ISSN 0020-4412, Instruments and Experimental Techniques, 2014, Vol. 57, No. 6, pp. 749–750. © Pleiades Publishing, Ltd., 2014.
Original Russian Text © A.G. Zherlitsyn, V.V. Buyantuev, V.S. Kositsyn, V.P. Shiyan, 2014, published in Pribory i Tekhnika Eksperimenta, 2014, No. 6, pp. 100–101.

PHYSICAL INSTRUMENTS FOR ECOLOGY, MEDICINE, AND BIOLOGY

A Microwave Plasmatron

A. G. Zherlitsyn, V. V. Buyantuev, V. S. Kositsyn, and V. P. Shiyan

Institute of Physics and Technology, National Research Tomsk Polytechnic University, pr. Lenina 2a, Tomsk, 634050 Russia
e-mail: schijan@tpu.ru

Received December 16, 2013; in final form, February 10, 2014

Abstract—A waveguide-type plasmatron based on a waveguide-to-coaxial adapter (WCA) has been developed. Nitrogen is used as a plasma-forming medium. The microwave discharge initiator based on a disordered stacking of tungsten spirals placed on the end wall of the inner conductor of the coaxial line of WCA has been designed and experimentally tested. A sustained plasma torch is obtained at the atmospheric pressure and a microwave generator power of 1.5 kW. The designed plasmatron is oriented to application in plants for utilizing associated petroleum gas and producing a methane–hydrogen mixture and a carbon nanomaterial.

DOI: 10.1134/S0020441214050200

The need for the rational use of natural resources poses a problem of deep processing of natural and associated petroleum production gases. Among implementation methods for this process, the use of microwave discharge plasma is a matter of special interest. Many authors point to a high efficiency of discharges of this type used for fulfilling a number of endothermal plasmachemical reactions [1].

This work presents a waveguide-type microwave plasmatron with a tungsten discharge initiator, which is the main assembly of the plant implementing utilization processes of hydrocarbon gases in accordance with the technology described in [2].

The block diagram of the designed microwave plasmatron is shown in Fig. 1. Physically, it is a waveguide-to-coaxial adapter (WCA) consisting of rectangular waveguide *1* and coaxial line *2* with hollow inner conductor *3* and outer conductor *4*, which forms a discharge chamber.

This WCA belongs to button-type adapters with a broad band (about 20%) and high electric strength, which allows one to use the WCA with high power levels. Rectangular waveguide *1* with a cross section of 90×45 mm^2 is made of a 2-mm-thickness stainless steel. Inner conductor *3* of coaxial line *2* with a 16-mm diameter and outer conductor *4* with a 40-mm inner diameter are also made of stainless steel.

Waveguide *1* is equipped with pipeline *5* for supplying the plasma-forming gas. Movable short-circuiting switch *6* is placed at the output end of the waveguide to adjust the plasmatron mode. Initiator *7* in the form of a disordered stacking of tungsten spirals is placed on the end wall of inner conductor *3* of coaxial line *2* to initiate a microwave discharge.

The plasmatron is powered from a microwave generator based on an M-143-1 magnetron (OAO Tantal, Saratov, Russia) with an output regulated power of up to 1.5 kW in the continuous mode and an operating frequency of 2450 ± 50 MHz. The magnetron is protected against the reflected wave (if the discharge fails) by using a BΦBB2-13 ferrite isolator (Ferrit Research and Production Association, St. Petersburg), which is intended for use with continuous microwave powers up to 3 kW.

At the initial stage of the study of the microwave plasmatron, the cold measurements of the matching and attenuation parameters of its waveguide system were preliminarily performed by a P2-56 panoramic meter, which measures voltage standing wave ratios (VSWRs) and attenuation constants (α) in a frequency range of 2200–4400 MHz. The measurements were performed without ferrite isolator. The frequency dependencies of the VSWR and attenuation constant α are given in Fig. 2. As it follows from these dependences, the VSWR value is 1.3 at the operating frequency of 2450 MHz, and the attenuation constant $\alpha = 2$ dB. This is quite acceptable for the normal operation of the plasmatron.

