ISSN 0040-6015, Thermal Engineering, 2013, Vol. 60, No. 12, pp. 878–881. © Pleiades Publishing, Inc., 2013.
Original Russian Text © A.S. An'shakov, E.K. Urbakh, S.I. Rad'ko, A.E. Urbakh, V.A. Faleev, 2013, published in Teploenergetika.

STEAM BOILERS, POWER-GENERATING FUEL, BURNERS, AND BOILER AUXILIARY EQUIPMENT

Generator of Steam Plasma for Gasification of Solid Fuels

A. S. An'shakov, E. K. Urbakh, S. I. Rad'ko, A. E. Urbakh, and V. A. Faleev

*Kutateladze Institute of Thermal Physics, Siberian Branch, Russian Academy of Sciences,
pr. Akademika Lavrent'eva 1, Novosibirsk, 630090 Russia*

Abstract—A structural design of an electric-arc steam plasma torch (plasmatron) with copper tubular electrodes has been proposed and implemented. Operational parameters are determined for the stable generation of steam plasma. Experimental data are presented on the energy characteristics of the plasma generator with the capacity up to 100 kW.

Keywords: plasmatron, arc discharge, water steam, tubular electrode, energy characteristics, steam plasma gasification

DOI: 10.1134/S0040601513120021

The term "solid fuels" will hereinafter be understood not only as coal and coal mining waste but also as renewable energy resources such as solid domestic, agricultural, and carbonaceous industrial waste. An efficient way for integrated utilization of solid fuels in power industry is their gasification yielding high-energy synthesis gas (mixture of hydrogen and carbon monoxide) and nontoxic slag.

The analysis of the known methods for thermal processing of solid fuels shows that over the last 20–30 years attention has mostly been focused on plasma gasification [1–3]. High temperatures in the flow of electric arc plasma (3000–5000°C) provide a significant yield of combustible gases (90% (by volume) or more), environmental cleanness and technological safety. There, the greatest gasification effect is achieved when low-temperature water-steam plasma is used [4, 5], which is not only the heat transfer medium but also an active agent in the physical and chemical reactions. Among the important advantages of steam plasma is the absence of nitrogen oxides under the operation of a steam plasma torch as distinct from electric arc air heaters.

In [4], it is shown that the steam-plasma gasification of coal provides the 90–95% conversion of carbon dioxide into gas and the gas yield with a ratio of H_2/CO = 1.56–1.70. Taking into account the imperfections of the process equipment the specific energy consumption in the experiment was about 3 kWh/kg. The gasification of the organic component of municipal solid waste, sawdust, rice husks, and biological sludge deposits in the air plasma yields the synthesis gas from 80 to 97% (by volume) with the ratio H_2/CO = 1.5–3.0 [3]. The specific energy consumption is about 0.6–1.2 kWh/kg. The replacement of air plasma by the water-steam plasma increases the heat of the synthesis gas combustion from 10 to 18–20 MJ/m (under normal conditions) [2].

The above-reported parameters of the steam-plasma gasification of coal and carbonaceous wastes demonstrate the high efficiency of the new technology. Numerous publications in the national and foreign press confirm the obvious prospective viability of gasification of solid fuels with the use of steam-thermal plasma.

The implementation of this technology in the industrial production of synthesis gas requires powerful and serviceable electric arc generators of water-steam plasma. The purpose of this paper is to develop a fundamentally new design concept of the plasma generator for heating the water steam and to investigate its energy characteristics.

Water-steam plasma possesses unique properties, i.e., high enthalpy, environmental friendliness, and it is widely available. Therefore, its application range is quite wide: from power engineering to plasma chemistry and from metallurgy to machine building. Figure 1 shows the data on the enthalpy of different gases depending on the temperature [6]. It can be seen that the water plasma enthalpy exceeds that of air, argon, nitrogen, and oxygen plasma states, and only the hydrogen plasma is higher than it.

To date, the design of stationary operating steam plasma torches necessarily includes a tungsten thermionic cathode [6, 7], which requires protective environment in the form of pure argon or nitrogen contaminating the steam plasma. Moreover, these gases are quite expensive. In this connection, the transition to the design of the water plasma generator with copper tubular electrodes is an important task.