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Plasma processing of fossil fuels

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This paper presents the results of studies of plasma-assisted processing of gaseous and solid fuels. They are plasma processing of uranium-bearing shale, plasma ignition, gasification, hydrogenation, radiant-plasma processing, and complex processing of solid fuels, and cracking of hydrocarbon gases. The application of these technologies to produce hydrogen, carbon, hydrocarbon gases, synthesis gas, valuable components from the mineral mass of coal (MMC) meets modern ecological and economic requirements.

Plasma ignition of coal results in the formation of highly reactive two-component fuel (fuel gas and coke residue) from low-rank coal. It is formed at T = 900-1200 K, which allows the process at relatively low specific power consumption (0.05-0.4 kWh/kg of coal) and leverage at thermal power plants for oil-free boiler start-up and pulverized flame stabilization. Plasma gasification and complex processing of coal to produce synthesis gas and valuable components from MMC were investigated numerically and experimentally. At complex processing of coal simultaneously with gasification of organic matter in the same reactor coke carbon restores MMC oxides and valuable components, such as industrial silicon, ferrosilicon, aluminum and carbosilicon and microelements of heavy metals (uranium, molybdenum, vanadium, and others) are formed. Plasmochemical hydrogenation of coal is a new process of direct production of acetylene and alkenes in the gas phase, in contrast to conventional hydrogenation (liquefaction) of coal. As a result of experiments on low-rank coal hydrogenation in plasmochemical reactor at its power of 50 kW gas of the following composition was obtained, mass %: C_2H_6=50, C_2H_2=30, C_2H_4=10. Radiant-plasma processing of coal allows increasing the degree of conversion of the initial fuel by 48%. At plasma processing of uranium-bearing shale, the following indicators have been achieved: at process temperatures 2700 - 2900 K degree of oil shale gasification was 56.2 - 66.4%, the efficiency of microelements transfer into the gas phase reached for uranium - 48.0 - 78.6%, molybdenum - 54.5 - 79.0%, and vanadium - 58.6 - 81.3%. Plasmochemical cracking is to heat hydrocarbon gases in arc reactor to a temperature of pyrolysis (1900-2300 K) with the formation of fine carbon and hydrogen in unified technological process. During the experiments hydrogen and soot were obtained. Physicochemical analysis of the soot samples has shown that they are different nanocarbon structures mainly in the form of "colossal" nanotubes.

Biography

Alexander B. Ustimenko was born on August 24, 1962, in Alma-Ata, Kazakhstan. He graduated from Kazakh State University, Physical department in 1984. He has Candidate Degree on physical and mathematical sciences (equivalent to PhD), topic of the Thesis is "High-temperature heating and gasification of coal particles", Moscow, 1991, Doctor Degree on technical sciences, topic of the Thesis is "Plasma-fuel systems for fuel utilization efficiency increase" Moscow, 2012. 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 Combustion Problems Institute 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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