Plant for production of wood polymeric paving slabs

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Abstract. The article describes in detail the developed method of obtaining composite wood-polymer paving slabs, obtained on the basis of wood waste and secondary polymeric resources. According to this method, samples of a light and effective composite material in the form of paving slabs were obtained in a laboratory installation. The results of experimental studies of the operational properties of the material obtained are presented, in particular, the abrasion rates and the degree of the material water absorption were determined. A qualitative analysis of the performance criteria of the obtained material in comparison with the polymer-sand and cement-sand compositions was conducted. On the basis of the research carried out, a pilot plant was developed for producing composite wood-polymer paving slabs, its technical characteristics were described in detail, and the allowable ranges for the technological parameters of the plant were determined. The obtained ranges will make it possible to make calculations correctly, establish the limits of experimental variation, and carry out a number of other research complexes on the unit, the purpose of which will be to determine the optimal operational parameters of the process for producing wood-polymer paving slabs.

1. Introduction

Nowadays, the range of goods on the market of building materials is diverse. To ensure competitiveness in this industry, it is necessary to create products with high quality and performance indicators that can also remain attractive in the price range. Our country has virtually inexhaustible forest resources, but the development of the woodworking industry in the manufacture of quality materials based on wood and its waste remains low [1-3].

The existing problem of creating resource-saving technologies and the irrational use of wood waste processing industries suggests the feasibility and necessity of using wood as a raw material in the production of new, effective in its performance qualities, composite materials. The production of wood-polymer composites is one of the areas in which unclaimed wood waste can be used [4].

In this regard, there is a vital task of developing a technology for the production of composite products made on the basis of wood waste and secondary polymers, with specified properties and the possibility of their use in various fields of activity, for example, in the production of composite paving slabs and paving stones.

2. Studying the problem
Considering the high requirements imposed on the operational properties of the material intended for the device of road decking, in particular on frost resistance and abrasion, it was proposed to use wood raw material as a filler, which is previously subjected to soft contact thermal modification [5-6]. This technological process will increase the strength characteristics and reduce the degree of water absorption of the final material. Thermal modification results in a reduction of hydroxyl groups of cellulose, which contributes to an increase in the bondability with the polymer, its deeper penetration into the pores of the modified ground wood particles [7-9]. However, the increased temperature of thermal modification also contributes to the depolymerization of lignin, changes in its plasticity, which entails partial clogging of the pores and hampers the penetration of the molten polymer into the crushed particles [10]. On the contrary, low lignin content in such cellulose materials of secondary raw materials as cardboard, paper causes high porosity and specific surface of particles. In this regard, the main scientific novelty of the developed technology is the introduction of thermally modified secondary cellulose-containing wastes with a high content of cellulose, crushed to a dispersed state, into the polymer [11-15].

As a result, a method for producing composite wood-polymer paving slabs was developed (claim for an invention of the Russian Federation No. 2014102985). The method consists in mixing the filler and binder, followed by molding and curing [16-17]. Thermoformed wood flour is used as filler in the amount of 70% by weight, secondary polyethylene is used as the polymer in the amount of 24% by weight, and chemical additives and modifiers are also contained in the amount of 6% by weight. The first stage in the technological chain is the grinding of raw wood by means of a mechanical processing unit, into which wood waste with a size from 5 to 35 mm is fed [18]. This process is necessary for the further efficient process of soft thermal modification of wood raw materials in a specialized chamber for modification, the process takes place at various temperatures from 130 to 150 °C. After the modified wood raw material is sent to fine grinding, as a result, wood thermal modified flour of fraction 180 is formed, ready to be used as a filler in the product being developed. The resulting raw materials are extruded together with the polymer at a temperature of from 160 to 190 °C, then continuously formed into tiles and cooled.

In order to determine the qualitative analysis of the operational properties of the material obtained, in comparison with analogues, studies of samples of composite paving slabs were conducted on the basis of the laboratory of the department of Processing Wood Materials of FSBEI HE "KNRTU".

