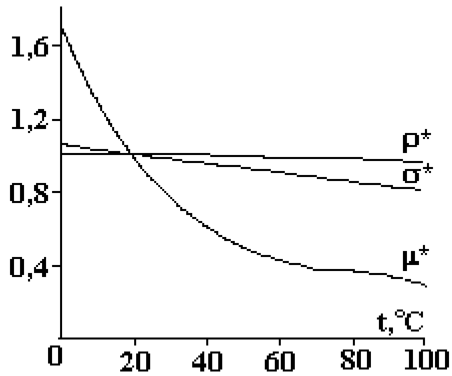

Fig.1. Dependence of the relative values of physical parameters of a water drop on temperature

$$\rho^* = \frac{\rho_2}{\rho_1} \qquad \mu^* = \frac{\mu_2}{\mu_1} \qquad \sigma^* = \frac{\sigma_2}{\sigma_1}$$

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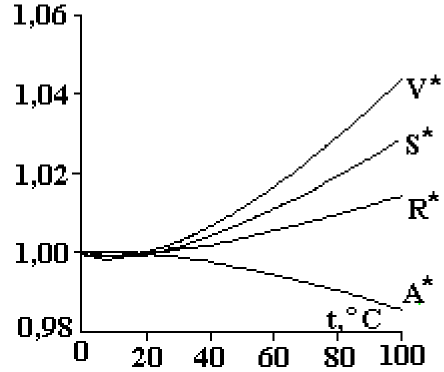


Fig. 2. Dependence of relative geometrical parameters of a water droplet on temperature

$$V^* = \frac{V_2}{V_1} \qquad S^* = \frac{S_2}{S_1} \qquad R^* = \frac{R_2}{R_1} \qquad A^* = \frac{S^*}{V^*}$$

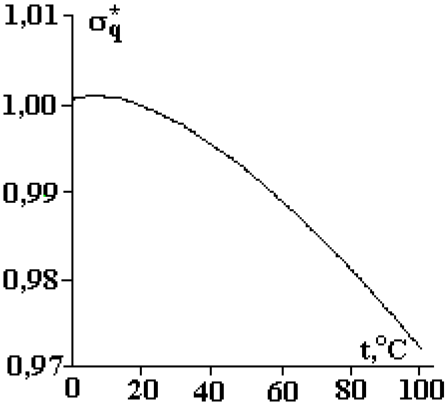


Fig. 3. Dependence of a droplet surface charge density on liquid temperature

$$\sigma_q = \frac{q}{4\pi r^2}; \qquad \sigma_q^* = \frac{\sigma_{q_2}}{\sigma_{q_1}}$$

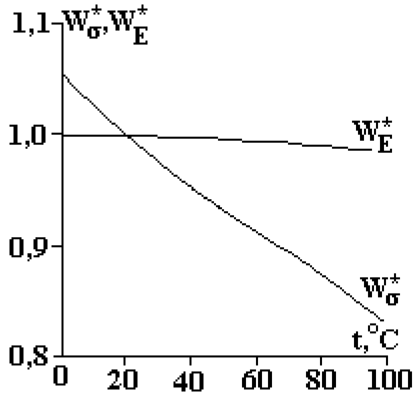
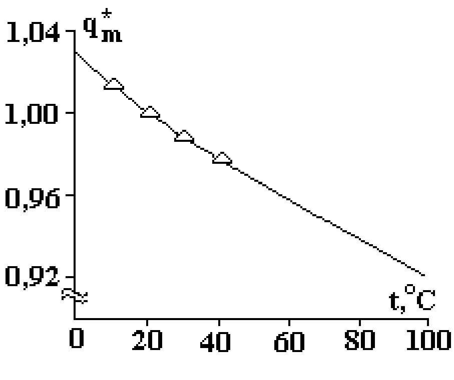


Fig.4. Dependence of surface energy and electric field energy of a charge droplet on liquid temperature

$$W_E^* = \frac{r_1}{r_2} \qquad W_\sigma^* = \frac{\sigma_2 r_2^2}{\sigma_1 r_1^2}$$



$$q_m^* = \frac{q_{m2}}{q_{m1}} = \left(\frac{\sigma_{l2}}{\sigma_{l1}}\right)^{1/2} \left(\frac{\rho_{l1}}{\rho_{l2}}\right)^{1/2}.$$

Δ - Elghazaly H.M.A, Castle G.S.P. // Inst. Phys. Conf. Ser. 1987.№85. -P. 121-126.

