Study of dust-electron plasma discharge on condition parallel of the velocity vector of the gas flow and electric field

2013 J. Phys.: Conf. Ser. 479 012001

(http://iopscience.iop.org/1742-6596/479/1/012001)

Study of dust-electron plasma discharge on condition parallel of the velocity vector of the gas flow and electric field

G Dautov[1], I Dautov[1], I Fayrushin[2] and N Kashapov[2]

1 Department of General Physics. Kazan National Research Technical University after name A.N.Tupolev – KAI, Kazan, Russian Federation

2 Department of Technical Physics and Energetics. Kazan Federal University, Kazan, Russian Federation

E-mail: fairushin_ilnaz@mail.ru

Abstract. Investigated non-independent electrical discharge in the longitudinal flow of dust-electron plasma. Found that the charge transfer in the discharge gap is mainly free electrons and positively charged dust particles.

1. Introduction

Dust-electron plasma is formed in combustion of gaseous and liquid fuels and gas-thermal plasma coating of parts and products in the plasma chemical reactors , in the chambers of jet engines for liquid and solid fuels, in MHD generator channels [1]. A number of studies [2-6] constructed mathematical models to carry out numerical calculations of the parameters dust-electron plasma, taking into account the size of the physical properties of the microparticles and composition of the plasma gas. Having thermionic emission from the surface of the microparticles results in the formation of free electrons, the positive charge particles compensating provided nonquasineutrality in general such a low-temperature plasma. However , there is still no reliable experimental data showing that the charge composition of the plasma dust-electron provided mainly positively charged microparticles and free electrons.

2. Experiments and results

Studies conducted in the experimental installation schematically shown in Fig. 1.

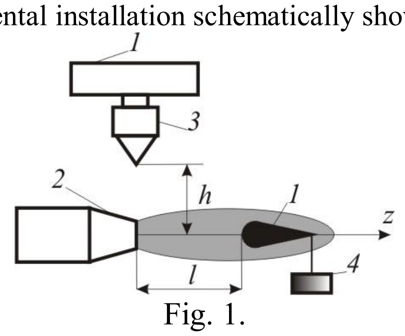

Fig. 1.

The distance between electrodes $l = 2 \cdot 10^{-2}$ m exhibited at moving the movable ceramic platform *4*. One electrode shape for reducing the droplet flow disturbances along the dust *z*. *2* served electrode nozzle of the gas burner . The output section of the dispenser *3* was located at a height h = $3 \cdot 10^{-2}$ m from the axis of the flow at the nozzle exit *2* , powder varied by controlling the input voltage electromagnetic vibrator *5* and maintained the value of $g = 4{,}8 \cdot 10^{-5}$kg / s . The average temperature of the plasma flow was varied from 1500 to 1900 K by adjusting the flow of oxygen in the burner , the flow rate of propane was maintained constant at a value of $2{,}4 \cdot 10^{-5}$ kg / s . In experiments used powders KCl and NaCl, consisting of particles with diameters of $4 \cdot 10^{-5}$ to $6{,}3 \cdot 10^{-5}$ m and the powder of Al_2O_3 - $5 \cdot 10^{-5}$ m embodiment using two input voltage , the electrode *1* - cathode (below the text "straight polarity"), one electrode - the anode ("reverse polarity").

The use of chemical compounds at a temperature of the plasma provides a significant thermionic emission from the surface of the dust particles and at the same time , due to the formation of ions , can get the values of the current non-self- discharge on the orders of her superior absolute error of measurement instruments applied in the transition areas. The particle size and the selected flow rate *g* provide great value of their total surface area and sufficient residence time in the discharge volume of the bulk of the dust component of the plasma. Were dust particles weighing KCl, NaCl and Al_2O_3 collected on the electrode 1 , on the movable platform 4 and scattered along the interelectrode gap at a distance $l = 2 \cdot 10^{-2}$m when they are in the plasma flow . A large percentage of particles reaches the electrode 1 and passes through the plasma discharge.

