RESOURCE-SAVING TECHNOLOGICAL COMPLEX FOR POLYMER WASTE PROCESSING

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Abstract. A technological complex for the production of composite mixtures from techno genic polymer materials is presented in the article. The development of resource-saving technology and special equipment is considered for complex processing of techno genic polymer materials with various physical and mechanical characteristics. The functions of the dispersed composition of the crushed polymeric materials under different conditions are constructed and rational operating modes of the rotor-centrifugal unit are established. To improve the efficiency and expand the technological capabilities of the rotor-centrifugal unit, a patent-protected construction of a combined-action separator with a step-by-step separation of material of various fractions has been developed.

The need to conduct research on the development of technological complexes for the processing of polymeric waste using the scientific and methodological foundations for the integrated utilization of techno genic materials is caused by the need to minimize the anthropogenic impact of industrial objects on the environment.

The aim of this work is to develop a technological complex for the processing of polymeric waste and to determine its optimum operating modes to minimize the anthropogenic impact of industrial objects on the environment.

In Belgorod region in Ltd "TK" Ekotrans” collection, sorting, processing and utilization of techno genic materials (TM) are organized. One of the technological tasks is to reduce the energy costs of the process and improve the quality of grinding of classified TM, in particular, PERT bottles [1, 2]. To solve this important research and production problem, we consider the developed technological complex for the production of composite mixtures from techno genic polymer materials (Fig. 1) [3].

The technological complex operates in the following way. The starting material is fed to the delivery tray 2 by means of a telpher 1. A conveyor belt 3 is mounted at the bottom of the tray. By means of a belt conveyor and a plate feeder 4, the material is fed to a rotor-centrifugal unit (RCU) 6. To trap metallic inclusions before the RCU an inclined tray with a magnet is established. In the upper part of the RCU, studded rolls are installed, to prepare PERT bottles for grinding, compressing and making air discharge holes in them. In the first coarse grinding chamber, the material is ground with disk cutters and, under the action of centrifugal forces, moves into the fine grinding chamber. There, the polymeric material is ground with wire brushes to a powdery state. After the RCU, the ground material is pumped to the separator by pneumatic conveying 7. The burden is divided into fractions by the action of air streams. Not fully ground material is deposed in the lower cone and returned to the regrinding in the second chamber of the RCU. The dusty fraction moves through the upper opening into the aspiration system.

The conditional material, deposited in the cyclones 8, enters the screw feeder 9. By means of the feeder 9 and the elevator 11, the raw material enters the bunker of the components of the composite mixtures 12. The bunker is equipped with partitions that separate it into three zones for separate, accumulation and storage of components. Before "Noria"a bunker of additional components of composite mixtures 10 is installed. From the bunker of additives 10, along the vertical elevator, the components are transported to the bunker compartments 12. Cell feeders are installed in the bottom of each compartment. From the bunker 12, the components enter the blade mixer 13, where they are mixed. After that, the composite mixtures is fed on the belt conveyor 14 for packing and weighing [4].

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Figure 1. Technological complex of production of composite mixtures from technogenic polymer materials:
1 - telpher; 2 - delivery tray; 3, 14 - belt conveyor; 4 - plate feeder; 5 - the magnet; 6 - rotor-centrifugal unit; 7 - separator; 8 - cyclone; 9 - screw feeder; 10 - bunker of additional components; 11 - elevator; 12 - bunker of components of composite mixtures; 13 - the mixer; 15 - scales; 16 - big bag

The change in the granulometric composition of a material during its grinding was investigated in this paper. This is due to the need to use a separator that ensures the recirculation of material flows and their division into separate fractions.

