Methods of recovering schungite's adsorptive properties after processing red beet juice

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ABSTRACT

Introduction. Shungite investigated regeneration techniques for reuse in the production technology of red beet juice.

Material and methods. Using shungita (carbon adsorbent nature), chosen due to the peculiarities of its structure. Comparison of the adsorption properties of the regenerated different methods shungita conducted using the cleaning effect of the juice of red beet pectins.

Results and discssion. An important component is the presence shungite he fullerene carbon nanotubes, which is formed by the surface of active carbon rings. Shungit has free pore space represented by a three-dimensional maze of interconnected expansion and contraction of various sizes and shapes, including micro - meso - macropores. Exhaust shungit dried in muffle furnace at different temperatures and durations. The second method - the use of superheated steam to restore the adsorption properties shungite. The expediency of using the method of regeneration shungita superheated steam at a temperature t=170º within 30 min. Reach the maximum effect of red beet juice purification of pectins regenerated steam shungita 34%.

Introduction

In technology of producing red beet juice and its food dye it is feasible to use natural mineral shungite for adsorptive purification of juice from unwanted impurities [2-6].

Shungite is the only known mineral, which contains fullerenes (recently discovered new globular form of carbon existence). Feature of fullerenes structure is that atoms of carbon in molecules are located at peaks of regular hexagons and pentagons that cover the surface of the sphere and form closed polyhedrons created by even number of coordinated carbon atoms.

Difference between fullerenes and particles which have metallic properties lies in surface location of electron cloud and possibility of carbon structure to change the form. Electromagnetic waves dispersion is determined by fluctuations of electrons, which are divided by and modes. During adsorption on electrically neutral surface the modes of fullerenes are localized, and a particle losses its metallic properties, resulting in creation of connected electron-positron pair in upper state. Thus, mineral shows bipolar properties.

Important feature of shungite is fullerene carbon nanotubes which have cylindrical pores with diameter of 1-6 nm, length – up to several microns. Cylindrical surface of tubes is created by rings of active carbon and also has empty pores.

The basis of shungite structure is globule which consists of graphite-like nets, formed in packages. A package has 6 graphite-like flat nets with quantity of carbon atoms attaining 300-600 and a curved net, consisting of 400 carbon atoms.

The sorbent has a structure where ordered zones of carbon rings – hexagons interchange with disordered zones. Contrary to graphite shungite has free porous space, which is represented as three-dimensional labyrinth of interconnected widenings and narrowings of different size and form. In this respect, there are micropores of up to 2 nm, mesopores and macropores.

Material and methods

Shungite regeneration was conducted in experimental laboratory installation, scheme of which is presented in fig.1.

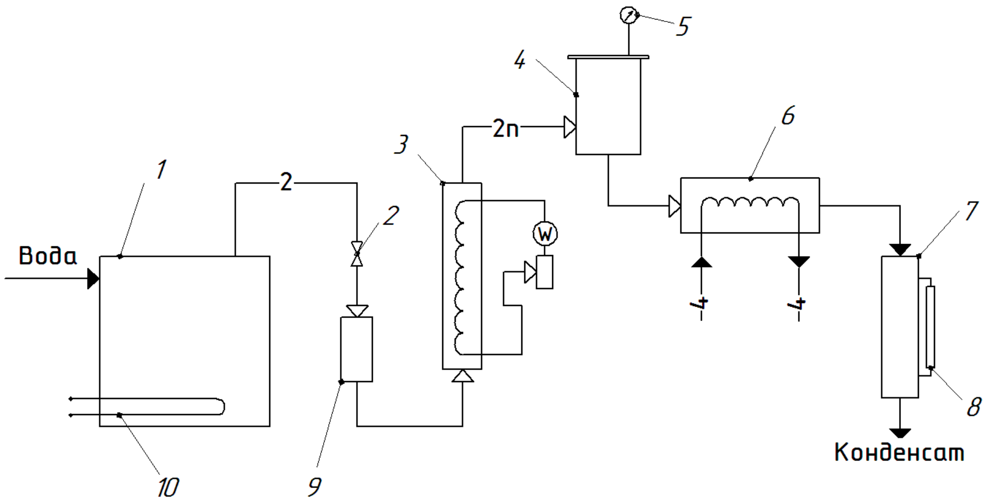

Fig. 1. Scheme of research installation for shungite regeneration
1 – steam boiler; 2 – valve; 3 – steam superheater; 4 – research unit; 5 – manometer; 6 – condenser; 7 – collecting tank; 8 – gage glass; 9 – separator; 10 – electrical tubular heater.

It operates in the following way: spent adsorbent is regenerated by superheated water steam, created in steam boiler 1 electrical tubular heater 10 and its passing through separator 9 and superheater 3. Test sample of adsorbent (10 g) was placed in research unit 4, pressure in which was measured by manometer 5. Spent steam proceeded to condenser 6, condensed steam accumulated in collecting tank 7. Level of condensed steam was measured with the help of gage glass 8.

Red beet juice purification effect was calculated pursuant to formula:

$$E = \frac{100 \cdot (K_1 - K_2)}{K_1}$$

whereas K_1 and K_2 – quantity of target component in juice processed and juice not processed by shungite.

Results and discussions

During adsorption purification of red beet juice shungite surface and pores were filled with adsorbed impurities and as the result mineral's capacity to adsorb impurities gradually decreases. To recover adsorptive capacity of shungite it was necessary to find effective method for adsorbent regeneration. Economic feasibility, availability of water steam as well as appropriate equipment of canning plants were the leading criteria in search [7].