Fig . 2 shows the temperature distribution along the radius *r* of the plasma stream dust-electron at *z* = 1,8·10-2 m (curve *1*) and *z* = 5·10-2 m (curve *2*). The origin of the z-axis is selected in the nozzle outlet of the gas burner , curves 1 and 2 the values obtained for the discharge current $I = 3{,}5 \cdot 10^{-4}$A at " straight polarity ", the discharge voltage $U = 400$ V , powder $g = 4{,}8 \cdot 10^{-5}$ kg / s . On the resulting chart to select an area of the curve 1 width of $5 \cdot 10^{-3}$ m, in which there is a large temperature gradient flow. When you move along in the direction of the discharge nozzle remains the distribution and the width of the selected area is reduced to $2 \cdot 10^{-3}$m (curve *2*). The temperature and the nature of its distribution remain when the U and the polarity of the electrodes . Thus, the highlighted areas for measuring the characteristics of dust-electron plasma averaged temperature was selected at the expense of propane and oxygen.

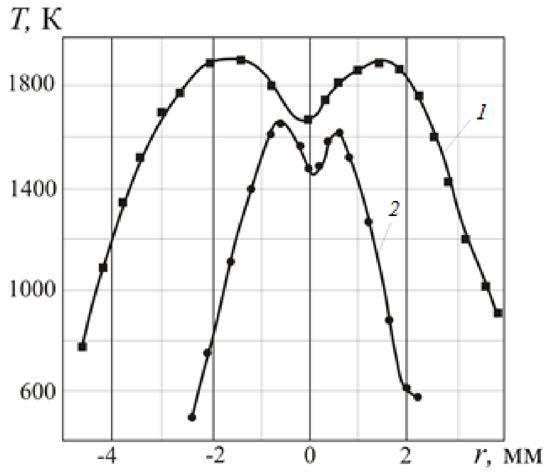

Fig. 2.

For a rough estimate of the contribution of various physical processes in the change of the current density used in the family of non-self-discharge voltage characteristics presented in figures 3-5.

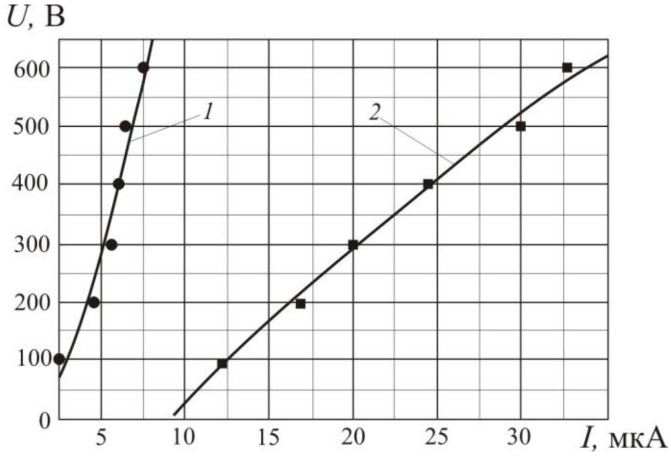

Fig. 3.

As can be seen from Figure 3, $g = 0$, $l = 2\cdot10$ 3m, $T = 1600$ K, a change of "reverse " direction (curve *1*) to " direct " (curve *2*) leads to an increase in the current. The value of the current in the "straight polarity " depends on how dirty the surface of the tungsten cathode sputtering products and duration of heating it in a stream of plasma , therefore , to assess the contribution of thermionic emission , we take the maximum difference CVC - $I = 25\cdot10^{-6}$A .

Passing through the plasma, dust particles can serve as sources of positive and negative ions. Assuming that the change of the polarity of the electrodes does not lead to significant changes in the conditions of formation of these ions , their contribution can be estimated by comparing the current-voltage characteristics obtained with reverse polarity combining bits at a rate of powder without it. Figure 4 curve *1* is obtained for g = 0 , curve *2* for $g = 4{,}8\cdot10^{-5}$kg / Al2O3 with reverse polarity and the same values of other parameters $l = 10\cdot2^{-3}$m, $T = 1600$ K , $h = 3\cdot10^{-2}$ m . In order not to take into account the possible contribution of the electrode processes for evaluation will be used for the entire period of maximum change in value of the difference *U* discharge CVC - $I = 2\cdot10^{-6}$A.

