Investigation of soot nanoparticles during liquid hydrocarbons combustion with water steam gasification

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In this study, we investigate properties of combustion-generated soot particles in the original laboratory-scale burner device with water steam gasification. This regime provides drastic intensification of the liquid hydrocarbons combustion due to the supply of a superheated water steam jet into the reaction zone [Alexeenko, 2014]. Such combustion regime can be a promising way to incinerate the low-grade fuels and dangerous industrial wastes with heat-power generation.

Samples were collected from the flame by ejector diluter, slowing down the combustion and coagulation processes. Particle number concentration and size spectrum were measured by diffusion aerosol spectrometer in the gasification region, in the flame and in combustion products cooled to room temperature. The concentration in the outer flame decreases rapidly with increasing distance from burner edge *h* from 10^8 to $5{\cdot}10^6$ cm^{-3} (Fig.1) due to combustion, mixing with the ambient air and coagulation.

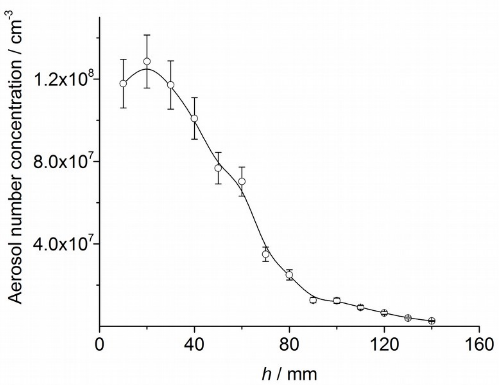

Figure 1. The concentration of soot particles along the vertical axis of the burner.

The size and shape of soot particles were studied by TEM JEM-100SX. The sampling was carried out by a low-pressure impactor. Aerosol is formed as fractal-like aggregates consisting of small primary particles (Fig. 2). The aggregate characteristic size increases with *h*. In the cooled combustion products (after a long lifetime) branched aggregates become compact and similar in shape to a sphere (Fig.2d). HRTEM observations show a concentrical, onion-like structure of individual soot nanospherule (primary particle) with interplanar spacing between layers less than 1 nm, well-known structure for soot [Ishiguro, 1997]. In the gasification region, both primary particles and aggregates size are smaller than in outer flame. Frequency distribution functions for primary particles (TEM measurement) are shown as an example for some sampling points in Fig.3.

Soot mass concentration in combustion products was approximately 3.5 mg/m^3. Corresponding mass median diameter was 90 nm. For diesel fuel consumption 888 g/h (762 g of carbon per hour) and exit gas volume-flow rate 15 m^3/h, underburning is below 0.01%. Measurement results for water steam gasification regime were compared with results for compressed air jet supply.

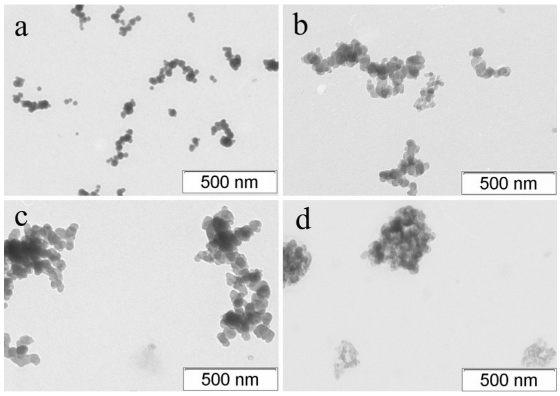

Figure 2. Soot particles from different sampling points: a) *h* = –20 mm – gasification region; b) *h* = 0 mm – burner edge; c) *h* = 120 mm – top of flame; d) cooled products of combustion.

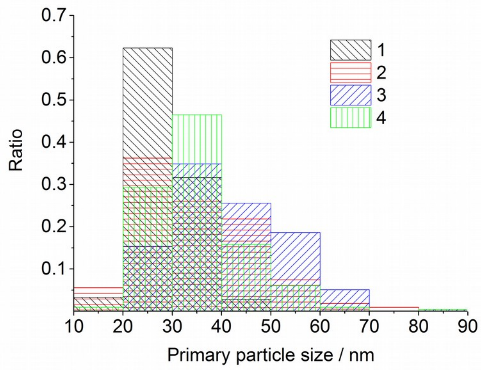

Figure 3. Frequency distributions for primary particles size being a part of aggregates: 1 – *h* = –20 mm; 2 – *h* = 0 mm; 3 – *h* = 120 mm; 4 – cooled products of combustion.

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