ANALYSIS OF THE PRODUCTION AND PROPERTIES OF WOOD-POLYMER COMPOSITE MATERIALS

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ABSTRACT: *Wood-polymer composite materials are one of the main directions in the social life of mankind and have great prospects in the world, Due to the fact that they show the best and highest performance in terms of physical and mechanical properties of wood and polymer. Initially, the study of composite materials based on wood and wood filler began by German scientists in the 1930s, and by 1941, it was introduced into industrial production. Phenol-formaldehyde and urea-formaldehyde resins were mainly used as binders in these composite materials. Later, after it was determined that these resins were partially harmful to human health, scientists conducted research on other types of binders in the production of wood shavings, wood fiber and wood filler-based products and materials. In the*

production of such composite materials, only the brand of urea-formaldehyde resin (LT), the brand of low toxicity, has been preserved, but it is also harmful to human health. Research has shown that polymers (polyvinyl chloride, polyolefins) can be used as binders in the production of wood filler-based compositions, and on this basis, the production of composite materials began. These materials and products came to be known as wood-polymer composite materials. Another peculiarity of this production technology is that the modes of operation of the processes in the production and technology vary depending on the place of production, the climatic conditions of the region. Therefore, the countries producing wood-polymer composite materials in the world will develop technology depending on their climate and weather conditions. The main difference in these technologies is observed in two processes:

- Preparation of raw materials and chemicals for production

- Temperature regimes in the production process

It is these two aspects that play a major role in the production of a quality product. The most important process in this production is the preparation of wood filler for production, because we know that the wood structure is porous and has the property of absorbing moisture from the air. We know that wood is divided into two types: deciduous and pine. Due to its structure of hardwood than softwood, the optimal wood wool for production should be above 8 ± 10%. In the production of materials, pine is used as a raw material. In this regard, in this work, we used local poplar wood and assume the technological feasibility of composites consisting of wood and a thermoplastic matrix for use in thermoforming at four mass fractions in the composition of wood fillers. For this purpose, an analysis of the viscoelastic, thermomechanical and thermophysical properties of a composite consisting of polyvinyl chloride was carried out.

Key words: *poplar, primary polyvinyl chloride, components of composites, technology, tensile strength.*

INTRODUCTION: Wood has been a necessary material for human existence since primitive times due to its prevalence, renewability and environmental friendliness, relative ease of processing and excellent mechanical properties. With the development of technology, wood began to be used as a raw material for fuel, tools, boats, vehicles, bridges, furniture, engineering materials, weapons and even energy. Now the tree is widely used in various parts of human life. Wood has a porous structure composed of various cell walls, mainly composed of biopolymers, i.e. carbohydrate polymers of cellulose and hemicellulose, and phenolic polymers of lignin. The dense structure of wood provides it with high specific strength. Therefore, some high quality wood can be used as a building material. However, wood components are easily destroyed by microorganisms and are susceptible to fire damage. In addition, since the most functional group in the cell walls of wood is the hydroxyl group, the hygroscopic properties of these groups can lead to poor dimensional stability of the wood. In other words, wood shrinks when it dries and swells when wet. All these shortcomings limit the use of wood as a high quality material.

In addition, with the development of society, wood consumption is growing rapidly year by year. However, on the contrary, the production of high-quality wood has declined sharply. The apparent contradiction has prompted researchers to look for alternative low-quality resources for value-added applications. To achieve these goals, appropriate technologies are needed to improve the properties of low-quality resources (especially certain wood qualities) (eg, mechanical properties, dimensional stability, chipping resistance, and heat resistance) to meet end-use requirements. The aforementioned unfavorable behavior of wood is mainly due to the presence of many hydroxyl groups in the main components of wood and various cell cavities within the wood (the main pathways for moisture movement), blocking these reaction areas or closing the gaps not only makes the wood more resistant. to moisture resistance and can improve the physical and biological properties of decomposition. Therefore, the treatment to change the structure of wood and thereby improve its physical and

mechanical properties, as well as durability, is carried out by chemical modification, chemical impregnation, pressing with heating and heating at high temperatures.

One of the methods for improving the properties of wood, which has received much attention in recent decades, is the production of wood-polymer composites by forming polymers from unsaturated monomers inside wood holes (vessels). The resulting polymer simultaneously enhances the mechanical properties of wood and can delay or prevent the impact of water or microorganisms on the wood matrix. This multifunctional treatment helps prevent possible environmental damage from preservatives washed off the chemically treated wood.