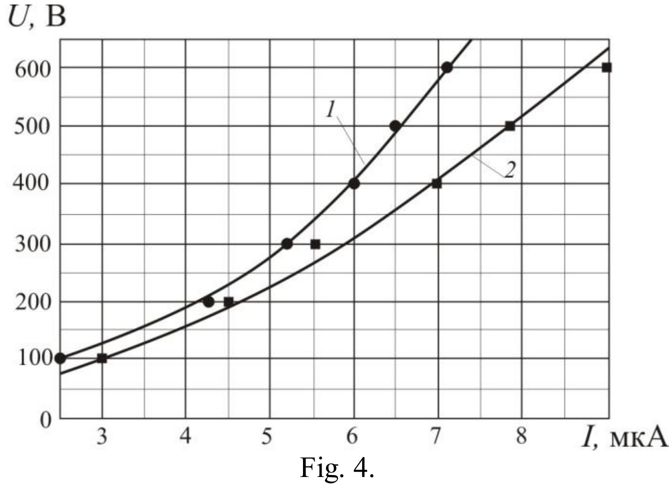

Fig. 4.

Shown in Fig. 5 CVC obtained with "normal polarity" and the values of the parameters $g = 4{,}8\cdot10^{-5}$ kg / s, $l = 10\cdot2^{-3}$m, $T = 1600$ K, $h = 3\cdot10^{-2}$ m, curves *1*,*2* and *3* of KCl, NaCl and Al_2O_3, respectively. The obtained values of the currents and the reduced estimate the contributions of different processes revealed that the charge transfer dust particles in coincidence directions of the flow rate pyleelektronnoy plasma and electric field non-self-discharge makes the greatest contribution to the high amperage.

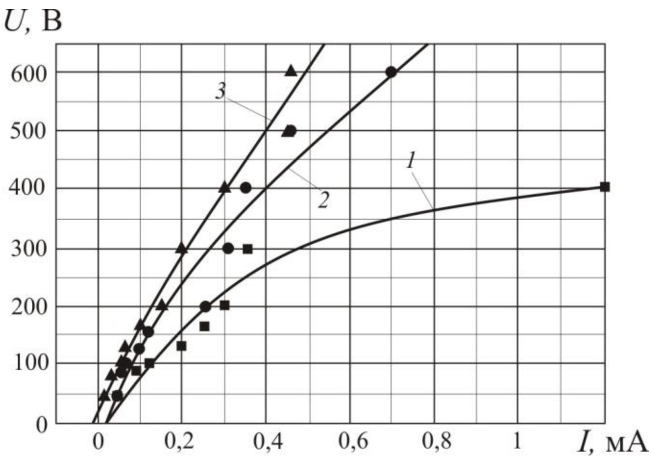

Fig. 5.

Unable to get a stable repeatability for KCl powder for discharge voltages $U \geq 400$ V. Depending on the environmental conditions (humidity and temperature of the air in the laboratory, the state of the cathode surface, etc.) when such discharge voltages change the current strength of up to several mA.

References

[1] Fortov V.E., Khrapak A.G., Yakubov I.T.Physics of strongly coupled plasmas. Textbook. allowance. M. FIZMATLIT , 2004 . 528 .
[2] Dautov G.Yu., Sabitov Sh.R., Fayrushin I.I. 2007 Vestnik of Tupolev KSTU **1** 29-32
[3] Dautov G.Yu., Dautov I.G., Fayrushin I.I. 2009 Vestnik of Tupolev KSTU **1** 57-59.
[4] Dautov I.G., Mardanshin R.M., Fayrushin I.I., Ashrapov T.F. 2010 Vestnik of Tupolev KSTU **3** 143-148.
[5] Dautov I.G., Kashapov N.F., Mardanshin RM, Fayrushin I.I. 2010 Vestnik of Tupolev KSTU **4** 134-136.
[6] V.I. Vishnyakov 2012 Phys. Rev. E **85** 026402.