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DEVELOPMENT OF PROCESSING TECHNOLOGY FOR POLYMER WASTE OF JSC "BELTSVETMET"

The article describes the composition, structure, performance and technological characteristics of polymer wastes resulting from cutting of batteries on JSC "Beltsvetmet". Such wastes can be divided into two types that are encouraged to use as a polymer matrix and a filler, respectively, during polymer composites production. It was revealed that the samples of composite materials based on wastes compared to primary raw materials have a high enough performance (tensile strength, elongation at break, bending strength, tensile and bending module of elasticity, impact strength, density, shrinkage, water absorption). Such composites can be used for the manufacture of products for technical purposes which do not impose stringent requirements. Offered materials can be processed by standard methods on an ordinary equipment. The mode of obtaining products from polymeric composites by injection molding method is also matched in the paper. The products that can come from the materials are proposed. Making of composite materials from polymer wastes allows to the enterprise to get an additional profit and reduce the degree of influence on environment.

Key words: polymer wastes, performance and technological properties, polymeric composites, processing parameters.

Introduction. In the Republic of Belarus the problem of recycling of production and consumption wastes is becoming increasingly urgent from year to year. Such wastes can be used as secondary raw materials, reducing the demand for primary natural resources. The situation is exacerbated also by the fact that in the Republic of Belarus in many cases such wastes are utilized by landfilling, that negatively affects the environment. Using the recycled wastes it is possible not only to achieve economic benefits, but also to improve the ecological situation in the country.

One type of the wastes, used not effectively in the country today, is polymer-containing wastes, resulting from the cutting of batteries in JSC "Beltsvetmet". Part of these products is used as secondary raw materials for molding products, while the second part is most often utilized by landfilling. In this regard, the question about the possibility of more complete utilization of such wastes for production purposes arises, that would reduce the burden of the enterprise on the environment [1].

Main part. In the present paper the results of research aimed at the development of the effective technology of recycling of polymer-containing wastes generated at JSC "Beltsvetmet" resulting from the cutting of batteries are described. In the first stage of work the composition and structure of such wastes was determined [2]. Polymer-containing wastes obtained in JSC "Beltsvetmet" can be divided into two types:

1) wastes generated as a result of cutting of batteries cases (BC);

2) wastes generated as a result of cutting of inner part of the batteries (FWB).

Wastes of these two types differ substantially in composition and properties – BC are composed primarily of thermoplastic polypropylene, while the FWB contain a large number of crosslinked, infusible material. It was concluded that the wastes of the first type can be used as the polymer matrix, while the wastes of the second type – as the filler [2]. The compositions based on these components were investigated in this work.

As a result of the studies, it was found out that compositions based on BC, containing FWB as the filler, have quite acceptable physical and mechanical characteristics (Table 1). Such composition potentially can be used for the molding of technical products, to which strict requirements are not imposed [3].

However, the actual was also the verification of technological characteristics of the proposed compositions. In this regard, the researches of indicators characterizing the possibility of obtaining from these materials products by injection molding were conducted. Thus, it was found that the value of the melt flow index (MFR) for BC is $(2{,}4 \pm 0{,}08)$ g/10 min, which corresponds to the lower-limit for its processing by injection molding. It was concluded that this material and compositions based on it can be processed by injection molding. At the same time, by introducing the shredded wastes of FWB into the compositions based on BC the viscosity of the polymer melt to some extent increases, and as the result it becomes more difficult to process it using the proposed method.

Table 1

Performance and technological properties of the compositions, obtained from polymer-containing wastes from batteries

Index	Material					Polypropylene*
	BC	BC + 5% FWB	BC + 10% FWB	BC + 15% FWB	BC + 20% FWB	
Bulk density, g/cm^3	0.33	–	–	–	–	0.4–0.5
Angle of friction, deg.	31.5	–	–	–	–	–
Linear shrinkage, %	1.0	–	1.46	–	1.13	1.0–2.5
MFR, g/10 min	2.40 ± 0.08	–	–	–	–	–
Density, g/cm^3	0.92	0.93	0.95	0.98	1.02	0.90–0.91
Yield strength (tension), MPa	24.2	20.3	18.4	18.2	17.1	25–35
Tensile strength, MPa	17.3	18.4	16.0	15.7	15.7	30–32
Elastic modulus, MPa: – tension – bending	 807 1,136	 679 1,193	 670 1,165	 645 1,117	 643 1,099	 1220 1,860
Bending strength (at maximum load), MPa	32.7	33.4	31.6	30.2	28.7	50
Impact strength (Sharpy), kJ/m^2	39.3	46.7	38.0	28.7	27.3	20–40
Coefficient of water absorption, %	0.06	–	–	–	0.15	0.09

* For reference [4].