Poplar has been widely used and used in Uzbekistan since ancient times, and it has a special role in the life of the population in construction as wood products. Therefore, the cultivation of poplar has always been at a high level. Since the main raw materials for the woodworking industry are imported from other countries such as Russia, Kazakhstan, China, etc. These wood composite materials (chipboard, MDF, plywood, etc.). In connection with this and taking into account the need for wood and furniture products, plantations with a total area of up to 11,000 hectares have been created in several regions of Uzbekistan since 2018 to create a raw material base based on poplar. Most of this will be in the Tashkent region and the Ferghana Valley. Because of the climatic conditions in Central Asia, the range of tree species is not so great.

Poplar (Populus): density 400-455 kg/m^3

Belongs to the type of coniferous trees with a scattered tuberous tree. Poplar - a tree that has a core, around the core is wide, white; the core is light brown and yellowish brown, and these colors do not differ from each other. Annual layers are rarely distinguished, tubes and small core rays are not visible. Poplar is soft, light, dries a little and warps a little. It has industrial and economic species: black poplar (black poplar) and white poplar (silver).

Wood-polymer composite materials are currently widely used by a number of developed countries in Europe and Asia in the field of construction and furniture

production using raw materials based on innovative technologies. The basis of these raw materials and materials are high-molecular compounds - polymers. The advantages of these materials:

- These materials are produced entirely on the basis of automated innovative technology

- The physical and mechanical properties of these polymer-based materials are very high, so the service life and operation are higher than other materials.

- The main advantages of these materials are that they are 100% moisture and water-resistant products and they will never change their facial and surface textures, do not change color.

- This production is 100% considered without waste

Including these advantages, these products are widely used in the fields of construction in the production of furniture and wood products, in the decoration of train cars and the decoration of building facades. In production, 4 types of polymers are mainly used. Polyvinyl chloride, polyethylene, polypropylene, polystyrene.

We offer and study technological parameters and use for the production of composite materials from these polyvinyl chloride polymers. Products that we offer are made on the basis of recycled polyvinyl chloride. Currently, insulating corrugations for cables, pipes and fittings, linoleum, polyvinyl chloride (PVC) lamination, etc. are produced on the basis of primary PVC.

Based on the above modifications of wood and the development of research on wood-polymer composites, this article provides an overview of the production, physical and mechanical properties, performance and application of wood-polymer composites.

METHODS AND MATERIALS:

Wood-polymer composite (WPC) materials (Fig. 1) are manufactured at a plant that produces WPC based on polyolefins and pine wood waste (Khamkor-R, Tashkent region, Uzbekistan) like many other WPC materials. But pine is a tree

which is an imported raw material. Therefore, in this research work, our goal, taking into account the wood raw material base in our region, is to develop the technology of WPC materials based on local raw materials, that is, the localization of raw materials and chemicals for the production of a new type of material in Uzbekistan.

Figure 1: There samples of WPC product and poplars waste

Raw materials and chemical additives:

Wood fillers used in this work, poplar tree waste, from the Tashkent region to local sawmills serving institutions (Uzbekistan). Polyvinyl chloride suspension grade S-6346-M (SG-5) was purchased from the “NavaiAzot” chemical complex. Calcium carbonate ($CaCO_3$) was purchased from Kashkadarya region. Other used chemical additives: modifiers, heat stabilizers, foaming agents and lubricants were purchased from Shandong Donglin New Materials Co. Ltd (Shandong, China). All chemicals were used without further purification.

Composite mix preparation:

The preparation of a wood-polymer composite mixture requires a special technology. We prepared a composite mixture and samples were taken by formulating four different mass fractions of wood filler 1 (5.46%), 2 (7.96%), 3 (10.46%), 4 (12.96%). The percentage composition was calculated based on the weight of the polymer. To obtain samples each time, the following series of technological processes were used. First, a wood filler is made from the first poplar

sawdust, using a mill, we grind it into flour, then dry it with air drying until the moisture content of the flour drops to 8%. In our study, we used wood flour in the 500-800 grade, which means a wood flour fraction of 500-800 microns. In an air dryer, wood flour is dried with hot air at a pressure of 6 MPa at a temperature of 105-110 °C for 3-5 minutes at high speed. Then the dried wood flour in place with other chemicals and fillers is loaded onto a high-speed mixer to mix and make a composite mixture. In this process, the composite is mixed at a temperature of 125-130 °C at a speed of 3000 rpm. The process lasts 20-25 minutes in this process, the pressure will also be 6 MPa. The next process is kneading the finished mixture. For this process, the mixture is fed into the storage hopper using a pipeline and mixed for 8 or 10 hours. Then it enters through the pipeline into the dosing hopper, and from there it goes to the extruder. With a laboratory extruder, we received samples with a width of 40 mm, a thickness of 10 mm, and since this production is molded in length, we selected the physical and mechanical properties according to the standards that we will test.