Attention was focused on the method of low temperature thermal regeneration of shungite which includes processing sorbent at 100-400°C. Such regeneration is mostly used to recover sorption capacities of carbon-bearing porous sorbents which have accumulated non-volatile and temperature-sensitive components of sorbate, which are dissolved and brought out by steam. In many cases such regeneration of adsorbent capacities is done directly in adsorption tanks, which saves production floor space and cuts down expenses of the plant. This method is save and available for all production conditions.

Efficiency of the chosen method was verified by comparing the results of purifying red beet juice from pectin substances before and after shungite regeneration [8].

To study the influence of temperature and duration on the process of desorbing pectin substances samples of spent sorbent were placed in muffle kiln and held at 140º, 200º and 300ºC during 10-120 min. Cooled adsorbent was used to process red beet juice at previously selected optimal parameters for pectin substances adsorption and then purification effect was measured.

Average data is presented in fig. 2.

The highest markers of purifying red beet juice from pectin substances, shown in fig. 2, are within the range of 24-32% at 300ºC, with duration of 30-120 min and 18-26% at 200ºC, duration of 30-120 min. It is not feasible to regenerate shungite at 140ºC, because maximum effect of purification achieved in this case does not exceed 10%. Regeneration duration of 10 min is not effective, so it is not applied thereafter.

Analysis of the obtained results shows that effect of purifying red beet juice from pectin substances by shungite regenerated at 300ºC is the best one.

Taking into account that regeneration of shungite in muffle kilns is complicated and expensive process, which entails large wastes of energy resources, it was decided to recover adsorption capacities of shungite with the help of superheated steam.

The next round of experiments was dedicated to determining efficient technological parameters for regenerating shungite with the help of superheated water steam.

Superheated water steam of 140…180ºC was used, 10ºC apart, with pressure of 0.3 MPa at each of the chosen temperatures. Regenerated shungite was used to purify red beet juice from pectin substances, and purification effect was assessed. Experiments lasted within 10-30 min with mass rate of steam being $2.305 \cdot 10^{-3}$ kg/ sec.

The obtained results are shown in fig.3.

As it is showed in fig.3, after 10 minutes of regenerating shungite with superheated water steam the purification effect increases from 9 to 20%. By increasing the duration of regeneration up to 20 min, the purification effect significantly goes up. For instance, with steam of 140ºC it constitutes 17% and grows to 32%. Maximum purification effect of 34% is achieved at regeneration temperature of 170º during 30 min.

The obtained data became a basis to optimize the process of regenerating shungite with superheated water steam.

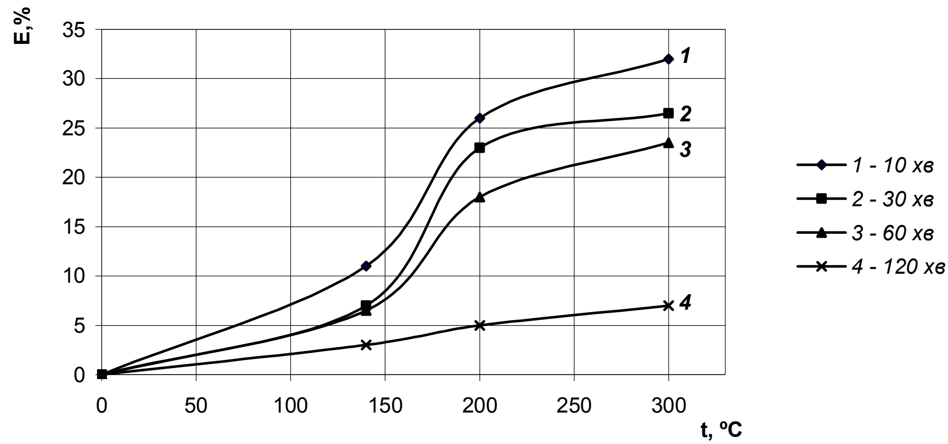

Fig. 2. Dependence of purification effect of red beet juice processed with thermally regenerated shungite on temperature and duration of shungite regeneration (E,% of original shungite constitutes 32%)

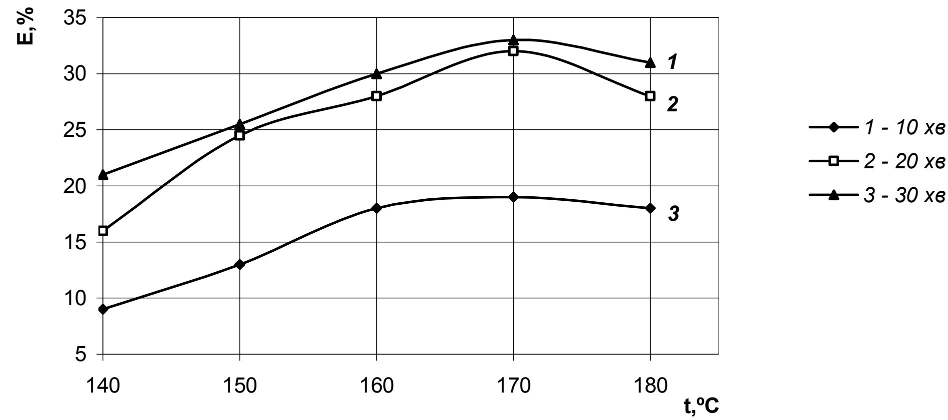

Fig. 3. Dependence of purification effect of red beet juice processed with shungite, regenerated with the help of superheated water steam, on temperature and regeneration duration

Conclusions

Investigated two methods of restoring shungita adsorption properties for reuse in cleaning juice from beet pectins: thermal activation method schungite in muffle furnaces and adsorbent treatment with superheated steam.

Proven benefits of regeneration shungita superheated steam. Established rational technological parameters regeneration shungita superheated steam temperature - duration - 30 minutes. When this high cleaning effect is achieved in 34 %.

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