World Academy of Science, Engineering and Technology
International Journal of Energy and Environmental Engineering
Vol:10, No:11, 2016

Numerical Investigation of Plasma-Fuel System (PFS) for Coal Ignition and Combustion

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Abstract : To enhance the efficiency of solid fuels' use, to decrease the fuel oil rate in the thermal power plants fuel balance and to minimize harmful emissions, a plasma technology of coal ignition, gasification and incineration is successfully applied. This technology is plasma thermochemical preparation of fuel for burning (PTCPF). In the framework of this concept, some portion of pulverized solid fuel (PF) is separated from the main PF flow and undergone the activation by arc plasma in a specific chamber with plasma torch – PFS. The air plasma flame is a source of heat and additional oxidation, it provides a high-temperature medium enriched with radicals, where the fuel mixture is heated, volatile components of coal are extracted, and carbon is partially gasified. This active blended fuel can ignite the main PF flow supplied into the furnace. This technology provides the boiler start-up and stabilization of PF flame and eliminates the necessity for addition of highly reactive fuel. In the report, a model of PTCPF, implemented as a program PlasmaKinTherm for the PFS calculation is described. The model combines thermodynamic and kinetic methods for describing the process of PTCPF in PFS. The numerical investigation of operational parameters of PFS depending on the electric power of the plasma generator and steam coal ash content revealed the temperature and velocity of gas and coal particles, and concentrations of PTCPF products dependences on the PFS length. Main mechanisms of PTCPF were disclosed. It was found that in the range of electric power of plasma generator from 40 to 100 kW high ash bituminous coal, having consumption 1667 kg/h is ignited stably. High level of temperature (1740 K) and concentration of combustible components (44%) at the PFS exit is a confirmation of it. Augmentation in power of plasma generator results displacement maxima temperatures and speeds of PTCPF products upstream (in the direction of the plasma source). The maximum temperature and velocity vary in a narrow range of values and practically do not depend on the power of the plasma torch. The numerical study of indicators of the process of PTCPF depending on the ash content in the range of its values 20-70% demonstrated that at the exit of PFS concentration of combustible components decreases with an increase in coal ash, the temperature of the gaseous products is increasing, and coal carbon conversion rate is increased to a maximum value when the ash content of 60%, dramatically decreasing with further increase in the ash content.

Keywords : coal, efficiency, ignition, numerical modeling, plasma generator, plasma-fuel system
Conference Title : ICEEE 2016 : International Conference on Energy and Environmental Engineering
Conference Location : Paris, France
Conference Dates : November 21-22, 2016