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Complex processing of solid fuel in plasma chemical reactor

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Currently and in the foreseeable future (up to 2100), the global economy is oriented to use organic fuels, mostly, solid fuels, the share of which constitutes 40% in the generation of electric power. Therefore, the development of technologies for their effective and environmentally friendly application represents a priority problem nowadays. This work presents the results of thermodynamic and experimental investigations of plasma technology for processing of low-grade coals. The use of this technology for producing target products (synthesis gas, hydrogen, technical carbon, and valuable components of mineral mass of coals) meets the modern environmental and economic requirements applied to basic industrial sectors. The plasma technology of coal processing for the production of synthesis gas from the Coal Organic Mass (COM) and valuable components from Coal Mineral Mass (CMM) is highly promising. Its essence is heating the coal dust by reducing electric arc plasma to the complete gasification temperature, when the COM converts into synthesis gas, free from particles of ash, nitrogen oxides and sulfur. At the same time, oxides of the CMM are reduced by the carbon residue, producing valuable components, such as technical silicon, ferrosilicon, aluminum and carbon silicon, as well as microelements of rare metals, such as uranium, molybdenum, vanadium, titanium. Thermodynamic analysis of the process was made using a versatile computation program TERRA. Calculations were carried out in the temperature range 300-4000 K and a pressure of 0.1 MPa. Bituminous coal with the ash content of 40% and the heating value 16.632 kJ/kg was taken for the investigation. The gaseous phase of coal processing products includes, basically, a synthesis gas with a concentration of up to 99 vol.% at 1500 K. CMM components completely converts from the condensed phase into the gaseous phase at a temperature above 2600 K. At temperatures above 3000 K, the gaseous phase includes, basically, Si, Al, Ca, Fe, Na, and compounds of SiO, SiH, AlH, and SiS. The latter compounds dissociate into relevant elements with increasing temperature. Complex coal conversion for the production of synthesis gas from COM and valuable components from CMM was investigated using a versatile experimental plant the main element of which was plug and flow plasma reactor. The material and thermal balances helped to find the integral indicators for the process. Plasma-steam gasification of the low-grade coal with CMM processing gave the synthesis gas yield 95.2%, the carbon gasification 92.3%, and coal desulfurization 95.2%. The reduced material of the CMM was found in the slag in the form of ferrosilicon as well as silicon and iron carbides. The maximum reduction of the CMM oxides was observed in the slag from the walls of the plasma reactor in the areas with maximum temperatures, reaching 47%. The thusly produced synthesis gas can be used for synthesis of methanol, or as a high-calorific reducing gas instead of blast-furnace coke as well as power gas for thermal power plants. Reduced material of CMM can be used in metallurgy.

Biography

A B Ustimenko graduated from Kazakh State University, Physical department in 1984. He received Candidate degree in 1991 on physical and mathematical sciences (equivalent to PhD), and topic of his thesis is "High-temperature heating and gasification of coal particles", Doctoral degree in 2012 on technical sciences, topic of his thesis is "Plasma-fuel systems for fuel utilization efficiency increase". From 1984 to 2001 he was a researcher of the Kazakh Scientific-Research Institute of Energetics. From 2001 to 2007 he was a leading staff scientist of Institute of Combustion Problems at al-Farabi Kazakh National University. Since 1991 he is with Research Department of Plasmotechnics (Kazakhstan) as CEO and since 2002 he is a leading staff scientist and Head of thermal physics department of Research Institute of Experimental and Theoretical Physics of Al-Farabi Kazakh National University.

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