RF TORCH DISCHARGE COMBINED WITH CONVENTIONAL BURNER

J. Janča, C. Tesař

Department of Physical Electronics, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

Introduction

For some special purposes the temperature of the neutral gas in the flame of the conventional burner has to be increased. It is necessary mainly when inflammable ecologically harmful gases and liquids are incinerated or when the conventional burner is used as a spectral source in emission or absorption spectral analysis. Temperatures of the neutral gas in the plasma of the unipolar qradio-frequency discharge excited at the atmospheric pressure in molecular gases are substantially higher than in the flame of the conventional burners; i.e. the temperature of 3 000 - 3 500 K can be obtained in the channel of the torch discharge [1-3]. Advantages of both the conventional burner and the unipolar radio-frequency (rf) discharge can be connected in the arrangement in which the unipolar rf discharge is superimposed through the flame of the conventional burner.

Experiment

The schematic representation of the design of the combined flame-rf plasma reactor is presented in Fig. 1. In the basic arrangement (Fig. 1a) n-heptane (0.12 ml.min^{-1} as a liquid) and oxygen (240 sccm) are supplied from the linear injector to the burner - electrode 3. After the flame ignition and its condition stabilization the assembly of quartz tube 4 with upper flange 8 and upper electrode 5 on carrying rod 7 is put on the lower flange 1. Through the reactor the argon carrier gas flows up (240 ml.min^{-1}). After application of the rf energy a unipolar discharge plasma is formed above the burner tip, both at normal and slightly increased pressure. This is impossible if the burner flame is not lighted. At such a design of combined flame-rf plasma reactor the discharge diverts from the vertical axis of the reactor. The flame combustion products do not pass through the space of the discharge in the whole volume. Therefore, the reactor design was modified (Fig. 1b). To lower flange an inter quartz tube 9 (chimney) was fixed gastight with a narrowing reaching its inter diameter 8 mm in the distance 25 mm above the excited electrode top. Different types of excited electrodes were tested (conical shape, stainless steel, titanium, copper). The optimal variant seems to be that in which a stainless steel capillary (I. D. 0.25, 5 mm long) is pressed into the top opening in the copper electrode and oxygen is supplied together with argon to the chimney. The plasma surrounds the whole top of the excited electrode around the burner opening from which gasified n-heptane flows. The fuel is decomposed totally in the space of the discharge plasma, which is forced to pass through the chimney and reaches in an axially symmetrical shape up to the tip of upper titanium electrode 5. The carrier rod of the burner

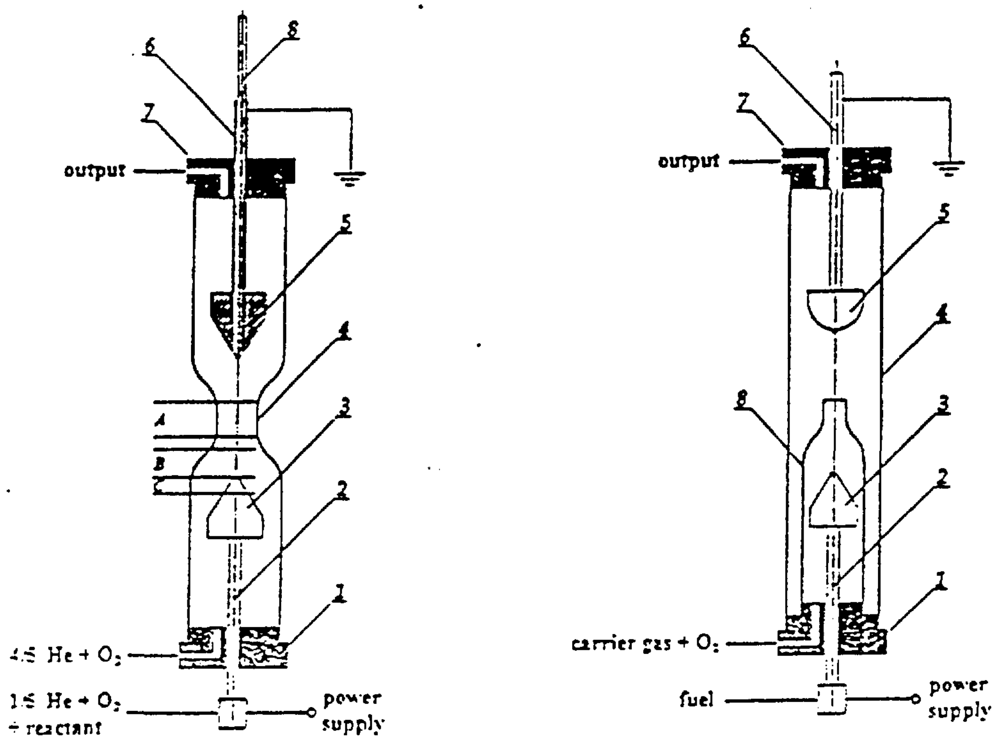

Figure 1: Diagram of the combined flame-rf plasma reactor: a - without chimney, b - with chimney, 1,7 - teflon flanges of the reactor, 2.6 - electrode supported rods, 3 - excited cooper electrode, 4 - quartz tube, length 350 mm (I.D. 33 mm), 5 - titanium upper electrode, 8 - inter quartz tube with narrowing (chimney)

is electrically conductively connected with the outlet of the matching network of the hf generator (13.56 MHz, 500 W max.). The amplitude of the rf voltage has to reach (2-3) kV and the power input at least 100 W. For the determination of the the temperature in different parts of the combined burner plasma the methods of emission spectroscopy were used. The temperatures measured in the conventional burner reach the maximum temperature 1900 K but in the burner with the superimposed rf discharge the neutral gas temperature substantially increases up to 2600 K but also the plasma volume increases substantially . Consequently, the resident time of reactants in the reaction zone increases .

Acknowledgement
The work was supported by Grant No. 202/96/0139 ofthe Grant Agency of the Czech Republic.

References

[1] U. Jecht and W. Kessler, Z. Phys. 178, 133 (1964).

[2] J. Janča, Czech. J. Phys. B. 17. 761 (1967).

[3] V. Farský and J. Janča, Beiträge aus der Plasmaphysik 8, 129 (1968).