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# DEVELOPMENT OF MATHEMATICAL AND GRAPHICAL RELATIONSHIPS FOR PREDICTING THE MECHANICAL AND HOT STRENGTH OF BLAST-FURNACE COKE PRODUCED FROM A STAMPED COAL CHARGE

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*A comprehensive study of coal concentrates that form the raw material base for coking at the enterprise was conducted. The study was carried out using a set of modern analysis methods, including sieve, technical, petrographic, and plastometric methods, as well as determining the grindability, swelling pressure, and chemical composition of the mineral part. The results obtained indicate a considerable variation in properties of coal concentrates included in the raw material base for coking. It has been established that individual components of the charge are characterized by significant differences in granulometric composition, technological properties, petrographic characteristics, and features of the mineral part, which directly affects the processes of the coal plasticity behavior and the formation of the coke structure. The study provides a scientific basis for the scientifically substantiated selection and adjustment of the composition of coal charges, taking into account the individual properties of their components, which allows for increased stability of the coking process.*

*It has been shown that an increase in the caking properties of coal mixtures, determined by both plastometric and petrographic methods, as well as an increase in their cokeability, contributes to the improvement of the mechanical strength of blast furnace coke. A close correlation between these parameters has been established: the correlation coefficients r, which characterize the degree of interdependence, are 0.9638 and 0.9486, respectively. Based on the experimental data obtained, graphical relationships were constructed and mathematical equations were developed that allow predicting the mechanical strength of coke obtained in the coking process based on the results of*

*laboratory studies of the quality of coal charges. In addition, a linear relationship was established between the coke reactivity index (CRI) and coke strength after reaction (CSR) for the experimental coke samples. Mathematical dependencies have been developed that allow the CRI and CSR values of laboratory coke to be predicted with sufficient accuracy based on data on the basicity ratio and the basicity index of the ash of the initial coal charges. Statistical evaluation of the obtained equations confirms their high reliability and accuracy: the correlation coefficients are 0.95–0.96, and the values of the standard deviation are within the range of 0.77–0.90.*

*The practical significance of the results obtained lies in the possibility of using them to optimize the composition of coal charges in industrial conditions of coke production. The proposed graphical and mathematical dependencies can be used for operational forecasting of blast furnace coke quality indicators at the stage of laboratory analysis of raw materials, which allows reducing the number of industrial tests, increasing the efficiency of using coal raw materials from different basins, and ensuring stable production of coke with high mechanical and high-temperature strength properties. This, in turn, will contribute to improving the efficiency of blast furnace production and reducing the cost of raw material preparation.*

Keywords: coal concentrates, charge, coke reactivity index, coke strength after reaction, mechanical strength of coke, mathematical modeling, predictive relationships.