The results showed that the composite wood-polymer pavement tiles created by the indicators of water absorption and abrasion (Figure 1 a, b) exceeds the composition of cement-sand mixtures, even though is inferior, but not significantly, to its counterpart from polymer-sand materials [19-21]. This is explained by the fact that in the latter case, river sand is used as a filler, initially superior to raw wood in terms of water absorption and abrasion. However, from the point of view of economic benefits, the

![Figure 1](image_url)
developed material exceeds the polymer composition. The cost of production is lower by 20%, which is certainly an important indicator in the final choice of building material by the construction developer [22-23].

Based on the research, a pilot plant was developed for producing composite wood-polymer paving slabs.

3. Description of the object under development

Figure 2 presents a schematic diagram of a pilot plant for the production of composite paving slabs based on thermally modified recyclable materials.

![Schematic diagram of a pilot plant for the production of composite pavers](image)

**Figure 2.** Schematic diagram of a pilot plant for the production of composite pavers: 1 - mechanical processing unit, 2 - modification chamber, 3 - screw conveyor, 4 - electric drive, 5 - crusher, 6 - screw conveyor, 7 - raw material storage bunker, 8 - extruder, 9 - dispenser, 10 - die, 11 - guillotine, 12 - conveyor, 13 - special forms, 14 - press, 15 - cooling chamber, 16 - finished product conveyor, 17 - finished product storage bunker.

The principle of operation is as follows: wood waste enters the mechanical processing unit 1 for grinding, after which the crushed wood particles enter the modification chamber 2, where they are exposed to heat at a temperature of 130-150°C. After thermal modification, wood raw materials are supplied through a screw conveyor 3 by means of an electric drive 4 to a crusher 5, where fine grinding of raw materials takes place, polymer waste is also fed there for grinding. The prepared raw material is then fed through a screw conveyor 6 into a storage bunker for raw material 7, in which the preparation of a homogeneous mixture from the polymer takes place with the addition of special additives in certain proportions. Next, the raw material enters the direct extruder 8, which is equipped with a pre-plasticization zone, where the polymer melts, then this melt enters the main working cylinder of the extruder. Thermally modified wood flour and special additives are also delivered to the main cylinder of the extruder through the metering device 9. The advantage of this technology is that the preliminary plasticization of polymer raw materials at high temperature before feeding into the main cylinder allows to quickly get rid of moisture in the wood raw material, which significantly improves the quality of products. Next, the mass is squeezed through the die 10, is cut off by a special guillotine 11 and enters the conveyor 12. The conveyor line is equipped with special forms 13, where the mass obtained after extrusion enters to. These forms are intended for the subsequent formation of composite pavers by means of a drum-type press 14. Figure 3 shows the mechanism for molding composite paving slabs.

![Mechanism of molding composite wood-polymer paving slabs](image)
After the formed paving slab enters the shaft-type cooling chamber 15, then the finished product is poured onto the finished product conveyor 16, after which it enters the bunker for storing the finished product 17. It is possible to regulate the technological parameters that affect the final properties of the wood-polymer material obtained at the developed plant. The ranges of variation of technological parameters on the plant are determined on the basis of the permissible ranges of variation of the properties of the material obtained. When creating a pilot plant for the production of composite paving slabs, it is necessary to set the allowable ranges of the basic physical, mechanical and performance properties of the composite paving slabs [24-28]: density 1100 - 1200 kg / m3; abrasion 0.25 - 0.3 g / cm²; flexural strength 39 - 40.5 MPa; water absorption by volume 0.3 - 0.35%; frost resistance during freezing-defrostation cycles (for ultimate compressive strength 10 OS) 48 - 50 MPa.

Given the ranges of properties of composite paving slabs, the ranges of variation of technological parameters at the plant were determined on the basis of the results of the conducted research: thermally modified wood filler - from 65 to 75% by weight; secondary polyethylene - from 18 to 30% by weight; chemical additives and modifiers - from 5 to 7% by weight.

4. Conclusion

Thus, the production technology of composite wood-polymer paving slabs is to determine the permissible ranges of technological parameters that determine the future regulations for experimental research in a pilot plant. The data will allow accurate calculations, establish permissible limits for experimental variation and carry out a number of other experimental studies on the developed installation to determine the optimal operational parameters of the process for producing composite paving slabs.

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