MATHEMATICAL MODELING of PLASMA PROCESSING LOW REACTIONARY COALS

S.Petrov, L.Kotlyarov, V.Yatsenko

The purpose of numerical modeling was research of coal burning intensification, finding - out of conditions at which there is the transition to independent burning of a dust coal mix. In the given work process of ignition and burning in the dust coal torch with a central jet low of temperature air plasma is considered. The schema of the flow in a dust coal torch is shown on fig. 1. The coal plasma torch represents heat isolated pipe (muffle) (1) with joined to it through a quartz pipe (2) electrical arch plasmatron (3), located on an axis of the torch. The coal dust is injected to an air plasma jet (4). Secondary air (5) is injected across an air-gap between the plasmatron body and quartz pipe. The flow in jet is supposed an axis symmetric, turbulence. The factors, which intensify burning, are ultrasonic irradiation, electrical potentials, the high-frequency fluctuations of arch current are stipulated. Were taken into account power, thermal and chemical interaction between carrying gas and particles coal dust. The characteristics of considered flow is the account of influence on burning of plasma effects, atomic oxygen, boundary layer, exited particles.

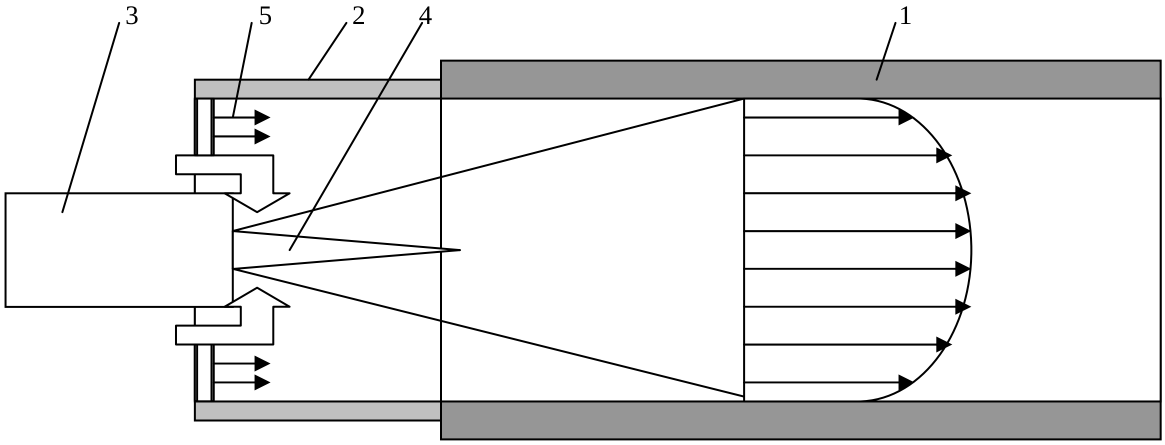

Fig.1. The coal plasma torch

In the mathematical model of the process under consideration, we take into account the jet-like character of two-phase flow at its initial part, water evaporation from coal particles, ash melting and its passage to the gas flow, particles' influence on the gas-flow structure, the polyfractional composition of burning coal dust, and radiation heat exchange between the coal particles and the reactor wall. Furthermore, we suppose that the melted ash in fine-grained form passes to the gas flow and immediately takes its velocity and temperature.

The size of coal particles remains constant up to the moment of complete ash melting and, after this, decreases, whereas their density is constant. The general procedure of computations is the following: First, we determine the geometrical parameters of the two-phase hot jet. The latter is considered to be homogeneous at this stage and has certain effective parameters, which are calculated according to the approach [1]. Further, we investigate the two-phase flow itself, where the velocities and temperatures of gas and particles are different. This flow has boundaries that have been found earlier. The equations describing momentum and energy conservation for the gas flow are the same as in [2].

We take into account six basic chemical reactions that are related to the combustion of coal particles [3]. The values of kinetic constants for these reactions were borrowed from [2]. In accordance with this model, we have developed a program in Turbo-Basic and have carried out a series of numerical experiments. The results obtained enable one to study the effect of different parameters on the considered process and to find ways for its improvement.

