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Coal Producer's Rubber Waste Processing Development

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Abstract. A large amount of rubber-containing waste, the bulk of which are worn automobile tires and conveyor belts, is produced at coal mining and coal processing enterprises using automobile tires, conveyor belts, etc. The volume of waste generated increases every year and reaches enormous proportions. The methods for processing rubber waste can be divided into three categories: grinding, pyrolysis (high and low temperature), and decomposition by means of chemical solvents. One of the known techniques of processing the worn-out tires is their regeneration, aimed at producing the new rubber substitute used in the production of rubber goods. However, the number of worn tires used for the production of regenerate does not exceed 20% of their total quantity. The new method for processing rubber waste through the pyrolysis process is considered in this article. Experimental data on the upgrading of the carbon residue of pyrolysis by the methods of heavy media separation, magnetic and vibroseparation, and thermal processing are presented.

1 Introduction

The decommissioned rubber goods are environmental pollutant. At the same time, the worn automobile tires, conveyor belts, etc., are a source of valuable secondary raw materials, such as rubber, technical carbon, metal cord. Ensuring the extraction and further use of the components of rubber goods will significantly reduce the consumption of some scarce natural resources.

The processing of rubber goods can be roughly divided into three categories: grinding, pyrolysis (high and low temperature), and decomposition by means of chemical solvents.

One of the techniques of processing the worn-out tires is their regeneration, aimed at producing the new rubber substitute used in the production of rubber goods. However, the number of used tires used for the production of regenerate does not exceed 20% of their total quantity [1-9].

In some countries, the worn automobile tires rubber crumbs are used for the production of rubber crumb, which is used in rubber-asphalt mixtures for road construction, for the partial bitumen substitution, for the production of building and technical materials and products, and as a component of polymer mixtures. In many countries, a promising solution

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to the problem is burning tires to produce heat and energy, and also as a fuel in the cement industry. In this way, it is possible to achieve a significant reduction in the amount of worn tires.

However, as a result, burning was not profitable either from an environmental or economic point of view. An alternative to burning is pyrolysis of worn tires. In pyrolysis, the feedstock in the reactor is decomposed at a temperature of about 450 ° C, resulting in the production of intermediates: gas, a liquid fuel fraction, a carbonaceous residue and a metal cord. The advantage of pyrolysis is its environmental safety, as a consequence of the process in the absence of atmospheric air, resulting in pyrolysis gases containing no toxic compounds such as sulfur dioxide, nitrogen oxides and carbon monoxide. During pyrolysis, a solid carbon residue is formed in the form of pieces and particles of broad fractional composition. This residue is of interest as a secondary raw material in certain branches of the chemical industry.

After quenching and cooling the carbonaceous solid residue is subjected to magnetic separation or sieved through a sieve, while the metal cord is separated. Liquid fuel and steel cord are sent to the warehouse for further shipment to the consumer.

Liquid products consisting of a mixture of gasoline, diesel fuel and mazut are used as fuel for boiler houses. Low-quality carbon often cannot find its application and is stored on the industrial site of the enterprise.

The greatest interest of industrialists and researchers is caused by the possibility of using a solid carbon residue of pyrolysis of tires in various spheres of economic activities. However, there are a number of application difficulties caused by the variability in the composition of the pyrolysis products, the poor quality of the products (high ash content and sulfur content), poor state of knowledge of the effects on pyrolysis products in order to improve their quality characteristics. The relevance of these studies is of great importance.

Technical carbon has an ash content of up to 20% by weight, because of the additives in the rubber, is very toxic due to technological process disturbances and the absence of aromatization and polycyclization reactions with the elimination of gaseous products that intensify at temperatures above 550 ^{0}C. It is not suitable for use as a sorbent, nor as a fuel, nor as a raw material for the electrode industry.

Thus, it becomes necessary to upgrade the carbon residue, taking into account its physical and chemical properties and the regularities of the processing processes.

2 Materials and methods

In the course of the work, studies were carried out to improve the solid carbonaceous residue of tire pyrolysis by magnetic separation methods and gravity concentration, heat treatment.

The solid carbon-containing residue of tire pyrolysis by OOO “Ekoshina” (Kemerovo) was taken as an object of study.

At the first stage of the research, the technical analysis of the carbon residue was carried out, when ash, moisture, analytical, sulfur content and heat of combustion were determined.

Then, the carbon residue was upgraded by magnetic and vibroseparation. After grinding the pieces of the carbon residue to the particle size of less than 1 mm, the metal cord particles were observed, which were separated by the magnetic separation method.

The experiments on the upgrading of the carbon residue by the method of heavy media separation were conducted. Heavy media wet separation is based on differences in the densities of the separation media, the recovered product (concentrate) and the waste. gravity concentration processes are characterized by high productivity of concentrating devices, simplicity of the production complex, relative cheapness and high efficiency of separation of mineral mixtures.

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Upgrading solid carbonaceous residue of tire pyrolysis was carried out in the experimental installation (Fig. 1), according to the principle of operation based on the method of heavy media separation. The processes of separation of the organic component of the carbon residue of the pyrolysis of tires and mineral particles differing in density occurred, were carried out.