Fig. 5. Dependence of a critical charge of a droplet on the liquid temperature

At the external condition change (temperature) the value of the critical charge-to-mass ratio of a charged droplet changes, what means, that there is a necessity of a prediction of charged droplet behavior as one wants to control the technological process.

The results of numerical calculations show, that as higher is one time lose of the charge by a disintegrating charged droplet, as lower numbers of disintegrations play the important role in the mass and charge transfer (generation of charged siblings). This is visible from the curves for droplet charge and mass (Fig.6) [1 – 3].

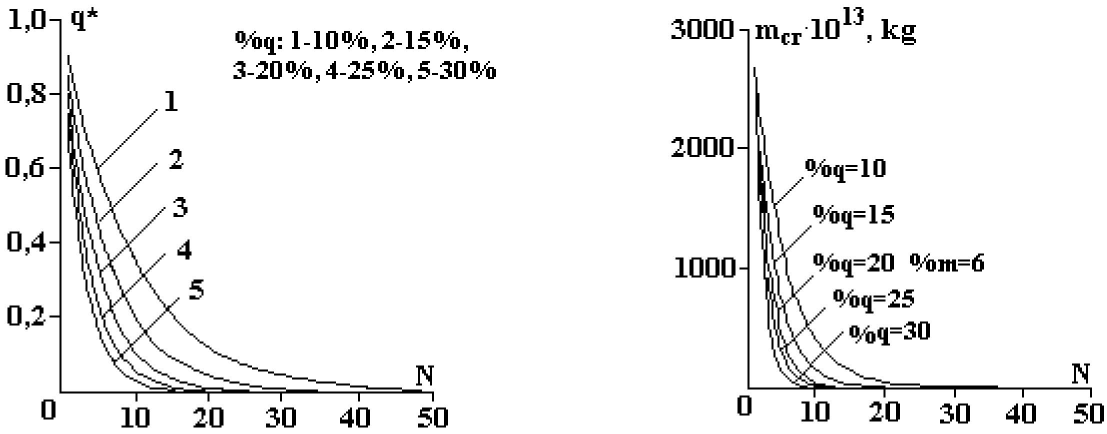


Fig. 6. Dependence of the a droplet charge, mass and radius on the number of EHD disintegrations

At one time charge loses %q=25% most import are first 5 EHD disintegrations, when droplet loses about 80-90% of it's initial charge. Also it is necessary to say, that with increasing of percent of one time loss of the mass %m during EHD disintegrations the number of generated siblings also increases. It is supposed, that all of the siblings have the same size, what is not far from the results from another references.

Taking into consideration the possibility of enhancement of the heat and mass transfer processes by the control of the behavior of charged droplets, numerical calculations were carried out for the charged droplets of the R-134a [1].

The comparison between relative values of the parameters of water and R-134a droplets is presented on Fig.8