References

1. G. N. Abramovich, Theory of Turbulent Jets [in Russian], Fizmatgiz, Moscow, 1960. – 715 p.
2. M. F. Zhukov, R. A. Kalinenko, A. A. Levitskii, and L. S. Polak, Plasma-Chemical Processing of Coal [in Russian], Nauka, Moscow, 1990. – 200 p.
3. V. I. Babii and Yu. F. Kuvaev, Burning of Coal Dust and Calculation of Coal-Dust Flame [in Russian], Energoizdat, Moscow, 1986. – 208 p.

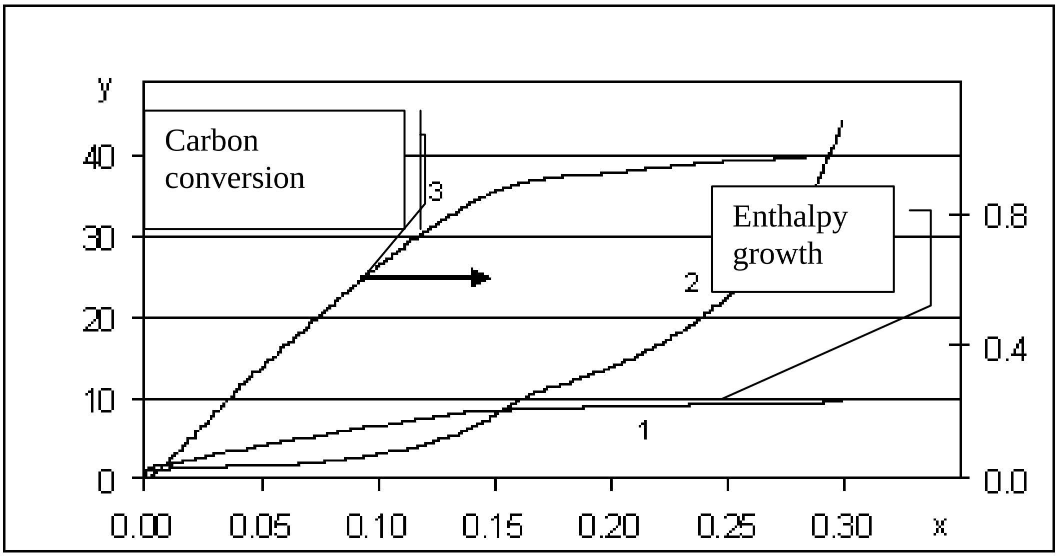

Fig.1. Carbon conversion and enthalpy growth along axis

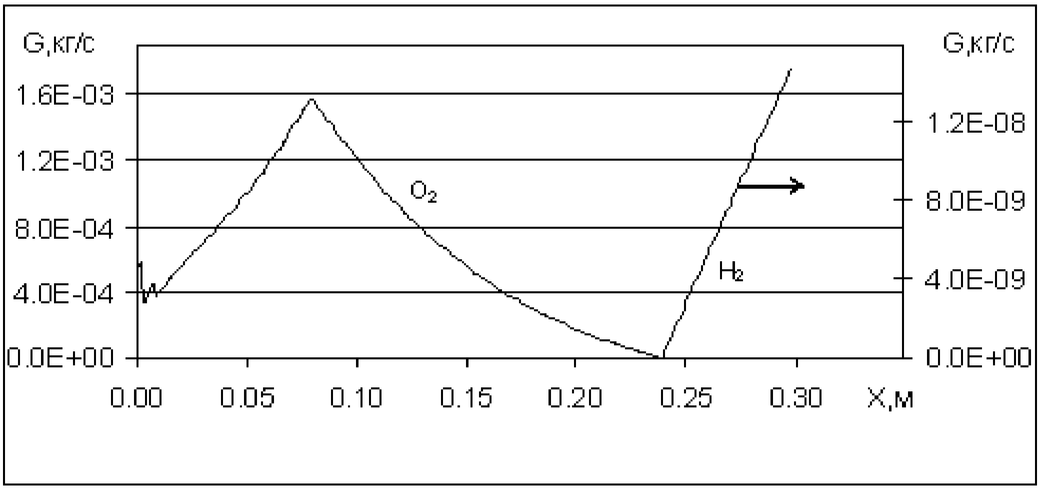

Fig.2. Flow rate of the gas component along axis

