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FILTRATION COMBUSTION FURNACE FOR HEAT TREATMENT OF REFRACTORY CERAMICS*

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At present, the development of high-temperature energy-efficient furnaces used for sintering operations is important to reduce the cost of production of products from refractory ceramic materials. In this work, the combustion of premixed fuel mixtures based on natural gas, air, and oxygen was experimentally studied in a prototype of a sintering furnace with the chamber of cylindrical shape which was filled with the packed bed of sphere ceramics. Temperature measurements were carried out using the thermocouple method and spectral pyrometry, which made it possible to provide an absolute error of less than 30 K. Combustion was studied in the range of specific natural gas flow rates from 7 to 107 nl•s $^{-1}$/m^2, fuel-to-oxidizer ratio from 0.40 to 3.30 , oxygen concentration in the oxidizer from 21 to 30 vol.%. In these ranges, temperature control is provided in the range of 1230 – 2220 K. The furnace allows the use of two combustion modes: (1) filtration combustion, when the narrow reaction front (combustion wave) freely propagates through the packed bed, (2) jet-stabilized combustion when the reaction front is aerodynamically stabilized by inlet nozzles used for supplying the fresh mixture into the packed bed. In the filtration combustion mode, the motion of the combustion wave was recorded at a speed of up to 0.1 mm/s in both upstream and downstream directions. The temperature of the packed bed increases with specific fuel consumption, and depends strongly non-linearly on the equivalence ratio. Forced gas-dynamic stabilization of the combustion wave near the flame trap makes it possible to increase the temperature of the packed bed by 100 – 300 K.

Test sintering of powder samples from magnesium oxide, aluminum oxide, and $MgAl_2O_4$ spinel was carried out at a temperature of 2170 K. It has been established that sintering in the filtration combustion mode is effective for obtaining products with a characteristic size of up to 10 mm. This sintering mode can be used to produce ceramic abrasive particles, thermal insulating fills, or catalyst carriers. The jet-stabilized combustion mode is effective for sintering large-format products, while immersing powder samples inside the porous inert media saves fuel twice as compared with free placement of the sample in the volume of the high-temperature furnace chamber. The new furnace based on the principles of combustion of gas mixtures in porous inert media will expand the range of technical devices for economical high-temperature sintering of ceramic materials.