WATER

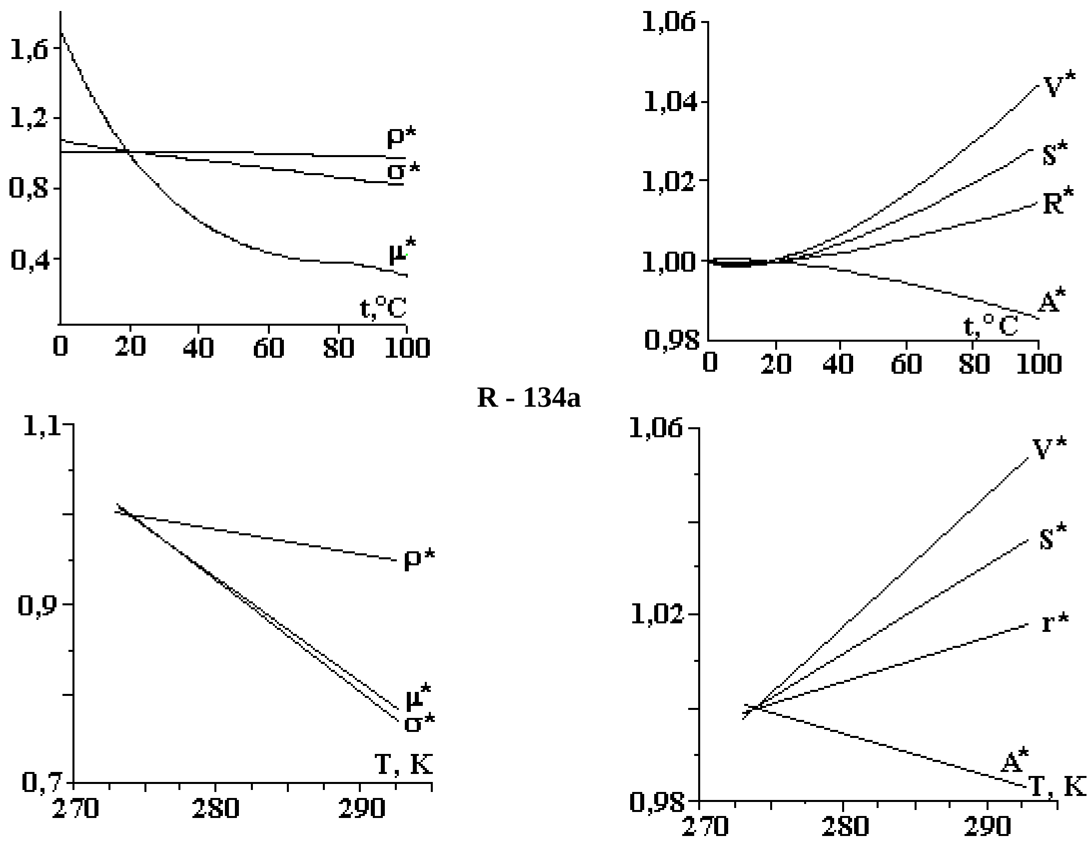
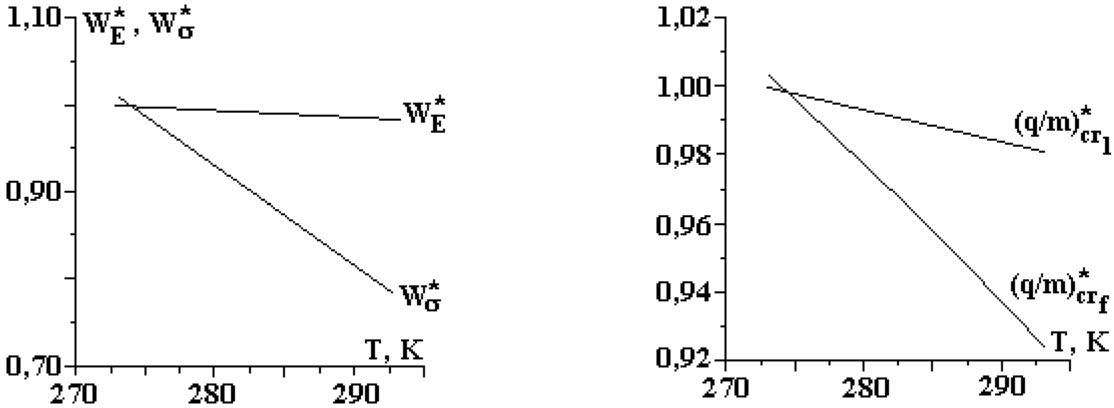


Fig.8. Comparison between relative values of the parameters of water and R-134a droplets

Numerical data for the waters and F-134a charged droplets are presented on the Fig.9.



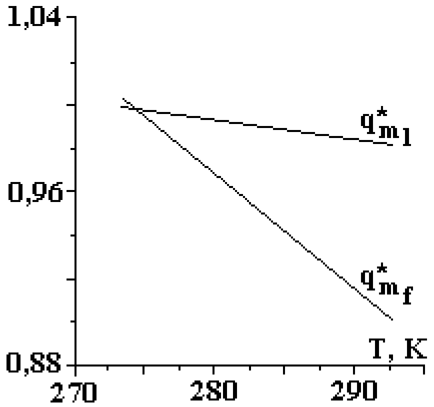


Fig. 9. Comparison between electro-physical parameters of water and R-134a droplets

The analysis of the Fig. 8 and 9 shows, that with liquid temperature increasing the changes of the physical and geometrical parameters of the R-134a droplet is more pronounced that for corresponding water droplet. Increasing of liquid temperature decreases the critical charge-to-mass ration of a charged droplets and with increasing of liquid temperature the charged R-134a droplet has more higher probability for EHD disintegrations than the charged water droplet [1 – 3].

The control of R-134a charged droplet behavior needs more deep knowledge about both the process of droplets charging (droplet charge-to-mass ration) and process of droplet evaporation.

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Summary

Geometrical, physical and electro-physical parameters of charged droplets change with changing of the parameters of gas phase are shown. Comparative analysis of the charged R-134a and liquid drops shows, that with liquid temperature increasing the changes of the physical and geometrical parameters of the R-134a droplet is more pronounced that for corresponding water droplet. It means that charged R-134a droplet has more higher probability for EHD disintegrations than the charged water droplet.