Development of scientific foundations for the processing of solid carbon-containing pyrolysis residue of rubber products

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The paper proposed methods for processing solid carbon-containing pyrolysis residue of rubber products (RP) to improve technical characteristics, which will expand its scope and reduce the consumption of some non-renewable natural resources, the possibility of using refined solid carbon-containing pyrolysis residue of rubber products and obtaining commercial products is investigated. **The aim of the work** is to develop and substantiate the scientific and technological foundations of the waste recycling process of rubber products in Kuzbass to obtain a refined solid carbon-containing residue with high technological properties.

The relevance of the work is due to the fact that in the production of all types of RP and after their operation, a large amount of rubber-containing waste arises. RP is practically not susceptible to destruction under the influence of climatic factors and the activity of microorganisms. Significant efforts are being made in various countries to develop environmentally friendly technologies and equipment for recycling rubber waste. The problem of recycling RP waste is of great environmental and economic importance. The modern market for recycling secondary waste is not able to accommodate the waste generated annually by RP.

The ban on the disposal of such waste will contribute to the formation of an infrastructure for waste collection and disposal, and the utilization of existing production facilities.

The main obstacles to the expanded use of such technologies are:

- low indicators of technological characteristics of RP waste recycling products,
- high environmental hazard of the feedstock,
- low efficiency of traditional processing technologies,
- the lack of scientifically based methodological recommendations and processes of physico-chemical effects on the initial waste of RP, taking into account their properties and reaching the planned indicators of the technical characteristics of the planned products of their processing.

The following tasks were tackled to achieve this aim:

– to develop an effective method for enriching the carbon-containing residue of pyrolysis of RP;

– to carry out a comparative analysis of the technical characteristics of the initial and refined carbon-containing residues of pyrolysis of RP;

– to optimize the technology for obtaining refined carbon residue, determine the kinetic parameters of reactions occurring during the destruction of RP and thermal refinement of a solid carbon-containing residue;

– to obtain marketable products: adsorbents, water-carbon fuel, molded fuel and ionistors based on refined carbon-containing pyrolysis residue of spent RP;

– to produce experimental batches of commercial products based on refined carbon-containing residue and to test them in the production conditions of an enterprise in the real sector of the economy.

Taking into account the existing research experience in this area, it has been established that during pyrolysis of waste of RP, a solid carbon-containing residue is formed in the form of pieces and particles of a wide fractional composition, which has high ash content and volatile matter yield, is very toxic due to violations of the technological regime, therefore there is a need for refinement taking into account its physico-chemical properties and the patterns of processing processes.

Studies on the refinement of solid carbon-containing residue of pyrolysis of RTI waste by various methods are shown.

The application of the developed method for enriching the carbon-containing residue of the pyrolysis of RP by the method of oil agglomeration makes it possible to reduce the ash content in the concentrate.

Refining the carbon-containing pyrolysis residue by thermal processing in the modes proposed in the work makes it possible to obtain a product with lower yields of volatile substances, humidity compared with the initial solid pyrolysis residue and products obtained by heavy-medium enrichment, magnetic separation and vibration separation.

As a result of a comparative analysis of the characteristics of the initial and refined carbon-containing residues of pyrolysis of RP using various methods: IR-spectroscopy, electron microscopy, X-ray phase analysis, it was found that due to the reactions occurring during refinement, the content of sulfur and hydrogen in the sample decreases.

Kinetic parameters (reaction order, activation energy) have been determined, which can be used to develop a mathematical model of the effect of temperature on the rate of reactions occurring during thermal refinement. This model can be used to predict the duration of the process in a given temperature range and optimize the technology for obtaining refined carbon residue.

Commercial products were obtained: adsorbents, water-carbon fuel, molded fuel and ionistors based on refined carbon-containing pyrolysis residue of spent RP.

Experimental batches were manufactured and tested in the production conditions of an enterprise in the real sector of the economy.

The work was carried out in accordance with the research plans of the Kuzbass State Technical University named after T.F. Gorbachev, an agreement with LLC "Kuznetskekologiya +" in Kaltan, Kemerovo region.

Scientific novelty:

It was shown for the first time that the use of the oil agglomeration method makes it possible to reduce the ash content of the carbon–containing residue of the pyrolysis of RP by two to three times due to the selective wettability of the particles of the solid residue of the pyrolysis of RP.

It was shown for the first time that the use of the thermal processing method makes it possible to improve the qualitative characteristics of a solid carbon-containing residue, with an increase in the temperature of the pyrolysis process to 800-850 ° C, the yield of volatile substances, humidity, and sulfur content decrease.

As a result of mathematical processing of experimental data of thermal analysis, it was found that the first-order equation is suitable for the destruction of RP and thermal processing of solid carbon-containing residue, the activation energy of various stages of the processes is determined.

For the first time, the possibility of recycling RP industrial waste to produce adsorbents, carbon-water fuels, molded fuels and ionistors has been shown.

Practical significance:

The experience of enriching the carbon residue of the pyrolysis of RP by the method of oil agglomeration (RF Patent № 2557652) can be used at enterprises in the real sector of the economy to obtain a concentrate with low ash content.

The developed method of refining a solid carbon-containing pyrolysis residue (RF Patent № 2679263) makes it possible to obtain a refined solid carbon-containing residue that can be used as an adsorbent, raw material for the production of carbon-water fuels, molded fuels and ionistors.

The research activity was carried out under the terms of an agreement with LLC "Kuznetskekologiya+" in Kaltan, Kemerovo region. Pilot batches of commercial products obtained from the carbon residue of pyrolysis of spent RP were tested at the installations of LLC Ecosystem Technologies (LLC Eco-Tech), Kemerovo.

The conducted industrial tests of commercial products obtained on the basis of refined carbon-containing pyrolysis residue of spent RP showed that the proposed approaches to their production can serve as a basis for practical use in fuel and energy complexes, which will contribute to solving the problem of recycling spent RP.

Statements submitted for defense:

– developed and justified technological methods for the preparation of solid pyrolysis products of RP waste, which allow to obtain a refined solid carbon-containing residue with a low sulfur content (S) from 0,25% wt. up to 0,5% wt.;

– the process of high-temperature pyrolysis of RP waste at a temperature of 800–850 ° C with an exposure time of 30 minutes at a weight of the initial sample of 150 g;

– the calculated kinetic parameters of the RP pyrolysis process make it possible to predict the effect of temperature on the rate of reactions of rubber degradation and refinement of the carbon-containing residue of RP pyrolysis.