RESULTS AND DISCUSSION:

The tensile strength of wood-polymer composite materials was carried out according to the method of GOST 11262-2017. For this purpose, samples were prepared in accordance with GOST 26277. That is, the dimensions are 120x4x15 mm. In addition, the speed of the device is set at 0.5% in accordance with this GOST. In preparation for testing, the samples were air-conditioned for 16 hours in accordance with GOST 12423-66. We calculated the tensile strength by applying the test results and showing them in the following table.

Table 1

Composition effect of samples on the strength of stretching

№	Samples		Consistency in stretching, MPa	Maximum elongation, mm	Average modulus of tensile strength, MPa
1	1 st recipe with wood fillers (5,46%)	A	4,8	2,08	4,908
		B	5,016	1,83	
2	2 nd recipe with wood fillers (7,96%)	A	6,63	2,326	6,11
		B	7,25	2,513	
		C	4,45	1,529	
3	3 rd recipe with wood fillers (10,46%)	A	8,15	2,995	6,925
		B	6,36	3,356	
		C	6,26	2,558	
4	4 th recipe with wood fillers (12,96%)	A	12,06	4,185	12,097
		B	10,2	3,747	
		C	14,03	4,101	

From the above results, in the table, we can see that an increase in the mass fraction of wood filler in the formulation of the composition led to an increase in tensile strength.

To test the bending strength of wood-polymer composite materials, samples were prepared in accordance with GOST 4648-71 by cutting in sizes 80x10x5 mm. This parameter was also determined in the test as the force velocity affected by the deformation (1.0 ± 0.5)%. The samples were air-conditioned for 16 hours in accordance with GOST 12423-66. The test results are summarized and expressed in the following table.

Table 2

Composition effect of samples on the strength of bending

№	Samples		Bending strength, MPa	Maximum bend, mm	Average bending strength, MPa
1	1 st recipe with wood fillers (5,46%)	A	7,82	1,845	6,273
		B	5,16	0,985	
		C	5,84	1,839	
2	2 nd recipe with wood fillers (7,96%)	A	7,62	2,966	7,586
		B	6,84	3,241	
		C	8,3	3,623	
3	3 rd recipe with wood fillers (10,46%)	A	8,74	1,871	8,406
		B	8,38	2,379	
		C	8,1	2,325	
4	4 th recipe with wood fillers (12,96%)	A	10,3	6,324	12,513
		B	13,4	5,669	
		C	13,84	4,942	

From the above results, in the table, we can see that an increase in the mass fraction of wood filler in the composition formulation led to an increase in the flexural strength.

In testing the above properties i.e. resistance to elongation, compression and bending, we used China Jinan Marxtest Technology Co. We carried out on the test equipment of the model ETM-10 of LTD.

CONCLUSIONS:

The comparisons between the materials obtained from PVC can be processed with materials obtained on the basis of wood belonging to various estimates showed a significant increase in all physical and mechanical properties associated with impregnated samples. The dimensional stability of the composite was increased compared to unprocessed wood, which made it impenetrable to absorb and retain

moisture. Two types of impregnation led to a significant improvement in the hardness of wood, parallel and perpendicular to the grains, while the average percentage increase exceeds 400% and 300%, respectively, which makes the composition very suitable for, for example, for the floor.

Given the cultivation of poplar throughout the regions and the territory of Uzbekistan, new production. The WPC of materials from local poplar and polyvinyl chloride is an interesting opportunity for the national forestry, construction and furniture washing sector. This possibility is especially valuable, given the availability of wood resources and, probably, creation of local supplies with limited environmental impact. Currently poplar the range is mainly used as building material for economic purposes, but they are not particularly suitable for this is use, given their high observation. WPC production can increase the value of the grounds of the poplar, both from an economic point of view and from the point of view of a longer service life with the possibility of further processing. It would be corresponds to the cascading use of wood encouraged by Central Asia. Products can also be interesting

In the supply chains of other Asian countries, where the plantations of the poplar are abundant. This study shows that WPC materials from poplar and PVC can be implemented using a process similar it is currently used to produce WPC from poplar and, apparently, requires only minor modifications some parameters. The properties of the WPC materials of the poplar produced on an industrial scale were actually found in accordance with the requirements of construction for supporting structures in dry conditions. Specific adjustments in the process could apparently bring this commission to fulfill the requirements use under load in wet conditions because these materials are not afraid of moisture. From this point of view, the use of special fasteners and connectors, for example, stainless steel, should be provided in order to avoid corrosion due to tannins and low pH of poplar wood and polyvinyl chloride. You should also study the analysis of costs and feedback with the market. In order to compare the slabs of sweet chestnut with WPC materials from different breeds and evaluate them suitability for established or innovative types of use. For this purpose,

the durability of the product will assessed by authors as another property useful for evaluating possible new applications.

Based on these results, we can conclude that the predominance of all physical and mechanical properties in the materials obtained on the basis of poplar wood is significant.

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