COMBUSTION OF FUEL MIXTURES IN A METHANE HYDRATE FLAME

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Abstract: The use of fossil fuels in the energy sector is accompanied by a number of problems such as depletion of energy resources as well as a high level of anthropogenic emissions. One of the options for solving these problems is the involvement of renewable energy resources in the energy sector such as sawdust and rapeseed oil. However, direct combustion of such fuels has a number of difficulties and limitations. To intensify ignition and to improve the environmental characteristics of sawdust and rapeseed oil combustion, the authors propose to use gas hydrates. During the dissociation process, the hydrate dissociates into a combustible component (methane) and water vapor. This vapor–gas mixture is fed into the combustion chamber together with the main fuel of plant origin. It has been experimentally established that the implementation of co-combustion allows achieving stable combustion of the fuel–air mixture and reducing the level of anthropogenic emissions entering the atmosphere during the generation of thermal energy.

Keywords: gas hydrate; biomass; anthropogenic emissions; co-combustion

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Figure Captions

Figure 1 Schematic of experimental setup: *1* — combustion chamber; *2* — dissociation unit; *3* — automation panel; *4* — fuel tank; *5* — gas burner; *6* — fuel injector; *7* and *8* — air compressors; *9* — blower fan; *10* — circulation pump; *11* — water tank; *12* — smoke exhauster; *13* — heat exchanger; *14* — gas analyzer; *15* — gas analyzer probe; *16* — fuel filter; T1, T2, T3, T4, and T5 — locations of thermocouples

Figure 2 Schematic of the methane hydrate dissociation unit: *1* — heat jacket with the possibility of electric heating; *2* — methane supply valve; *3* — automatic control unit of the electric heater; *4* — temperature sensor; *5* — pressure gauge; *6* — water supply valve; *7* — valve for controlling gas supply from the dissociation unit to the combustion chamber; *8* — gas hydrate; and *9* — personal computer

Figure 3 Values of the flame temperature at the outlet of the burner device (T_1), on the rear wall of the combustion chamber (T_2), in the flue gas line (T_3), and temperatures of the coolant of the direct (T_4) and return (T_5) circuits during the combined combustion of rapeseed oil with methane (solid curves) and hydrate gas (dashed curves). Modes: I — ignition; II — stable gas combustion; III — stable gas combustion when oil is supplied; and IV — stable combustion of the remaining gas

Figure 4 Values of the flame temperature at the outlet of the burner device (T_1), on the rear wall of the combustion chamber (T_2), in the flue gas line (T_3), and temperatures of the coolant of the direct (T_4) and return (T_5) circuits during joint combustion of wood sawdust with methane (solid curves) and hydrate gas (dashed curves). Modes: I — ignition; II — stable gas combustion; III — stable gas combustion when feeding sawdust; and IV — stable combustion of the remaining gas

Figure 5 Average concentrations of components in the flue gases (*1* — CO_2; *2* — CO; *3* — CH_4; *4* — NOx; and *5* — SO_2) during co-combustion of wood sawdust, rapeseed oil, methane, and methane hydrate in the model combustion chamber

Table Caption

Proximate and ultimate analyses of fuel components

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