Journal of Coal Chemistry 2026 No3 pages 10-21 *ISSN 1681-309X*
DOI: 10.31081/1681-309X-2026-0-3-10-21 Speciality G1 (161). U.D.C. 622.278+662.747

PHYSICAL MODELLING OF THE COAL GASIFICATION PROCESS WITH WATER VAPOUR UNDER HIGH THERMO-BAROMETRIC CONDITIONS

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A physical simulation of the coal gasification process in the Lviv-Volyn coalfield was carried out, using steam as the main reactant under high thermobaric design parameters (at temperatures of 850–1000 °C and pressures of 2.5–4 MPa respectively). To this end, a series of experimental studies were carried out under laboratory conditions at fixed thermobarometric parameters: pressures of 0.4, 1.2 and 3.6 MPa and temperatures of 850, 900 and 950 °C. The main component of the laboratory setup was a reactor-gas generator designed and constructed by us, made of heat-resistant steel ХН35ВТЮ, designed for high thermobaric parameters (at T max = 1000 °C, pressure P max = 4.0 MPa, at T = 850 °C, pressure P max = 25 MPa).

A laboratory experimental plant was designed, developed and assembled, equipped with measuring instruments, and a methodology for research into coal gasification was developed and refined, taking into account underground conditions; an analysis of the obtained data was carried out. Analyses were carried out on the feedstock, the combustible gas obtained, the tar and the condensate.

The optimal operating conditions for the steam coal gasification process were determined, which ensure that the quality and quantity of the final product come as close as possible to the theoretically possible limits. The effects of temperature, pressure, flow rate and reagent quality on the yield, composition and calorific value of the synthesised combustible gases were investigated. A material balance for the process was carried out. The magnitude of the mass imbalance indicates the magnitude of the total errors introduced during the experiments. Thus, the total error in the overall material balance of the process varied in absolute value from 0.7 to 6.3%. The total error for the coal feedstock across all experiments varied in absolute value from 0.4 to 5.9%. The given values of imbalance (total errors) indicate the reliability of the data obtained during the experiments. To determine the experimental error and verify adequacy, two experiments (No. 9, No. 14) were conducted under identical conditions (coal, reagent, pressure, temperature). The total errors for the coal feed are -2.4% and -0.8%, and for the material balance of the process -1.3% and -0.5% respectively, which indicates satisfactory accuracy of the experiments. A methodology and calculation of the heat balance for the gasification process are presented, and all necessary relationships for calculating the thermal and energy parameters of coal gasification are proposed in the model for the pyrolysis stage (1) and the gasification stage itself (2), as well as for the process as a whole.

The study highlights the significant heat losses in the laboratory gas generator reactor, which resulted in poor thermal and energy performance of the process. It is noted that in coal seam conditions, where thermal insulation is an order of magnitude higher, the thermal performance of the gasifier will be significantly better. Optimal operating conditions are justified for further pilot tests under field conditions, i.e. in coal seam conditions.

Keywords: coal, gasification, steam, high thermobaric parameters, calculation method, material balance, heat balance.

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Manuscript received 2026/03/16
Accepted for publication 2026/05/25
Published 2026/05/29

How to Cite:
1. Bryk D.V. Fizychne modeliuvannia protsesu hazyfikatsii vuhillia vodianoiu paroiu pry vysokykh termobarychnykh parametrakh / D.V. Bryk, S.D. Kalmuk // Vuhlekhimichnyi zhurnal. – 2026. – № 2. – S. 10-21. https://doi.org/10.31081/1681-309X-2026-0-3-10-21
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