Experimentally it was found that by the injection molding method compositions based on BC containing up to 20% of FWB can be processed. With the further increase of the content of FWB in the polymer composition the fluidity of the melt material is reduced to such an extent that it loses the ability to fill the mold cavity completely.

It is widely known that the technological parameters of the process of products molding have a significant impact on their performance. In connection with this in the work the analysis of the optimal parameters of injection molding of polymer compositions was done. During such process the maximum deformation and strength characteristics of the molding products can be achieved. Samples were obtained from compositions based on BC and FWB (containing 10 and 20%) on the injection molding machine Kuasy 60/20 at different temperatures, after that the physical and mechanical characteristics of these samples were evaluated. Testing of samples was carried out according to GOST 11262–80 on the Instron tensometer 2020. The results of these studies are presented in Fig. 1 and 2.

The experimental data show that to recycle BC and compositions on its basis the temperature range from 220 to 240°C is appropriate, since under such conditions the maximum performance characteristics of the resulting samples were obtained. This result is consistent with the information about the optimal mode of processing of polypropylene, which comprises the main part of BC. In addition, the other processing parameters for compositions based on BC and FWB were analyzed in this work. In Table 2 a complete list of optimal parameters of producing articles from such materials is presented.

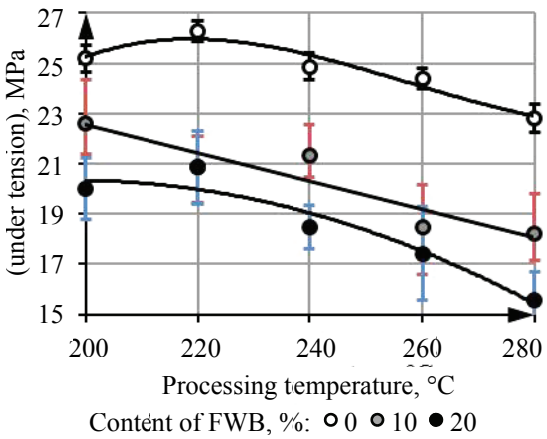

Fig. 1. The dependence of the yield strength (under tension) of polymer compositions on the temperature of their processing and content of the FWB

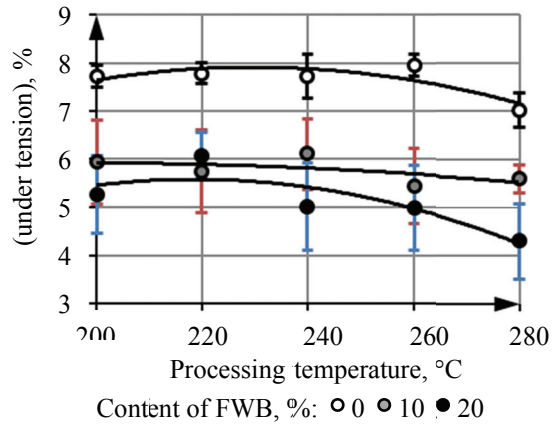

Fig. 2. The dependence of elongation at yield strength (under tension) of polymer compositions on the temperature of their processing and content of the FWB

Table 2

The optimal parameters of processing of compositions based on BC and FWB by injection molding method

Processing parameters (injection molding method)	Value
Injection temperature, °C	220–240
Mold temperature, °C	40–60
Injection pressure, not less than, MPa	120
Cooling time (depending on thickness of part), s	30–60
Time of holding under pressure (depending on thickness of part), s	4–12

Conclusion. In the course of this work the optimal conditions of manufacture of products from compositions based on polymer-containing wastes generated at JSC "Beltsvetmet" as a result of cutting of batteries were identified. Such materials have sufficiently high performance and technological characteristics (the tensile strength of the compositions is 5–20% less than the strength of the original polypropylene), it allows to produce from them technical products which are not imposed by strict requirements. Optionally, the proposed compositions can be modified to give the resulting products any specific properties. In addition, through the targeted use of all of the resulting polymer-containing wastes, the company has the ability to reduce the amount of wastes disposed by landfilling, thereby reducing the impact on the environment and at the same time, reducing the costs of such disposal, achieving additional economic effects.

The data obtained in the result of the study can be used in practice in the development of design and technological modes of industrial production processes for specific products from polymeric composite materials.

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