ISSN 0040-6015, Thermal Engineering, 2013, Vol. 60, No. 12, pp. 895–903. © Pleiades Publishing, Inc., 2013.
Original Russian Text © A.F. Ryzhkov, T.F. Bogatova, N.V. Val'tsev, S.I. Gordeev, G.I. Khudyakova, P.V. Osipov, N.A. Abaimov, N.V. Chernyavskii, V.L. Shul'man, 2013, published in Teploenergetika.

STEAM BOILERS, POWER-GENERATING FUEL, BURNERS, AND BOILER AUXILIARY EQUIPMENT

Development of Low-Temperature Thermochemical Conversion Reactors for Coal Power Engineering

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Abstract—The main principles applied in developing a technology for low-temperature thermochemical conversion of brown coals to obtain fuel gas and semicoke intended for being fired in two-fuel power installations are considered on the basis of a set of experimental and calculated investigations. The obtained results are compared with the experimental data obtained using other methods and with the results of previous industrial tests.

Keywords: built-in and external pyrolyzers, kinetic investigations, muffle cyclone-vortex reactor, oxydizing pyrolysis, thermogravimetric analysis, thermochemical conversion, partial gasification, calculations in ANSYS CFX and Thermoflow software systems

DOI: 10.1134/S0040601513120100

Thermochemical processing technologies for converting solid fuels into artificial gas suitable for producing electricity and synthetic liquid fuels at integrated coal gasification combined cycle (IGCC) plants, coal- and biochemical (gas-to-liquids) plants, and cogeneration stations equipped with internal-combustion engines constitute one of the trends in the coal power engineering and polygeneration around the world. Two main lines of activities on development of gas generator technologies have been emerged around the world.

Construction of high-temperature high-capacity (0.5–1.0 GW) dual-purpose (for power-generating and technological applications) installations is the dominating line [1]. Such installations operate, as a rule, with oxygen blasting, at high pressure (4.5–8.0 MPa), high-temperatures (1800–2200°C), and with slag-tap removal (STR).

Development of low-temperature (1200–1300°C) installations for a moderate power capacity (100–150 MW) is an alternative line of works in this field. Such installations operate with air or enriched blasting at atmospheric pressure and with dry slag removal. The state of ash in the active zone depends, as in the furnaces of power-generating boilers [2], on the aerodynamic circuit of the thermochemical conversion reactor. Partial melting of ash may occur in flow-type and fixed-bed reactors; fluidized-bed reactors operate without melting of ash.

The technology allows any carbon-containing raw material to be processed, including coal, petroleum coke, furnace fuel oil, biomass, prepared solid domestic wastes, etc. The developments are currently at the level of pilot and demonstration projects. The fact that the use low-temperature gasification of solid fuel is more preferable is due to the following reasons:

(i) The active zone operates at lower temperatures (1200–1300°C).

(ii) Less stringent requirements are imposed on the fuel quality

(iii) A smaller-capacity gas generator is required, and the system is better suited for use in small-scale and regional power-generating facilities.

(iv) It is easier to organize steam–air blasting than steam–oxygen blasting.

(v) Low-temperature gasification systems are less capital intensive, simpler, and are highly reliable in operation.

The above-mentioned advantages prompt specialists to search for satisfactory technological solutions. However, for installations equipped with low-temperature thermochemical conversion (LTTC) reactors to be successfully promoted in the market of innovative technologies, they must have indicators commensurable with those for large-capacity high-temperature gasifiers.

The main problems encountered during operation of LTTC reactors are stemming from a low rate of thermal conversions and from the fact that thermochemical conversions are considerably incomplete and selective at these temperatures. As a result, with a reactor operating at air excess factor $\alpha < 1$, the yield from