УДК 678.674

V. M. Kasperovich, PhD (Engineering), assistant professor (BSTU);
V. V. Yatsenka, PhD (Chemistry), assistant professor (BSTU);
M. M. Revyako, D.Sc. (Engineering), professor (BSTU); **A. F. Petrushenia**, PhD student (BSTU)

REGULATION OF PROPERTIES OF HIGHLY FILLED WOOD COMPOUNDS BY THERMOPLASTIC MATRIX MODIFYING

The current trend of production of new materials substitutes of wood to Republic of Belarus is connected with creation of hi-tech knowledge-intensive production of an environmentally friendly material – the thermoplastic wood and polymeric composite (WPC).

The main problem of creation of high-filled DPK is that at introduction of wood fillers the complex of indicators of mechanical and rheological properties, in particular strength characteristics and the composition indicator of fluidity of fusion (IFF) considerably changes. In work DPK samples from chemically modified thermolayer and a wood flour with the raised physicomechanical and rheological characteristics accepted for processing of compositions by methods of molding under pressure and extrusion were received.

Introduction. Today it is important to develop new technologies for producing composite materials in which the basic polymers are replaced with newer ones. They are environmentally friendly in production and safe in operation of the finished product. One such a direction is the replacement of thermoset binders in the production of wood-polymer composites into thermoplastics and the creation of such high-tech production of environmentally friendly material as thermoplastic wood-polymer composites (WPC).

WPC products have a specific set of positive properties: aesthetic appearance, relatively low density, good strength, resistance to atmospheric agents, water resistance, affinity with wood, lack of shrinkage and warping, ease of handling, ease of installation, environmental friendliness, soundproofing, low operating costs. Wood-polymer composite material combines mechanical and chemical advantages of its two components: the wood and polymer [1].

The wood flour as well as various wood wastes can be used as the wood filler.

Particle size and moisture content are requirements applied to the WPC wood flour and determined its properties. The filler amount can reach 80% [2].

Polyolefins and PVC are used as the polymer binder.

The main problem to design the heavy WPC is that the introduction of fillers considerably varies complex strength and technological characteristics of the composition.

Main part. The aim of this study was production of wood-plastic composites from modified thermoplastic and wood flour having improved physical and physical and mechanical characteristics.

Determination of the preferred filler content and modifying agents in WPC was realized by physical, mechanical and technological characteristics such as impact strength, flexural strength, melt flow index.

Pine wood flour with specific surface of 20 m^2/g was used as wooden subcomponent. Weight content of the filler is injected from 10 to 60 wt. %. Polyethylene 277-73 (GOST 16338-85) and polypropylene 21130 (GOST 26996-86) with high values of melt flow index (up to 35 g/10 min.) were used as polymer component. Those polymers marks were chosen taking into account that for production of samples we adopted the technology of injection molding. Use of low-viscosity polymer materials improves distribution of wood flour in a binder. It will increase the physical and physicalcal characteristics of the resulting samples.

0.2 wt. % of dicumyl peroxide (MPC) was introduced as modifying agent. It allows to activate polymer molecules to increase the interaction with the wood filler and dioctyl phthalate (DOP) in an amount of 3 wt. % and to improve the distribution of the mixture components and flowability and hence the processability of the composition while processing.

Temperature regime of processing compositions was chosen in the range of 150–190°C. This limitation was based on the low thermal resistance of the wood. However it should be noted that this restriction is not absolute since Delignit cellulose can be used in wood-plastic compositions and lignin is the most temperature-sensitive component of wood materials.

The recycling of compositions was made by the injection molding.

The following results presented in Table 1were obtained in the process of investigation of the dependence of the toughness of the particulate composition and weight content of wood filler.

Based on these results we can conclude that the toughness decreases when filler content increases. A transition layer is formed. The polymer macromolecules partially lose segmental mobility as a result of sorption on the filler surface. It causes the deteriorations of shock characteristics of material. The introduction of modifying agent leads to the increase in toughness due to the enhanced interaction with the components polyolefin timber. Activation of polyolefins MPC leads to the interaction of polyolefin macroradicals with phenolic hydroxyl groups and with reactive lignin atoms.

Table 1

Resilient modulus

Filler weight content, %		0	20	30	40	50	60
Resilient modulus of original composition, J/m^2	PP	600	138	115	89	72	58
	PE	600	200	143	118	103	97
Resilient modulus of composition with modifying agents, J/m^2	PP	630	256	240	210	200	195
	PE	640	340	310	275	221	212

Table 2

Cross-breaking strength

Filler weight content, %		0	20	30	40	50	60
Cross-breaking strength of original composition, kgs/mm^2	PP	3.54	4.24	4.40	4.21	3.92	3.42
	PE	4.27	4.61	4.79	4.54	4.08	3.49
Cross-breaking strength of composition with modifying agents, kgs/mm^2	PP	3.65	4.44	4.62	4.31	4.11	3.62
	PE	4.33	4.73	4.85	4.65	4.18	3.55

Table 3

Melt Index

Filler weight content, %		0	20	30	40	50	60
Melt Index of composition, g/10 min	PP	35.4	6.2	3.2	2.2	1.7	0.9
	PE	18.1	5.9	3.0	1.9	1.5	0.9

Formed bonds increase interaction between components of the composition, and the presence of a plasticizer DOP increases mobility that leads to the increasing of toughness.

Also some researches of the effect of composition on the strength characteristics of the flexural strength were conducted in the process of the experiment. The strength results obtained as a result of static bending are shown in Table 2.

According to these results we can conclude that with increasing wood flour content flexural strength is reduced under static bending. The destruction of filled plastics is strongly influenced by the structural characteristics of the boundary layer and the presence of the interfacial polymer (filler microscopic defects). Stress concentration in these places is one of the reasons for the cracks appearance. When developing in filled polymer the hairline crack can «stretch» in the filler particles, It leads to slower processes of destruction. On the other hand filler is the stress concentrator which makes the polymer more brittle. Consequently the strength properties of the compounded material will be determined by predominance of one of these processes.

The results obtained in the study of modified compositions correlate with the findings written above as DOP being the lubricant contributes to the contact improving at the interface of the filler – polymer and dicumyl peroxide increases the strength of the thermoplastic matrix and increases the strength of the entire system.

During the experiment researches of the effect of the particulate composition and mass content of wood filler on melt flow were conducted. The results are shown in Table 3.

When analyzed the results it can be concluded that with increasing filler content the melt flow index decreases.

This is connected tothe fact that with increasing of concentration of the wood meal the friction in the system increases. It leads to an increase of melt viscosity.

Introduction of MPC and DOP has not led to significant changes of MFI compared with the filled system due to the fact that the plasticizing effect of DOP over the effect of MPC and SSS does not undergo any significant changes.

Conclusion. When analyzed the results of the researches it can be concluded that the samples derived from polypropylene (PE) and wood flour have sufficient operational and have certain mechanical strength characteristics compared with the samples derived from the pure polymer.

The researches have shown that the introduction of modifiers allowed increasing the physical and chemical properties of WPC with a slight decrease of rheological characteristics. It allows processing of designed composition not only by extrusion but also by injection molding.

References

1. Клесов, А. А. Древесно-полимерные композиты / А. А. Клесов. – СПб.: НОиТ, 2010. – 756 с.

2. Древесно-полимерные композиционные материалы // Сетевая академия мебели. С-а-m.narod.ru. [Электронный ресурс] – М., 2002. – Режим доступа: http://c-a-m.narod.ru/wpc/wood-plastic-composites-defin.html. – Дата доступа: 03.05.2012.

Received 28.02.2013