Technology for separating powdered materials from petroleum coke using a two-rotor gravity classifier

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Abstract. After refining petroleum products, a lot of petroleum coke residue remains. From year to year, the amount of coke on the planet is increasing, and scientists around the world are looking for ways to rationally use the remaining petroleum coke. Many oil refineries process heavy portions of petroleum products. Most often, new technologies are associated with the emergence of new by-products. The article highlights a new two-rotor technology for a gravity classifier for producing powder materials from petroleum coke. Petroleum coke powder is considered a necessary raw material for many industries. The main goal is to obtain a dispersed composition of coke based on new technologies and use it in many industries. Fine powder materials are considered the most important for industry.

1 Introduction

Petroleum coke grinding is the process of turning large pieces of this material into small particles to improve its quality. During the grinding process, the coke structure is destroyed and its size is reduced to the required size. This makes it possible to increase the efficiency of further processing of coke, improve its properties and increase the value of the final product. Coke grinding is done through various methods such as the use of crushers, hammers, saws and lasers. Each method has its own advantages and disadvantages, so the choice of method depends on specific conditions and requirements. For example, crushers produce small and uniform coke particles, but require a lot of energy and time. Hammers and saws can also be effective, but they can damage equipment and cause environmental pollution. Lasers are the most precise method of grinding, but they require special equipment and highly qualified personnel. In chemical technology, all types of grinding are used, which end with colloidal grinding, when the particle size reaches 1 micron, and the particle size reaches micron fractions. The variety of types and sizes of mills is explained by the characteristics of the chemical industry and the diversity of their scales. There are small crushers with a capacity of several kilograms per hour, plants up to 1500 t/h. But the operation of such technologically advanced machines requires a lot of effort and energy. A gravity crushing classifier with two rotors, proposed by scientists from the Namangan Engineering Institute of Engineering and Technology, 7, st. Kasansay, Namangan, 160115, Uzbekistan.
and Technology Institute, is a modern solution for such machines. This technological machine, unlike other machines of this type, has the feature of simultaneous grinding and classification of crushed solid materials. To operate the device, one 4 kV 1500 rpm or 7 kV 1500 rpm electric motor is sufficient; they can be selected and installed depending on the characteristics of the material [1].

2 Materials and methods

After grinding, coke can be used in various industries, such as the production of steel, fertilizers, chemicals and other products. However, before using coke, it is necessary to carry out additional processing to remove impurities and improve its properties [2].

Thus, the crushing of petroleum coke is an important step in its processing and use. The choice of the grinding method should be based on specific conditions and requirements in order to get the maximum effect from the coke processing process.

Depending on the nature and origin of petroleum coke, its structural composition differs significantly, and the degree of grinding is not the same. Solid blocks can form from highly crushed coke containing more than 3 — 5% moisture in areas with harsh climatic conditions, which complicates the conditions of its transportation [3]. With a content of 1.5—2.0 weight. % of water coke in the process of storage and transportation is very dusty. Therefore, in the existing GOST 22898-78, a water content of 3 wt. % is allowed for delayed coking petroleum cokes [4].

![Diagram of the two-rotor gravity classifier](image)

**Fig. 1.** Two-rotor gravity classifier.

The classifier performs the work in the following order, a sample of coke (3-15 cm in diameter), fed through the loading zone (3), enters between the teeth of a moving (750 min/s) cone. Between the cone of the fixed gear located opposite (9), the coke rotates in the vertical direction and is crushed between the teeth. Movable and fixed teeth in the form of a horizontal cone are made of durable stainless steel, while the distance between the teeth is reduced from top to bottom. This leads to the grinding of coke pieces with a diameter of 3-
15 cm with an interval of 0.5-0.05 cm. The movable toothed cone (7) is mounted on a large rotor, and the rotor (4) is connected to the electric motor through a large auger (2). The rotor and augers (5) are interconnected by large and small gears. The rotor (12) is reinforced with a bearing. The crushed pieces of coke enter through the outlet grid (11), located in the lower part of the cone, into a conical loop (13). The output grid of the product is installed on the basis of impeccable technological calculations, which, in accordance with the product description, ensures that the two-rotor gear gravity classifier can be used for other purposes. Crushed coke particles enter through a conical loop (15) into a toothed drum (movable), the toothed drum grinds coke particles at a speed of (1500 min/C) in the spaces between the toothed drums (16) to a finely dispersed state. Teeth are installed on the movable and stationary drums to ensure the impact on coke particles at high impacts. Coke pellets that escape the impact (1) fall between the teeth embedded in the housing and come back again. These drums (6) are attached to the electric motor through a small rotor. It is in this part of the classifier that a gravitational event occurs with a fine-dispersed phase air flow (14) the product moves through the exit zone to the cyclone. On the other hand, the heavy fraction undergoes repeated crushing, and the heavier part (17) is separated down through the exit zone (for the coarse-dispersed phase).

