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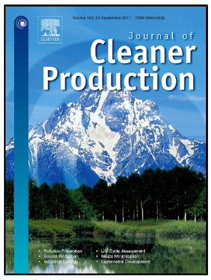

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Ignition of composite liquid fuel droplets based on coal and oil processing waste by heated air flow

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Abstract

To expand the resource base of fuels and methods of hydrocarbon waste recovery, this paper presents the study of the ignition features and conditions of composite fuel slurries based on wastes from coal, chemical, petrochemical, energy, and transport industries. Composite liquid fuels have been prepared using basic components: filter cakes of low-caking, nonbaking, and bituminous coal; engine, turbine, and transformer oil waste; plasticizer. According to a well-known experimental approach, the investigations of the ignition processes have been performed for single fuel droplets (with a radius ranging from 0.5 mm to 1.5 mm) covering a fast-response thermocouple junction. A heated air flow – the ignition source of a droplet – was formed by a specialized blower and a heater. The air temperature varied within the range of 600–900 K. The oxidizer flow velocity was about 3 m/s. With the help of particle image velocimetry hardware and Actual Flow software, we determined the conditions and characteristics of the oxidizer flow transformation around droplets of various shapes. The typical stages of fuel droplet ignition were identified using high-speed video cameras and Tema Automotive software: heating; the evaporation of water and flammable liquid; the thermal decomposition of coal; the formation and ignition of a gas-vapor mixture; the heating of coke residue; the heterogeneous ignition and combustion of carbon. Further, ignition delay times were determined under the conditions of low temperature (600–900 K) heating, as well as the combustion times of fuel droplets with different compositions. Finally, the minimum temperatures were specified sufficient for the sustainable ignition of composite liquid fuel. The established ranges of minimum temperatures show the possibility of burning fuel slurries based on coal and oil processing wastes in heat and power boilers of different capacity. The temperature modes can be adjusted to the required environmental, economic and energy performance indicators. The maximum temperature of a droplet during the combustion process is more than 1,100 K. This result confirms the high combustion heat of fuel slurries, even those based on typical industrial wastes, and shows great prospects of their application in the thermal power engineering. The wide use of abundant industrial wastes as the main fuel components of coal water slurries containing petrochemicals is a high-potential solution to the global problem of their recovery and the reduction of the environmental load of coal-based thermal power engineering on the nature and humankind.