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ENERGY SAVING, NEW, AND RENEWABLE ENERGY SOURCES

The Thermochemical Analysis of the Effectiveness of Various Gasification Technologies

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Abstract—The authors studied the process of gasification of solid fuels and wastes by means of modified model accounting the absence of equilibrium in the Boudouard reaction. A comparison was made between auto- and allothermal gasification, and it was demonstrated that the former method is more advantageous with respect to (as an indicator) thermochemical efficiency. The feasibility of producing highly calorific synthesis gas using an oxygen blast is discussed. A thermodynamic model of the facility for producing such synthesis gas has been developed that involves the gas turbine used for driving an oxygen plant of the adsorption type.

Keywords: simulation of the gasification process, plasma gasification, gasification with air, oxygen-steam gasification, gasification of solid fuels, waste gasification

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Reorientation of all energy technologies toward the use of gaseous fuel that has been seen over the last few decades is due to convenience and high effectiveness of its use, as well as to the low level of the adverse impact on the environment. Gasification opens up new vistas for efficient utilization of local (renewable) fuel reserves, such as wood, peat, other highly calorific raw materials, as well as wastes, for environmentally clean power production. Upon gasification the key constituents of emissions to the atmosphere are "acid gases," which are adequately fixed by absorbents and even can be a source of valuable products, such as sulfur produced from H_2S in the Klaus cycle.

In technologies of gasification of solid fuels that have been developed abroad over more than a century, two principal objectives were pursued: production of domestic gas and production of synthetic hydrocarbons, in particular, liquid fuel in Fischer–Tropsch processes. Stringent requirements imposed upon synthesis gas and the efficiency of the technology are met in this case owing to the implementation of oxygen as an oxidizer during gasification. In Russia, with the ready availability of petroleum and natural gas, production of synthetic gasoline was not justified economically, but there were developed technologies of gasification with the use of air as an oxidizer for the needs of local energy generating facilities [1], among other things, for improving living conditions in regions of logging, in order to produce low-cost gaseous fuel from wood processing residues as a raw material with a "negative" cost. However, to intensify the gasification processes and improve the gas quality, the use of oxygen can only be reasonable in the case of developing new technologies of its production. Today, instead of costly cryogenic plants, there are widely used inexpensive and much less complex in operation facilities for adsorption separation of air, although they are inferior to cryogenic plants as to specific energy consumption per 1 m^3 of the oxidizer (under normal conditions). They are suited in the best way possible in their scale to small power-generating facilities, especially for remote regions.

The next step forward in the development of gasification was made in connection with the development of plasma technologies for destruction of hazardous combustible wastes. To the latter belong chloroplasts, many pesticides, by-products of the organic synthesis, and other substances, upon combustion of which supertoxicants—dioxin-like compounds—are produced that are almost as toxic as the agents contained in chemical weapons (destruction of which nears completion). Thermal destruction of this kind of materials is most rational in the reducing medium of a gasifier with subsequent thermal destruction of hazardous components and fixation of pollutants in exhaust products. Plasma-jet remelting is also used for decontamination of solid slag residues containing heavy metals, etc., by means of melting them into a vitreous mass that prevents hazardous compounds from being washed out by groundwater. In such facilities intended for waste treatment the gasification process occurs very intensely due to high temperature, and in some investigations it is considered as a promising method for utilizing energy stored in biomass.

To preclude excessive optimism, it should be recalled that, despite the enormous progress in the field of production and use of products of coal gasification and creation of very large pilot power plants