EHD cell parameters and collector effective area

M D Babushkin, A V Kashin and K G Antipova
Institute for Electrophysics and Electric Power RAS, 18 Dvortsovaya Promenade, Saint Petersburg, 191186, Russia

E-mail: artem-benz@mail.ru

Abstract. In this paper, we investigated the effect of the collector electrode surface area (and the collector mass) on the thrust characteristics atmospheric air to drop EHD cell of the system. While the experiment the perimeter of the receiving electrode changed, and the length of the collector remained unconverted.

1. Introduction
In recent years, an increasing interest in the development of methods for electro-hydrodynamic (EHD) control of gas flows has manifested itself throughout the world [1–3]. Atmospheric airflow EHD devices consist of a plasma emitter, a drift region (acceleration block) and ion collector (neutralizer). Often, these three parts are united in one and form an EHD cell. The optimization of the EHD cell electrode system can significantly affect its efficiency [4–6].

Early studies in this area showed low attractive of such propulsion systems due to their low efficiency and low thrust. However, the high value of specific thrust at low power value makes it possible to use these effects for design small aircraft. Also, optimization of the parameters EHD-cell can significantly affect to its efficiency, weight and thrust [7–8].

2. Design of experimental installation
Figure 1 shows the experimental setup: (1) High-voltage power supply SPELLMAN SL-30, (2) 100 kΩ current-limiting resistor 115K1J20BT; (3) voltmeter M2015; (4) EHD cell; (5) Faraday cage; (6) balance Scout Pro; (7) microammeter RUICHI.

The parameters of the EHD cell were: emitter with a radius of \( r_w = 0.04 \) mm; collector with a constant radius of \( r_c = 0.8 \) mm and a variable perimeter made of aluminum foil with a thickness of 35 μm; interelectrode height of \( H = 18 \) mm; intercollector with a distance \( l_1 = 10 \) mm; collector with a length \( l_2 = 135.3 \pm 0.1 \) mm; number of collectors \( n = 6 \).

3. Principle of operation
In the process of creating thrust occur the following phenomena. On the wire emitters, voltage is supplied from the power source. Around them forms a region with a strong electromagnetic field. The field strength is high enough to cause an air ionization: free electrons accelerated in this area collide with neutrals and ionize them, resulting in even more electrons.

At some distance (out of ionization region) the electric field becomes not enough strong to support this process. In this region positive or negative charged molecules move to the collector in dependence on polarity of the electrodes. The main contribution of the volume force to the formation of the
electrodynamic flow occurs in the interelectrode space between the emitter and collector electrodes, at the same time most of ions neutralize on the collectors.

Figure 1. Experimental setup.

4. Results
On the figure 2 and 3 VAC and the dependence of the thrust on the current for the cell of the electrode system are presented with a mass of the electrodes $m = 0.32$ g and an area $S = 1.32$ cm$^2$. It can be seen from the graphs that after the ignition of the corona the dependence of the current and voltage is quadratic. Accordingly, applying a higher voltage to the electrodes we receive a higher value of thrust. However, raising the voltage indefinitely is impossible, since there will be a breakdown of the discharge gap and a drastic decreased of the system efficiency. The breakdown voltage is determined by the distance between the electrodes, which significantly affects the mass of the supporting elements of the whole electrode system.

Figure 2. Voltage-amperic characteristic of the EHD-cell.  Figure 3. Dependence of the thrust on the current for the cell.

Also, the area of the collectors affects the efficiency of recombination of charged molecules, the larger their area, the higher the probability of their deionization on the surface of the electrodes and the smaller the reverse EHD flow. But at the same time their weight is also growing. As a result of
experiments, it was shown that a decrease of the collector parameter has an insignificant influence on
the absolute value of the thrust $F$ (figure 4).

During the experiments, it was observed that for the considered geometry with a small gap between
the electrodes the maximum thrust is achieved with a positive corona for any value of the emitter area.
Also, as a result of comparing the obtained data with other studies, it can be assumed that the choice of
the polarity of the electrodes depends on the geometrical parameters of the cell, in particular, the size of
the interelectrode space. We suppose that there are certain parameters of the geometry of the cell, in
which there will be no difference between the positive and negative polarities in the maximum thrust.

The effective collector area from the results is presented in figure 5. It can be seen that the specific
thrust (the ratio of the thrust to the mass of the collectors) per unit length increases with a decrease in
their perimeter and, accordingly The thrust exceeds the weight of the electrode system by more than 60
times with a value of $I = 250 \mu A$. Thus, the use of the collectors with a smaller surface area (with a
smaller perimeter) leads to an increase of the payload mass.
5. Conclusions
The obtained results make it possible to determine the ways of reducing the mass of the electrode systems of the EHD-cells, and the ways to choice their optimal parameters to achieve the maximum efficiency.

References
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