Corona discharge in high temperature high pressure gases

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Corona discharge finds a large scale application in various technological processes. It is widely used in electrostatic precipitators for gas cleaning in chemical industry and machinery, in biomass, especially wood, combustion, etc. The electrohydrodynamic (EHD) phenomena, which are based on corona discharge electric wind effects, find their application in EHD-pumps. The compact EHD heat exchanges in which the move of gas takes place due to electric wind could serve as a good example for perspective development.

The scope of current report is the study of corona discharge, preferably, direct current (DC) corona discharge, in compact ionizers, which includes a grounded electrode in which a star-shaped high voltage (HV) electrode is installed. The electrode system could consist of a grounded tube or a metal grid cylinder and the star-shaped electrodes could have various thicknesses and number of the needles. The Fig.1,a presents the corona discharge in an electrode system tube – star-shaped electrode and the Fig.1,b presents the photo of the corona discharge from a selected needle.

Fig.1,a

Fig.1,b

Fig.1 Corona discharge from a star-shaped electrode

The aim of the study is the analysis of the influence of operation conditions (geometry of the electrode system, number of HV electrode needles, polarity of applied voltage and gas temperature and pressure) on the corona discharge current-voltage characteristics (CVC).

It is proposed to describe the CVCs using the general Townsend equation, in which the dependence of corona discharge current I [A] from the applied voltage U [V] could be presented as $I = AU(U - U_0)$, where A is a complex coefficient [A/V²], U_0 [V] is corona discharge onset voltage.

The results show, that at fixed grounded electrode geometry, with increase of number of needles, at constant value of applied voltage the total corona discharge current increases, but corona current per single needle decreases. The corresponding dependence of the parameter A on the number of needles N is obtained. The change of the geometry of the grounded electrode from a ring-form to the tube one (increase of the electrode height), results in increase of the stability of corona discharge due to diminishing the edge-effects.

The increase of gas temperature results in linear decrease of corona discharge onset voltage U_0, what could be explained by the change of density and electric resistivity of the gas. At constant value of applied voltage, corona current linearly increases. If the increase of gas temperature results in increase of corona current at U=*const*, the increase of gas pressure works oppositely, e.g. at U=*const* the current I decreases.

In the report the authors describe the observed phenomena introducing the corresponding functional dependence of the complex coefficient A not only from the geometry of the electrode system, but also from the gas temperature and pressure.

The experimental results were compared with the results of literature survey, preferably, for the air. An attempt is done to extend the results both to some of gases such N_2, CO_2, helium, some of gas-mixtures and synthetic gas.

The results of investigations are important for extension of fundamental knowledge of the physics of corona discharge phenomena in various gases. The understanding of the tendencies of changing of CVCs depending on ionizer operation conditions opens the possibilities for extrapolation of obtained data to high temperature and high pressure (HTHP) gases. The applied part of the study relates to the development of HTHP electrostatic precipitators and compact HTHP EHD equipment.