To study the process of fine grinding of technogenic polymer materials in the second chamber of the RCU, some experiments were carried out. Hammer crusher in testing experiments is used as an analogue of the second chamber of the RCU with a wire brush rotor [5]. The crushed material was weighed and divided into portions of 100 gr. There were the following experiments on grinding PET bottles with a hammer crusher. A mesh with an opening diameter of 2 mm was installed in the crusher. The material was crushed during 1, 4 and 7 minutes. To determine the fractional composition of the material, after each experiment, the crushed material that has fallen into the bag and the material that remained in the crusher chamber were collected separately, sieved on sieves with different opening diameters and weighed (Figure 2-4). In the experiments, sieves with opening diameters of 2, 4, 7 and 10 mm were used. According to the results of the experiments, the functions of the dispersed composition of the crushed material for different grinding time were constructed (Fig. 5). It can be seen from the graphs that when the grinding time of the material increases, the size of the material fractions decreases. In the course of the experiments it was established that the crushed material, whose size exceeds the diameter of the grid openings, in view of its elastoplastic properties, passes through the mesh. In this case, part of the finely ground-product in the crusher is trapped in the aspiration system.

Figure 2. Material with a particle size of $4 \text{ mm} \leq d < 7 \text{ mm}$
Figure 3. Material with a particle size of $2 \text{ mm} \leq d < 4 \text{ mm}$

Figure 4. Material with particle size $d < 2 \text{ mm}$

Figure 5. Differential curves of the particle distribution according to their size

To increase the efficiency of the grinding process and return to the re-grinding of particles passing through the hammer crusher grid, it is necessary to use a separator together with the RCU.

The design of the combined action separator used with stepwise separation of material from different fractions (fig 6) consists of two steps. The first stage serves for the isolation of a coarse product, the second for a fine product [6]. The separator works in the following way. The initial gas-material flow enters tangentially into the lower truncated cone 6 on the loading branch 8. Ascending along a spiral along the
ascending line, the largest particles of the mixture are pressed under the action of a centrifugal force to the inner surface of the truncated cones 5 and 6. Particles lose their speed due to the increasing section of the classifier and fall into the grooved channel. The unloading of the product is carried out through the discharge pipe 7. The degree of classification of the mixture can be regulated by changing the pressure of the compressed air. To ensure the free flow of particles through the discharge pipe 7, the angle of inclination to the vertical axis must coincide with the angle of the natural slope of the material. Entering the upper part of the classifier housing, the fine particles along the tangentially integrated nozzles enter the remote elements 14, where the gas material stream rotates in the annular channel. The bulk of the particles trapped in the central chamber passes from it together with the gas material stream into the part of the upper chamber 1. From where the smallest particles, under the influence of excess pressure and additional rarefaction, created by the electric actuator of the separator 3, enter the dust collector 9 and then to the cylindrical mesh frames 12 and the muffled sleeves 13. A baffle with holes 11 installed in the upper part of the dust collector 11, made of a gas-impermeable material, prevents the entry of a large number of material particles into the upper part of the classifier. This, in turn, prevents them from entering the atmosphere, and the openings made on it serve to pass the gas flow and create an additional rarefaction by the electric drive of the rotor 3. The particles caught in the dust collector 9 are discharged from it through the discharge pipe 10.

**Figure 6.** General view of the separator: 1 - upper part of the casing; 3 - electric drive of the separator; 4 - impeller with blades, 5, 6 - upper and lower truncated cones, respectively; 7, 8 - unloading and loading pipes, respectively; 9 - a dust collector; 10 - central discharge pipe; 11 - partition with holes; 12 - cylindrical mesh frames; 13 - fabric sleeves; 14 - remote elements; 15 - clean gas pipeline.

Thus, we have developed a resource-saving technology and special equipment for complex processing of technogenic polymer materials with various physical and mechanical characteristics. A design for combined grinding has been developed. According to the results of studies of the operating modes of the RCU, the functions of the dispersed composition of the ground polymeric materials under different conditions were built, which allowed establishing rational modes of operation of the RCU and its efficiency at different grinding time. To improve the effectiveness of the RCU, a patent-protected construction of a combined-action separator with a step-by-step separation of material from various fractions was developed.

The application of the RCU in combination with a closed-cycle separator allows expanding the technological possibilities:

- regulation of the aerodynamic parameters of the separator with the possibility of using polydisperse materials with different granulometry and density;
- the possibility of air cooling of the crushed polymeric materials and prevention of their spontaneous thermoplastic aggregation due to a decrease in their adhesion capacity.

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