3 Results and discussion

The degree of grinding of the material was determined by the formula:

\[ i = \frac{D_{cp}}{d_{cp}} \]  

where \( D_{cp} \) and \( d_{cp} \) - weighted average sizes of pieces of raw and crushed material, m.

To determine the technological characteristics of the classifier, a series of experiments were conducted to study the influence of parameters such as the rotation speed of disks and the air flow velocity along the classifier section on the separation process. Figure 2 shows the dependence of the change in the dispersed composition of a large fraction at different air speeds [5]. Based on the obtained dependence of the change in the dispersed composition of a large fraction with a change in air velocity (Figure 2), it can be concluded that an increase in air velocity leads to the involvement of small particles of material in a large fraction. As a result, the monofractionality of the composition worsens, thereby reducing the effectiveness of classification [6].

![Fig. 2. Change in dispersed composition of the coarse fraction with changing air speed.](image)

Changing the rotor speed slightly affects the dispersion of a large fraction of the material. At the same time, its increase contributes to an increase in the efficiency of separation of
solid pyrolysis products of petroleum coke waste. Analyzing the obtained graphical dependencies of the classification efficiency on air flow, it was found that the separation efficiency of petroleum coke products increases with an increase in air flow from 1 m/s to 2 m/s, while the separation efficiency varies from 47.27% to 86.95% [7].

With a further increase in the air flow velocity to 2.75 m/s, the classification efficiency decreases to 80.6%.

The presence of a maximum is primarily due to the fact that with the initial increase in the air flow velocity (from 1 m/s to 2 m/s) a larger number of particles up to 1 mm in size are involved in the ascending process. For example, at a flow rate of 1 m/s, the number of particles in the resulting fine product with a size of 0.5 mm is 0.88%, and at 2 m/s - 15.77%. [8]. After overcoming a certain limit, in our case 2 m/s, particles of larger sizes (≥ 1 mm) are involved in the flow, since with increasing flow velocity, the coefficient of resistance of particles that pollute the fine fraction increases, thereby reducing the efficiency of classification [6]. It follows from this that the choice of optimal air flow depends primarily on the required size of the separated materials. Thus, if the trifle consists of smaller particles, the flow velocity will be lower than if the trifle consists of larger particles, since larger particles are carried away by a high-speed flow.

A decrease in the classification efficiency with an increase in the rotor speed is associated with an increase in the number of particle impacts on the walls of the apparatus and among themselves. With each impact on the wall, part of the kinetic energy of the particle is lost. The particle after impact loses part of the component of the axial velocity of its movement. This loss is then compensated by the carrier energy of the flow, which leads to the acceleration of the particles to the initial values of the ocular velocity component. An increase in the velocity of particles in this case is also possible due to their collision with faster particles. This collision leads to an exchange of momentum, due to which slow-moving particles accelerate, and fast-moving ones slow down. As a result of particle collisions, larger particles are present in the finely dispersed product, the speed of which increases when colliding with faster particles. Accordingly, the particles of the small fraction, the speed of which slows down, pollute the product of the large fraction.

4 Conclusion

As a result of research on the gravitational separation of petroleum coke products, the operating parameters of a rotating graphite classifier have been established, ensuring highly efficient separation of the material into small and large fractions. A classification efficiency of 86.95% is achieved at a rotor speed of 500 rpm and an air flow speed of 2 m/s, which in turn is achieved by removing the amount of fine particles and using them as raw materials for many industries. To date, there are many types and technologies for obtaining dispersed materials, which make up a combination of several continuous-acting devices. In the case of the device returned above, it differs in that it embodies the entire process in one device. On the other hand, the whole process is designed in such a way that it is driven by a single electric motor. This, in turn, guarantees efficiency and achieving 85% of the result with low energy costs.

References

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