Plasma Assisted Combustion of Paraffin Mixture

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The question of the additional activation of paraffin based solid fuels is examined. The use of plasma stimulation for this purpose is proposed. The mixture of n-paraffin and stearin in the solid state as the model of the solid paraffin based fuel is used. The plasma assisted combustion of this model is experimentally investigated. The voltage-current characteristics of discharge at the different regimes are measured. The emission spectrums of a flame and the plasma torch emission spectrum are obtained. The population temperatures of excited rotational levels are determined. The flame temperature during the combustion of solid paraffin containing mixture is calculated.

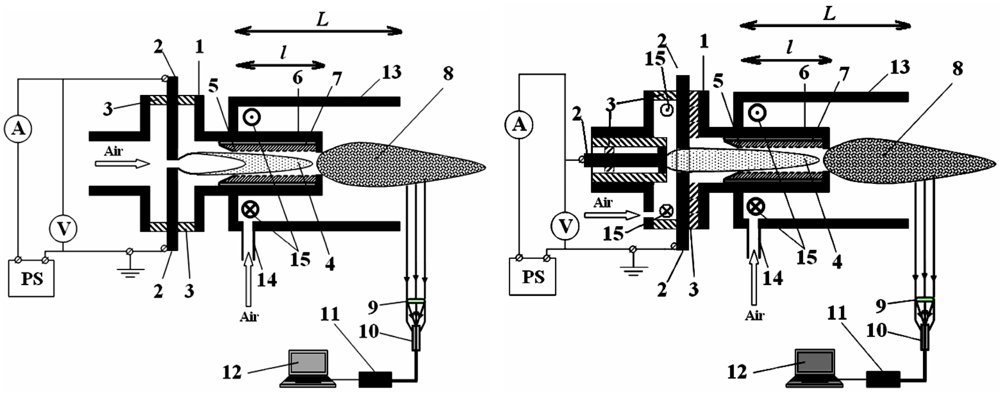
The idea of using a nonequilibrium low temperature plasma for ignition or combustion stabilization seems to be promising today [1]. A number of papers devoted to results review on different gas discharges, used for plasma-assisted ignition and combustion, namely: streamers, dielectric barrier discharges, radiofrequency discharges, pulsed nanosecond discharges (sparks, dielectric barrier discharges, volume nanosecond discharges) and different mechanisms for them, such as ion chemistry and chemistry of excited species, are proposed and investigated [2, 3, 4]. However, the focus was only gas-phase fuel mixtures, and studies to stabilize the solid fuels combustion are practically absent.

The idea of using paraffin for new fuel creating was realized in recent years [5]. It is well-known that paraffin is saturated carbons which contain only carbon and hydrogen and have the general formula C_nH_{2n+2}. The paraffin can be found in the liquid and solid state depending on the number of $–CH_2–$ groups [6]. In spite of the presence of merit significant paraffin based fuel, the question about its advantage in the comparison with the traditional petrol fuels is debatable. One of this discussion reasons connected with chemical sluggishness of paraffin [7, 8]. The need for an additional activation of the combustion appears in connection with this fact. Plasma stimulation is the most effective means for this purpose. Depending on the field of application, the paraffin based fuels can exist in a liquid and solid state. Such experiments for solid paraffin and its mixtures were not carried out in contrast to liquid paraffin. In this work the results of solid paraffin combustion with the aid of the plasma of transverse and rotational gliding arc studies are represented.

The mixture of n-paraffin and stearin in the solid state as the model of the solid paraffin based fuel is used [9]. The fuel composition is 80% n-paraffin mixture with the number $–CH_2–$ groups from $C_{18}H_{38}$ to $C_{35}H_{72}$ and 20% stearin ($C_{17}H_{35}COOH$).