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**References**
1. Nag, D., Haldar, S. K., Choudhary, P. K., & Banerjee, P. K. (2009). Prediction of coke CSR from ash chemistry of coal blend. International Journal of Coal Preparation and Utilization, 29(3), 243–250. https://doi.org/10.1080/19392690903218117
2. Pyshyev, S., Shmeltser, K., Miroshnichenko, D., Kravchenko, S., Vytrykush, N., & Shved, M. (2025). Blast furnace coke requirements and methods of improving its quality: A review. Chemistry & Chemical Technology, 19(1), 174–182. https://doi.org/10.23939/chcht19.01.174
3. Kovalov, Ye. T., Vasyliev, Yu. S., Kuznychenko, V. M., Kryvonis, V. V., Danylov, O. B., & Soloviov, M. O. (2009). Teoriia ta praktyka vyrobnytstva domennoho koksu vysokoi yakosti z trambovanykh shykht znyzhenoi spekaemosti. Vuhlekhimichnyi zhurnal, (3-4), 24-30.
4. Husak, V. H., Havryliuk, V. Y., Mahomedov, M. S., Pasternak, O. O., Kovalev, E. T., & Drozdnyk, I. D. (2013). Optymizatsiia vuhilnoi syrovynnoi bazy dlia otrymannia koksu riadovoi ta pokrashchenoi yakosti. Vuhlekhimichnyi zhurnal, (3–4), 8–13.
5. Kuyumcu, H. Z., & Sander, S. (2014). Stamped and pressed coal cakes for carbonisation in by-product and heat-recovery coke ovens. Fuel, 121, 48–56. https://doi.org/10.1016/j.fuel.2013.12.028
6. Sand, A., Rosenkranz, J., & Kuyumcu, H. (2013). Modelling and simulation of stamp-charged coke making by 2-D discrete element method. Advanced Powder Technology, 24, 1039–1047. https://doi.org/10.1016/j.apt.2013.03.004
7. Rejdak, M., Galko, G., Sajdak, M., & Wierczorek, A. (2022). Stamp-charged cokemaking technology – An empirical model for prediction of coal charge density for stamp charging coke oven batteries. Energies, 15, 9440. https://doi.org/10.3390/en14123401
8. Miroshnichenko, D., Koval, V., Kravchenko, S., Soloviev, M., Kogtin, A., Abdulin, S., & Grankin, O. (2024). Transfer of operating battery to loading with stamped charge. Petroleum and Coal, 66(2), 527–536.

9. Mukina, N. V., & Miroshnychenko, D. V. (2022). Koksuvannia trambovannykh vuhilnykh shykht. Vmist hazovoho vuhillia ≤40 %. Vuhlekhimichnyi zhurnal, (3), 4–15.
10. DSTU 4096–2002. (2002). Vuhillia bure, kamiane, antratsyt, horiuchi slantsi ta vuhilni brykety. Metody vidboru ta pidhotovky prob do laboratornykh vyprobovuvan (ISO 1988:1975, ISO 5069-1:1983, ISO 5069-2:1983, NEQ). Derzhstandart Ukrainy.
11. International Organization for Standardization. (2008). ISO 589:2008 Hard coal—Determination of total moisture. ISO.
12. International Organization for Standardization. (2024). ISO 1171:2024 Solid mineral fuels. Methods for determination of ash. ISO.
13. International Organization for Standardization. (2024). ISO 562:2024 Hard coal and coke—Determination of volatile matter. ISO.
14. International Organization for Standardization. (2020). ISO 334:2020 Coal and coke. Determination of total sulfur. Eschka method. ISO.
15. International Organization for Standardization. (2009). ISO 7404-3:2009 Methods for the petrographic analysis of coals. Part 3: Method of determining maceral group composition. ISO.
16. International Organization for Standardization. (2009). ISO 7404-5:2009 Methods for the petrographic analysis of coals. Part 5: Method of determining microscopically the reflectance of vitrinite. ISO.
17. DSTU 7722:2015. (2016). Vuhillia kamiane. Metod vyznachennia plastometrychnykh pokaznykiv. DP «UkrNDNTs».
18. DSTU 9045:2020. (2020). Palyvo tverde. Metody vyznachennia khimichnoho skladu zoly. DP «UkrNDNTs».
19. DSTU 8724:2017. (2018). Vuhillia kamiane ta shykhty na yoho osnovi. Metod vyznachennia tysku rozpyrannia, yakyi vynykaie pid chas koksuvannia. DP «UkrNDNTs».
20. International Organization for Standardization. (2015). ISO 5074:2015 Hard coal. Determination of Hardgrove grindability index. ISO.
21. International Organization for Standardization. (1980). ISO 556-80 Coke (greater than 20 mm in size)—Determination of mechanical strength. ISO.
22. International Organization for Standardization. (2006). ISO 18894:2006 Coke—Determination of coke reactivity index (CRI) and coke strength after reaction (CSR). ISO.
23. DSTU 7601:2014. (2014). Metod vyznachennia volohy v analitychnii probi. DP «UkrNDNTs».