The process of obtaining solid molded fuel from chemical production waste

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Abstract

A solution to the problem of industrial waste disposal to produce valuable and sought-after solid fuel is proposed in the presented work. **The aim of the work** is to develop an efficient method for obtaining solid molded fuel from chemical production waste - coke dust with a binder.

The relevance of the work lies in the fact that in the fuel and energy mix of Russia, as in a number of other countries, a significant share of fuel falls on coal and its products. A significant part of the coal is used for cokemaking, a valuable energy carrier and metal reducing agent. In the process of cokemaking processes, coke dust is formed. Coke dust scarcely find application because of the difficulty with its loading and transportation. Usually, coke dust is returned to the coking charge in an amount of 1% by weight of the charge (which reduces the payload of the coal charge) or can be processed on site, by applying different methods of compaction and packaging (but due to the lack of technology development, i.e. not being originally envisaged by the project of the plant, this happens very rarely). Due to the finely dispersed state and high ash content, coke dust is not suitable for direct use in blast furnace process and power generation. The volumes of generated coke dust are quite large and on average at one coke plant can reach 18,000-20,000 tons/year. The problem of utilization of coke dust for coke chemists is very relevant. Traditional methods of briquetting, developed for the whole range of hard coals, are of little use, and in most cases are not suitable for coke dust. Coke dust, due to its composition, characterized by a low content of humic acids, resins and bituminous substances, is briquetted only with the addition of expensive binders - bitumen, coal tar, etc., which significantly increase the cost of the briquettes. Currently, there is no common scientifically based approach to the choice of an efficient binder and technological regulations for coke dust briquetting in Russia. In this regard, the study of the coke dust briquetting process is an urgent applied research task.

The following tasks were tackled to achieve this aim:

- developing an efficient method for coke dust enrichment;
- selecting a binder for the production of coke dust-based solid molded fuel;
- identifying dependences of changes in the properties of the obtained fuel briquettes on the conditions of their formation;
- producing an experimental batch and testing of fuel briquettes from coke dust with a binder in an industrial environment;

– assessing the amount of emissions of carbon, sulfur, nitrogen oxides during the combustion of fuel briquettes from coke dust with a binder.

Taking into account the existing research experience in this area, it was decided to select an efficient method for enriching coke dust and select the optimal type of binder, which is also an industrial waste. Based on the results of the research, an efficient method for enriching coke dust by oil sintering has been developed. Within the framework of this work, several types of petrochemical waste, such as paraffin, bitumen, waste polymer products and substandard urea, were studied as binders. According to the results of the studies, briquettes obtained with the addition of polymer product waste as well as substandard urea as a binders have the best strength characteristics. The physical and chemical properties were determined and the mechanical strength tests of all briquettes were carried out. Taking into account the results of the research, briquettes obtained from coke dust with substandard urea and having satisfactory mechanical strength and lower volatile volatile-matter yield during combustion were selected for further research.

In the course of experiments on obtaining fuel briquettes based on a mixture of coke dust and substandard urea, regularities were revealed that made it possible to create a mathematical model that demonstrates the effect of the briquetting process parameters on the strength of the resulting briquettes, and to determine the most significant process parameters that affect the strength of the briquettes.

Experimental and calculated analysis of flue gases was carried out in the course of laboratory tests of briquette combustion. The composition of flue gases of fuel briquettes obtained from coke dust with substandard urea binder was compared with the composition of gas from traditional types of solid fuels - thermal coal and coke. The calculation results showed that due to the interaction of ammonia released during the combustion of briquettes with nitrogen oxides and sulfur dioxide, their content in flue gases is reduced by 50% compared to traditional fuels. An analysis of the composition of flue gases generated during the combustion of experimental briquettes in an air stream confirmed the calculated values of the content of harmful emissions.

Pilot-scale cast iron smelting was carried out in the mechanical repair shop of PJSC Koks, Kemerovo, using 20 wt. % of experimental briquettes instead of foundry coke. The smelting was carried out as per normal without loss of cast iron quality, which makes it possible to reduce the cost of raw materials by 6.4 wt. %.

Based on the results of the work carried out, an efficient method for coke dust enrichment by oil sintering was developed, the optimal binder was selected, which makes it possible to obtain strong briquettes and reduce the environmental load during fuel combustion due to their use. The performed calculations and experiments made it possible to select the optimal process conditions for the

production of fuel briquettes. The feasibility of using fuel briquettes has been confirmed by successful pilot tests.

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Scientific novelty:

1. It has been shown for the first time that the use of the oil agglomeration method makes it possible to reduce the ash content of coke dust by a factor of three due to the preferential wettability of dust particles.

2. For the first time, the possibility of recycling industrial waste - coke dust and substandard urea, due to their unique properties when interacting with each other, to produce fuel briquettes with improved performance characteristics is shown.

3. As a result of the processing of experimental data on the interaction of coke dust and urea, a mathematical model has been developed, which makes it possible to predict the strength of the resulting briquettes depending on the applied technological parameters of the process of briquetting coke dust with a binder - substandard urea.

4. It has been shown for the first time that during the combustion of fuel briquettes obtained from coke dust and substandard urea as a binder, there is a significant (up to 50%) reduction in atmospheric emissions of solid substances, NO_2, SO_2, observed through the implementation of selective non-catalytic reduction technology.

Practical relevance:

The experience of coke dust enrichment by the oil agglomeration method (RF Patent No. 2468071) obtained during the research can be used at the real economy enterprises to produce a concentrate with a low ash content.

Conducted industrial tests have shown that the proposed approaches to the production of briquettes can serve as the basis for their practical use in byproduct cokemaking and fuel and energy facilities, which will help solve the problem of coke dust utilization.

Statements submitted for defense:

– application of the process of coke dust enrichment by the method of oil agglomeration allows to reduce the content of ash (Ad) in the concentrate from 16.6% wt. up to 5% wt.;

– use of substandard urea compared to other industrial wastes (repolymers, paraffins, bitumen) makes it possible to obtain high quality fuel briquettes from coke dust;

– a mathematical model that takes into account the dependence of the strength of the obtained briquettes on the technological parameters of the process of briquetting coke dust with a binder - substandard urea, adequately reflects the actual conditions for obtaining fuel briquettes;

– replacement of foundry coke with fuel briquettes obtained from coke dust with a binder does not lead to a deviation from the standard smelting conditions and at the same time reduces the cost of raw materials by 6.4%;

– combustion of fuel briquettes obtained from coke dust and substandard urea as a binder leads to a significant (up to 50%) reduction in emissions of solid substances, NO_2, SO_2 into the air.