Characteristics of ignition and combustion of fuel blends based on coal slime

Ksenia Vershinina, Daniil Romanov, Vadim Dorokhov, Pavel Strizhak

National Research Tomsk Polytechnic University, 30, Lenin Avenue, Tomsk, Russia, 634050
vershininaks@tpu.ru

The purpose of this research was to study the main characteristics of the ignition and combustion of fuel compositions based on coal flotation waste (coal slime). Wood waste, waste turbine oil, and rapeseed oil were the additional components (5% wt.). Fuel mixtures were burned in a laboratory furnace in the form of slurry droplets, pellets, and a loose layer.

The temperature of stable heterogeneous ignition of all the studied fuels varied in the range of 480–550 °C. In the temperature range of 400–500°C, the volume fraction of CO in flue gases varied in the range of 1.3–4%, the fraction of CO_2 was 1.8–6%. In this temperature range, there is still no intense visible combustion of the coke residue, but oxidation occurs, which is well recorded using a gas analyzer. At higher temperatures (550–900 °C), the amount of carbon monoxide significantly decreased for all fuels, while the amount of carbon dioxide increased. In this temperature range, the generalized range of changes in the CO concentration was 0.5–3.1%, CO_2 was 1–9%.

The completeness of burnout improved with increasing temperature in the furnace. The main trend was that the mixtures of coal slime with additives burned out better than without additives. For example, the mass of the unburned residue of a coal slime pellet burned at 500 °C averaged about 40% of the initial mass of the sample. At a similar temperature, this value decreased to 27% if 5% sawdust was added to the pellet composition. In general, all additives increased burnout with similar efficiency (4–7% difference). During the combustion of water-containing slurry droplets at 700°C, the mass of the unburned residue was no more than 20% of the initial mass of the sample. Such values were not achieved even at 900 °C if the mixtures were burned in the form of a pellet or a loose layer. It can be concluded that there are quite good reasons to develop the technology of combustion of atomized fuel slurries, including due to the possibility of reducing losses that occur due to incomplete combustion.

The experiments confirmed that the diffusion of oxygen and combustion products outside the fuel and inside (in cracks and pores) can play a decisive role in the endo- and exothermic stages, especially at furnace temperatures below 800 °C. A more intense burnout is characteristic of slurry droplets. For fuel pellets, in general, the oxidation was weak due to the complicated supply of oxygen to the inner surfaces of the sample.

The composition of the fuel mixture largely determines the development of the combustion reaction. The decrease of the gas-phase ignition time by at least 2 times occurred when additives (turbine oil, sawdust, and rapeseed oil) were added to the coal slime. The decrease in the duration of the endothermic stage was maximum (3–6 times) when the coal slime was mixed with turbine oil, which, however, did not always lead to faster heterogeneous ignition.

The results obtained can be useful for optimizing technological processes at thermal power plants and boiler houses designed to burn fuel compositions based on combustible low-grade components and waste.

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