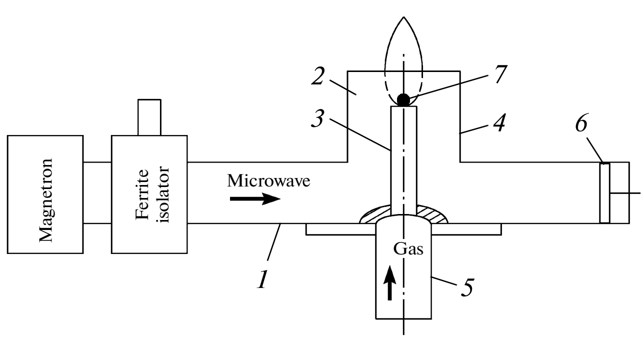

Fig. 1. Block diagram of the microwave plasmatron: (*1*) waveguide, (*2*) coaxial line, (*3*) inner conductor of the coaxial line, (*4*) outer conductor of the coaxial line, (*5*) pipeline, (*6*) short-circuiting switch, and (*7*) discharge initiator.

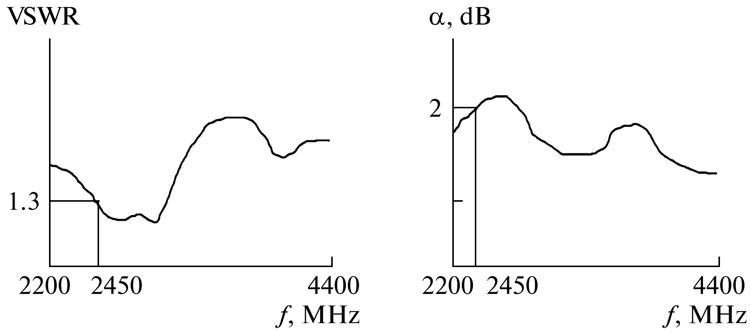

Fig. 2. Frequency dependence of the VSWR and attenuation constant α of the waveguide system in the microwave plasmatron.

The microwave plasmatron operates as follows. The plasma-forming gas (nitrogen) with a flow rate of up to 20 L/min is supplied through pipeline *5*, hollow inner conductor *3* of coaxial line *2*, and gas-permeability discharge initiator *7* to the cooled discharge chamber, and the microwave energy from the microwave generator is supplied through waveguide *1* and coaxial line *2*. Coaxial line *2* with shortened inner conductor *3* passes at its extension into a circular waveguide, which is the outer conductor *4* of the coaxial line.

As the microwave power applied to the discharge chamber is increased and the breakdown value of the electric intensity is reached, the microwave discharge is ignited. A plasma torch is formed by the gas flow in the discharge chamber. With the above plasma-forming gas flow rate, the torch length behind the exit of the discharge chamber is ~50 mm. To decrease the microwave power level required for ignition and maintenance of the stable microwave discharge, the tungsten initiator is applied. Due to formation of microdischarges between its parts, the initial plasma concentration is created, which facilitates ignition of the microwave discharge.

In the process of plasmatron operation, incident and reflected (from plasma) microwave power levels were monitored. Thus, when the incident power was 1.5 kW, the reflected power level was about 30 W, indicating good matching of the system.

Thus, the designed microwave plasmatron demonstrated its serviceability in experimental tests, giving grounds for its applicability for creating hydrocarbon gas processing plants.

REFERENCES

1. Babaritskii, A.I., Gerasimov, E.N., Demkin, S.A., Zhivotov, V.K., Knizhnik, A.A., Potapkin, B.V., Rusanov, V.D., Ryazantsev, E.I., Smirnov, R.V., and Sholin, G.V., *Techn. Phys.*, 2000, vol. 45, no. 11, p. 1411.

2. Medvedev, Yu.V., Zherlitsyn, A.G., Gyunter, V.E., Galanov, S.I., Shiyan, V.P., Ryabchikov, A.I., Sidorova, O.I., Yakovlev, V.G., Polygalov, Yu.I., Stepanov, V.P., Akhmedov, A.Yu., and Lider, D.V., RF Patent no. 2317943, *Byull. Izobr.*, 2008, no. 6. http://www.fips.ru

Translated by N. Pakhomova