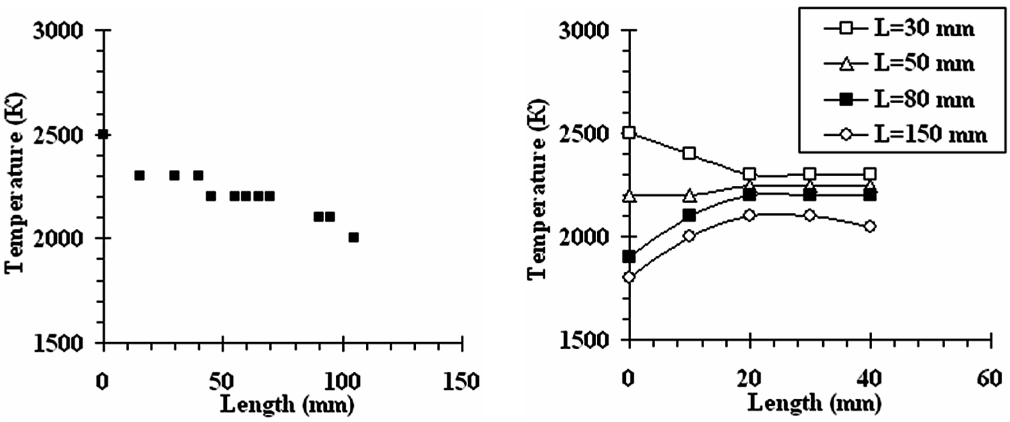
The schematic view of the plasma-dynamic system (PDS) for combustion activation of the paraffin containing solid mixture with transversal and rotating gliding arc is represented in Fig. 1. The PDS consists of the main steel chamber (1) into which through the dielectrics (3) are introduced two copper electrodes (2). The voltage was supplied between the electrodes (2) with the help of the DC power source powered up to 7 kV. The airflow will be given perpendicular to electrodes, forming the torch plasma (4). Compressor formed airflow, which was measured by rotameter. The torch of plasma is surrounded by wire grid (5) in the form of the cylinder with a diameter of 1 cm. The grid is attached to the steel cylindrical capsule (6). The space between the grid (5) and the steel capsule (6) filled with the investigated substance (7) whose weight was 3×10^{-3} kg. The flame (8) on the outlet of steel capsule (6) after discharge burning was formed.

Optical studies of flame were conducted with the aid of the optical system (Fig. 1a, b). Its composition is illuminating system (9), light-emitting diode (10), the spectrometer S-150-2-3648 USB (11) which measures of the spectra in the range of wavelengths from 200 to 1100 nm and computers (12). Combustion chamber (13) was connected to the steel capsule (6). The airflow (15) will be given tangentialy to surface of cylindrical combustion chamber (13) through orifice (14). The steel capsule (6) was immersed into combustion chamber on the length l = 20 mm. Axial distribution of temperature in flame with and without combustion chamber are shown in Fig. 2.



a) b)

Fig. 1: The schematic view of the plasma-dynamic system (PDS) for combustion activation of the paraffin containing solid mixture with transversal (a) and rotating gliding arc (b).



a) b)

Fig. 2: Axial distribution of temperature in flame: (a) – without combustion chamber; (b) – outlet of combustion chamber.

The comparison of experimental results with by the calculated radiation spectrums of blackbody was conducted on the basis of the continuous nature of the emission spectra of flame. Calculations were performed with the aid of the Planck formula.

As a result of study of combustion of the solid paraffin with the aid of the new developed plasma-dynamic system was established that:

Stearin vapor complicates discharge combustion. The emission spectrum of flame is continuous in stable burning regime and corresponds to the radiation spectrum of blackbody. The population temperature of rotational excited levels of hydroxyl OH (*A-X*) ($T_r^* = 2300 \pm 500$ K) is close to the temperature of the plasma assisted combustion (PAC) flame ($T_{PAC} = 2500 \pm 100$ K). This temperature is measured with the aid of the curves calculated according to the Planck formula. The population temperature of rotational excited levels of the OH (*A-X*) hydroxyl in the flame ($T_r^* = 2300 \pm 500$ K) is less than in torch plasma ($T_r^* = 2700 \pm 500$ K).

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