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COMPOSITION AND STRUCTURE POLYMER WASTE JSC "BELTSVETMET"

Composition and structure parameters of polymer waste generated in corporation "Beltsvetmet" resulting from the processing of automotive batteries were determined. It has been established that the waste characterized by considerable heterogeneity in composition and size. Data were obtained on the number and weight of components that are part of the waste. To identify the components have been used by IR spectroscopy and differential scanning calorimetry. On the basis of the mass of components has been found possible use for the manufacture of composite waste material as a binder and a filler. Was determined by grading the waste before and after grinding mill for milling. Were determined bulk density and moisture content of the crushed waste. Was shown the need for grinding and drying before processing waste into products.

Key words: polymer waste, batteries, structure, composition, particle size distribution, bulk density, moisture content.

Introduction. In recent years, the problem of recycling industrial and domestic wastes containing thermoplastic polymers has become increasingly urgent for the Republic of Belarus. This is due to the increase in the plastic waste volume, as well as to the price rise for polymeric. So, over the past 5 years, the cost of large-scale production of thermoplastic polymers in the world market increased by 2.0–2.5 times. The secondary materials have become more expensive too.

One of the main directions of the state policy of the Republic of Belarus regarding the issues of environmental safety is development of waste processing technologies.

In our country, there are industries that are interested in expanding the industrial use of secondary plastics. Only a small part of the waste is processed into a product, in the first place-industrial and sufficiently homogeneous wastes, having known and quite stable technological and operational properties.

At the same time, most of the sub-standard plastic wastes – mixed industrial and domestic – is not used, but can be a cheap raw material for non-critical devices and products and can find application particularly in construction, agriculture and utilities.

However, recycling of mixed nonstandard plastic waste is associated with increased labour expenditures and energy consumption. As a result it causes the product cost increase and the reduction of competitiveness [1].

So, one of the promising environmental projects implemented in the JSC "Beltsvetmet" is the reprocessing of used car storage batteries. In the end of 2009, for this purpose, it was put into operation modern equipment on which the batteries are separated to the composition faction not manually but mechanically. For processing batteries are taken together with electrolyte that is collected on all stages of production. When battery recycling mixed polymer wastes are also formed, which have not found the application so far. Currently, there is a significant number of battery producers, which use various polymer materials for their manufacturing [2]. As a result the composition of the waste generated in the enterprise is substantially heterogeneous.

To assess the possibility of processing such waste into products, first of all the information is required about their composition and structure, which is currently lacking.

The purpose of the work is to determine the composition and structure of polymer waste resulting from the processing of waste automotive batteries in JSC "Beltsvetmet".

Main part. Two types of waste, provided by JSC "Beltsvetmet" are studied:

1) wastes generated as a result of cutting enclosure batteries (hereinafter KAB);

2) The polymer-containing wastes, which are formed by cutting an internal part of the batteries (hereinafter POAB).

Waste KAB (Fig. 1) to visually represent predominantly coloured pieces of plastic, characterized by considerable heterogeneity in size and shape (from 2 to 17 cm). The waste also contain a polymeric film in small amounts, polymeric strands and filaments, rubber, wood, polymeric labels, glass wool.

Fig. 1. General view of waste KAB

Table 1

Granulometric content of the raw waste KAB

The equivalent particle size d_{equ}, mm	Less 15.6	From 15.6 to 21.2	From 21.2 to 26.7	From 26.7 to 33.7	More than 33.7	Waste in the film form
Fraction content, %	4.9	18.8	15.9	37.3	22.0	1.1

Waste POAB (Fig. 2) visual are mostly dark gray segments of the film, characterized by considerable heterogeneity in size (length of 2 mm up to 30 cm, width of 2 mm to 4 cm). There are also quite large (up to 3 cm) ebonite and plastic pieces, pieces of polymer film, polymeric strands and filaments and polymer labels, lead, glass wool, rubber.

Fig. 2. General view of waste POAB

A significant heterogeneity of original waste KAB (Table. 1) and POAB on sizes, the presence of large particles necessitate their grinding before use in the processes of product forming.

To study the composition and structure of the original waste, KAB and POAB waste sample of (at least 5 kg) were manually separated into individual components. The components were identified concerning density, melting temperature, behavior when exposed to open flame by IR spectroscopy with IR Fourier spectrometer NEXUS ESP (Thermo Scientific, USA). The melting point of thermoplastic component was determined by differential scanning calorimetry (DSC) using thermoanalytical system TGA/DSC–1/1600 HF (METTLER TOLEDO Instruments, Switzerland) and also using the device to determine the melt flow index IIRT–A.