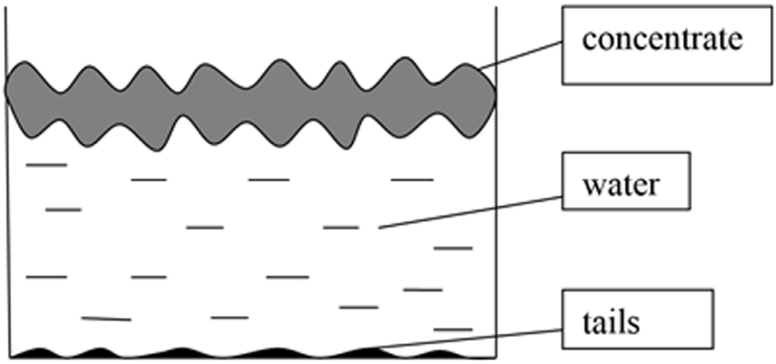

Fig. 1. Scheme of the installation for upgrading the solid carbonaceous residue of tire pyrolysis by the method of heavy media separation

The experiments of concentration of the solid carbonaceous residue of pyrolysis of tires of different grain sizes: > 0,315; 0,315÷0,8; 1,0÷>1,2 were conducted. For the maximum extraction of the organic constituent, the fraction 0,315÷0,8 is optimal, therefore it was taken for the study. Water (ρ=1000 кг/м^3) was used as heavy medium.

Upgrading of the carbon residue of tire pyrolysis by heat treatment was carried out by calcination in the muffle furnace at a temperature of 800±25°C.

3 Results and discussion

The results of the technical analysis of the feed solid carbon residue of tire pyrolysis are presented in Table. 1. From the data presented in Table. 1, it can be seen that the carbon residue has high values of ash content and volatiles yield.

Table 1. Technical analysis of the carbon residue of pyrolysis of worn tires

Test object	Analyte	Analyte content
Solid carbon residue of tire pyrolysis	Ash content: A^d, % wt.	8.9 – 20.40%
	Volatile content V^{daf}, % wt.	7.50 – 16.55%
	Moisture of analysis sample W_a, % wt.	0.65 -1.35%
	Sulfur content, % wt.	0.50 – 2.00
	Calorific value Q_s^r, kcal/kg	5500 - 6000

After grinding the pieces of the carbon residue to the particle size of less than 1 mm, the metal cord particles were observed, which were separated by the magnetic separation method.

It was possible to isolate up to 5% wt. magnetic inclusions by this method. However, the metal cord residues that do not have magnetic properties were visually observed. For the purpose of their isolation, the method of vibroseparation was applied. Metal inclusions had greater weight compared to the organic part and were easily separated using the vibroseparator. The yield of non-magnetic metal cord residues amounted to 1% by weight.

The experimental data on the concentration of the carbon residue by the method of heavy media separation are presented in Table 2.

the solid carbonaceous residue concentrated by means of this method, has low ash content (Ad), good concentrate yield (more than 80% by weight).

The obtained results showed high selectivity of the heavy media separation process and the possibility of producing the low-ash concentrate. From the data presented in Table 2, the concentration process effectiveness is evident, by producing low ash concentrates.

Table 2. Experimental data the carbon residue processing by the method of heavy media separation

Indicator	Heavy media separation
Ash content: A^d, % wt.	5.0-9.3
Volatile content V^{daf}, % wt.	12.0-15.5
Moisture of analysis sample W_a, % wt.	0.6
Sulfur content, % wt.	0.5
Calorific value Q_s^r, kcal/kg	6000-6200

Upgrading the carbon residue of tire pyrolysis by heat treatment was carried out by calcination in the muffle furnace at a temperature of 800±25°C. The mass loss after calcination was from 18.14 to 25.07% by weight.

The quality of the carbon-containing residue of tire pyrolysis was improved (Table 3) after calcinations. The sharp toxic smell disappeared, the pores were cleared and the cylindrical macro-openings became visible to the naked eye (Figure 2), which opens up the prospects for using the produced carbon residue as an adsorbent.

Fig. 2. Carbon residue of tire pyrolysis upgraded by heat treatment

Table 3. Data of the technical analysis of carbon residue of tire pyrolysis upgraded by heat treatment

Test object	Indicator	Value
Upgraded concentrate of solid carbonaceous residue of tire pyrolysis	Ash content: A^d, % wt.	6.5-10.0
	Volatile content V^{daf}, % wt.	0.27-0.38
	Moisture of analysis sample W_a, % wt.	0.20-0.26
	Sulfur content, % wt.	0.25-0.5
	Calorific value Q_s^r, kcal/kg	6250-6850

The solid carbonaceous residue upgraded by heat treatment had lower volatile yield and higher porosity. This makes it possible to use it as an adsorbent, raw material for the production of smokeless fuel, reducing agent for metals, etc.

4 Conclusion

The most promising direction of processing of rubber waste of coal-mining and coal-processing enterprises is pyrolysis. The solid carbon residue produced during pyrolysis is of poor quality, so further processing is required to uprade it.

To remove iron-containing and other mechanical impurities from the carbon residue, it is rational to use magnetic and vibroseparations.

The heat treatment it is most effective to reduce the content of volatile substances and increase the porosity of solid carbon residue.

Processing of rubber waste of coal-mining and coal-processing enterprises by means of pyrolysis will allow processing the significant amount of waste into commercial products and improve the environmental safety of these enterprises.

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