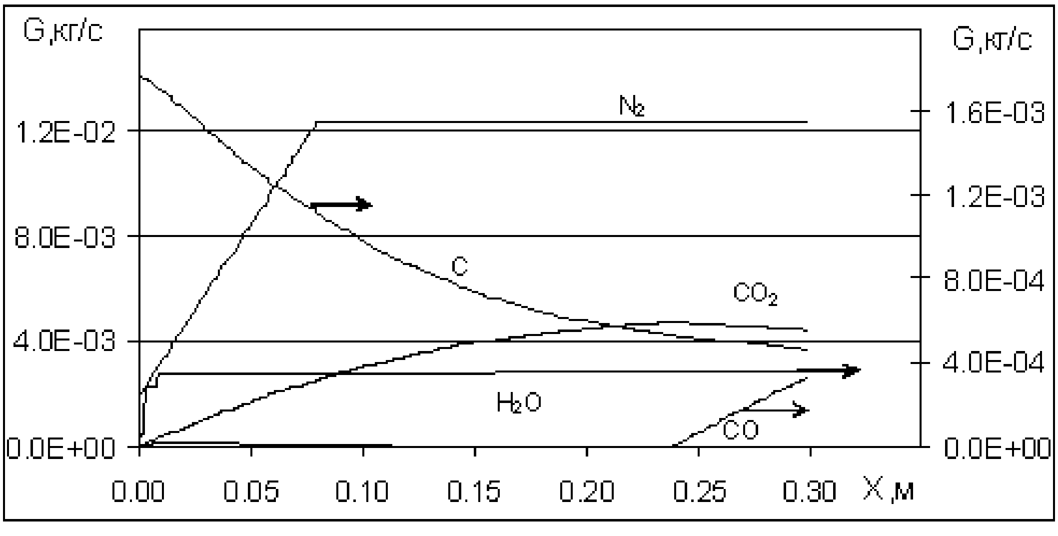

Fig.3. Flow rate of the gas component along axis

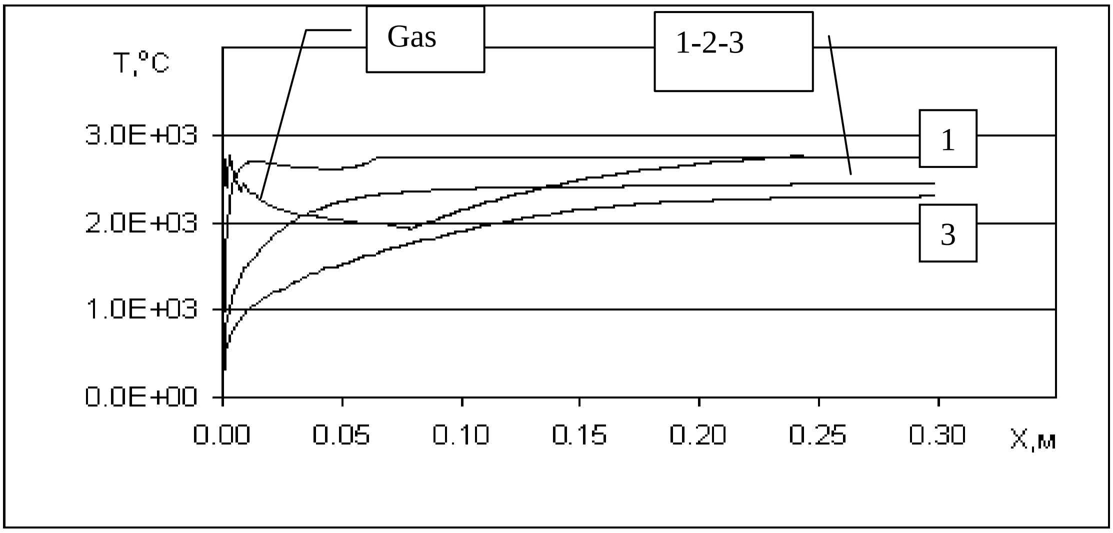

Fig.4., 1 – 17 mkm, 2 – 42 mkm, 3 – 75 mkm

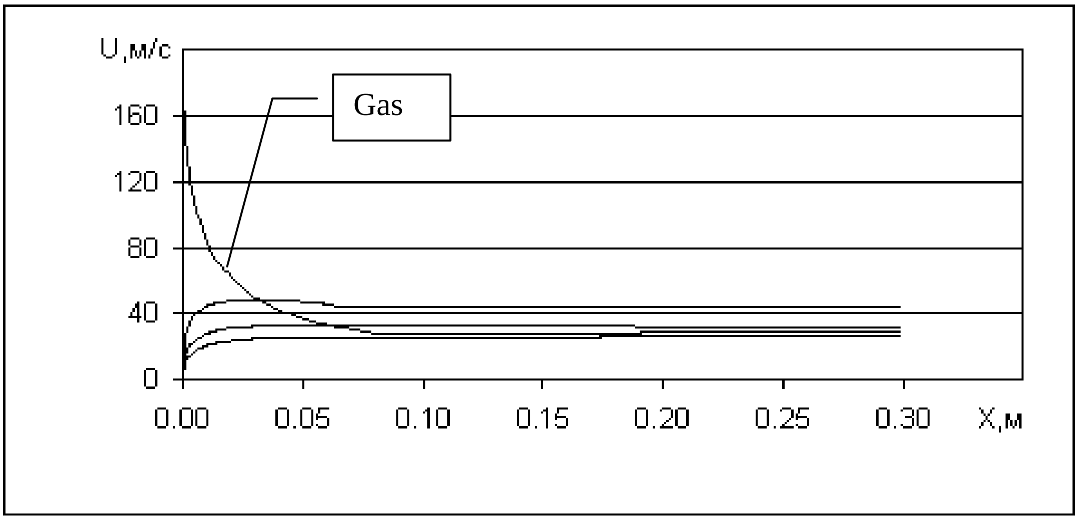

Fig.5., 1 – 17 mkm, 2 – 42 mkm, 3 – 75 mkm

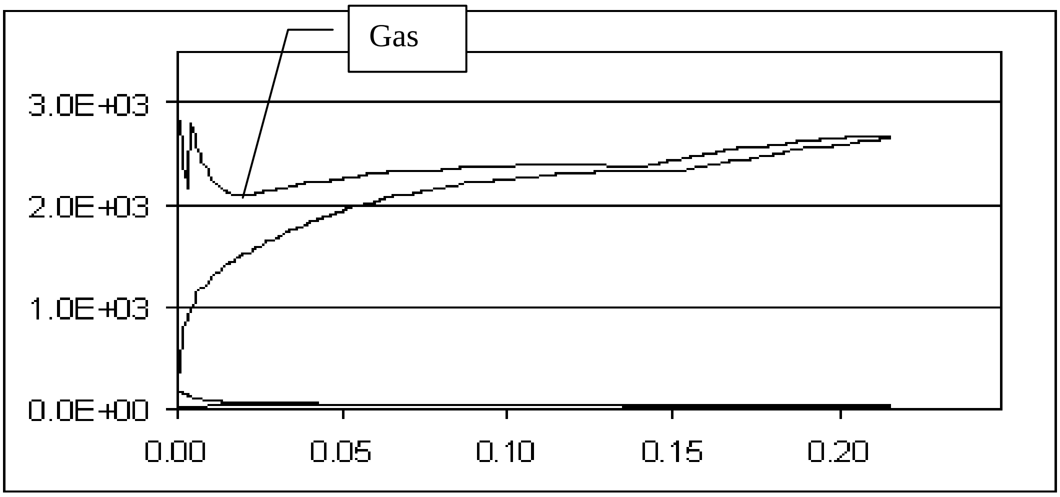

Fig.6.