The content of the components in the waste sample was determined by their weighing with help of a laboratory balance to an accuracy of 0.1 g.

The density of the POAB and KAB waste was determined by hydrostatic weighing according to GOST 15139–69. The ethyl alcohol was used as a working fluid.

High moisture content in polymeric materials may lead to deterioration of physical, mechanical and performance properties. Prior to processing such materials into articles it should be determined whether the drying is necessary and what the preferred mode of drying is. The moisture content of the waste KAB and POAB was determined by drying to constant weight at a temperature of (105 ± 2)°C. To control the uniformity of the material structure of different sets, and also for calculating the filling volume of tooling and machine hoppers used for processing into products it is necessary to have a component of bulk density, which is determined according to GOST 11035.1–93 as the ratio of the material mass to its volume.

Initial residues of KAB and POAB were crushed with the crusher CES 0090 M manufactured by CJSC "Atlant". Size distribution of the shredded waste was determined by sieve analysis with sieve shaker Analyzer Vibrostand PE-6700.

The weight content of the components in the composition of the waste KAB is given in Table 2. The composition of the waste KAB mostly (over 90%) consists of polypropylene. According to the source [2], polypropylene are most commonly used for the manufacture of battery enclosures, ABS plastics are used less.

Table 2

The component weight in the KAB waste composition

Material	Weight content, %
Polypropylene	91.8
ABS-plastic	5.8
The cross-linked high-density polyethylene	1.7
Rubber	0.5
Wood	0.2
Glass fibre	0.02
High density polyethylene	0.02
Polyvinyl chloride	0.01

In tote there are more than 97% of fusible (thermoplastic) component in the KAB content and less than 3% of infusible components. There are less than 1% of such materials as rubber, wood, glass fibre, high density polyethylene, polyvinylchloride.

The weight content of components in the POAB waste is given in Table 3. The composition of the waste POAB most (about 80%) contained a cross-linked high-density polyethylene, which does not melt during processing. Total infusible components in POAB about 90%, fusible (thermoplastic), about 10%. This indicates that the waste can only be used as a filler. Materials such as rubber, fiberglass, high-density polyethylene is less than 1%. Also contains lead in an amount up to 1% in the composition POAB.

Table 3

The component weight in the POAB waste composition

Material	Weight content, %
The cross-linked high-pressure polyethylene	78.3
Ebonite	9.9
Polyvinyl chloride	6.4
ABS plastic	3.1
Polypropylene	1.0
Lead	0.7
Glass fibre	0.4
High pressure polyethylene	0.1
Rubber	0.1

Table 4

Granulometric composition of shredded wastes KAB and POAB

The equivalent particle size d_{equ}, mm	Less 0.63	From 0.63 to 1.1	From 1.1 to 2.0	From 2.0 to 5.0	From 5.0 to 10.0
Fraction content for KAB wastes, %	2.4	1.6	11.0	81.1	3.1
Fraction content, for POAB wastes, %	8.1	3.8	19.4	51.6	17.1

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Granulometric waste composition of the KAB and POAB after grinding in a mill is represented in Table 4. It can be seen that the maximum waste particle size after crushing does not exceed 10 mm. The greatest number of particles have dimensions within the range of 2–5 mm. Particles of these sizes are most frequently used in processing of polymer materials.

The average density of KAB shredded wastes is 0.88 g/cm^3, the average density of the POAB shredded wastes – 1.38 g/cm^3. The value of the bulk density of KAB shredded wastes is 0.28 g/cm^3, for POAB shredder wastes – 0.18 g/cm^3. The moisture content of the KAB crushed wastes is 0.25%, for POAB wastes – 1.25%. The obtained data exceed the permissible moisture content in the polypropylene equal to 0.1%, indicating the need for material drying before the secondary recycling.

Conclusion. The composition and structure of polymer wastes provided by JSC "Beltsvetmet" were studied. Wastes are characterized by considerable heterogeneity of content and sizes. They include polymeric pieces, polymer film, polymer strands and filaments, rubber, wood, polymeric labels, glass wool, hard rubber, ebonite, lead. When producing goods, the KAB wastes can be used as polymeric binder, as they include most thermoplastic components and the POAB wastes – as filler, since they include most of infusible components. For processing into products, original wastes due to the significant heterogeneity of their particle sizes need to be crushed and dried. The obtained data can be used for designing of technological processes for polymer waste recycling.

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