Study of the possibility of using biomass coniferous in the production of composite materials

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Abstract. Processing of softwood biomass is a promising direction in the production of wood composite materials. Pre-treatment of waste debarking allows you to create chipboards with high thermal insulation and strength properties.

1. Introduction

Wood raw materials have a fairly complex and diverse structure and in cases where it is necessary to consider the mass of the entire tree, the term "biomass" is most often used.

In a live growing tree, there are three main parts: the crown, trunk, and root system. On average, the biomass of coniferous and deciduous species is distributed as follows: trunk-60-65 %, crown-15-20 %, roots and stump-15-30 % [1].

Standard logging technology separates the trunk of the tree from the crown and stumps with roots. All this remains in the woodlands. When using only stem wood, the loss of biomass in the logging process can be up to 35-40 %. In sawmilling, waste reaches 25-40%, and in woodworking -25 % or more.

In wood processing, the term "wood" refers to the bark-free tissue of the trunk, branches, and roots. At the same time, branches and roots are practically not used in the process of wood processing. In the total biomass, wood accounts for an average of 82 %, bark 15 % and tree greenery-3 %. For further use, the components of biomass need to be separated, since their structure and composition differ significantly from each other [2].

Coniferous species predominate in the forests of the Krasnoyarsk territory. The crown of coniferous trees is used very little. Needles are mainly used in the production of coniferous-vitamin flour. However, it should be noted that today whole directions of design application of needles are developing in the form of wall decorative noise-absorbing panels, biodegradable fabrics, furniture and carpets [3, 4]. Logging waste is practically not used, since its disposal is associated with a number of problems, including additional financial costs. Such waste is at best used as fuel. The main advantage of this fuel is its environmental safety, since its combustion produces a minimum amount of ash and harmful substances [5]. Along with pine needles, twigs and branches on the logging sites remains a large amount of waste wood cones. When felling a tree, the branches along with the cones located on them are cut off and remain in the cutting areas. In addition, with the increase in the volume of harvesting of coniferous seed stock in forest areas, the volume of waste generated after the extraction of seeds from cones increases.

Thus, the processing of softwood biomass is one of the most difficult problems in the complex of issues on the use of waste from wood processing, which is explained by the peculiar anatomical
structure of needles, bark and cones. If we consider the tree bark, the relevance of this problem is only increasing every year. The bark is undoubtedly the raw material of the future and new technological processes will be developed on its basis, thanks to which the bark will be used productively and profitably. Solving the problem of industrial use of bark is important and is considered as one of the most urgent tasks [6].

Scientists from different countries are searching for optimal solutions for the use of bark as a raw material for the pharmaceutical, chemical industries, agriculture and the production of construction, decorative and slab materials.

The problem of bark recycling is also present in our region. Currently, the main method of recycling bark in large quantities in a relatively simple process is its combustion.

The use of bark in the production of slabs for various purposes has not yet become widespread. The lack of interest in the bark as raw material for producing slabs in the domestic industry is due to the presence of large resources of other higher quality wood waste (sawmill waste and wood, felling residues, wood wood, etc.), allowing to receive fibreboard and particle board with high physical-mechanical indicators.

Bark is considered as an additive to the main raw material in the production of particle board, fiberboard, cardboard. However, a lot of experience in the use of bark has been accumulated only in the production of particle boards. The lack of interest in bark as a raw material is mainly due to the fact that with existing production technologies, for example, wood fiber boards, the use of bark in the amount of 15% of the mass of absolutely dry fiber worsens the strength indicators of finished boards [7].

The results of processing the husk of cones, pine nut shells, and the remains of cones are also widely known. The most famous material is «Kedroplast». This is pressed into the resin of cedar-SAP-the remains of a cedar cone after extracting the seeds. It should be noted that cedar seed cones are used to produce a number of valuable products. There are quite a large number of works devoted to the complex processing of cedar nut biomass [8-12]. Processing of cones of other coniferous breeds is even less common and is conducted much less often. Most often, such processing is reduced to the use of cones as fertilizers (extracts, ash), mulch or fuel-smoking briquettes.

Despite the fact that numerous studies are currently being conducted and there are developments by foreign and domestic authors on the use of wood biomass, including the production of slab materials, biomass is processed poorly in industrial conditions. This fact makes it possible to develop new materials with special pre-defined physical and mechanical properties using various methods of preparing wood biomass.

2. Materials and research techniques

The purpose of the work was to determine the mode of pressing chipboard using a fine-grained mass of bark as a binder. Determination of the optimal mode of pressing chipboard based on bark was made according to the $B^3$ plan. Factors and their levels of variation are shown in table 1.

| Table 1. Factors and levels of variation in the mode of pressing chipboard based on bark. |
|---------------------------------------------------------------|
| Name of the factor | Designation | The variation levels | upper | main | lower |
|--------------------|-------------|-----------------------|-------|------|-------|
| The pressure of pressing, MPa | P/X₁ | 1,4 | 1,0 | 0,6 |
| Specific duration of pressing, min /mm | τₓₓ/X₂ | 2,5 | 1,5 | 0,5 |
| Pressing temperature, °C | T/X₃ | 180 | 130 | 80 |
3. Results and Discussion

As a result of mathematical processing of experimental data, a regression equation was obtained that adequately describes the dependence of the strength limit for static bending on the compression mode of samples

\[
\sigma = 0.773333 - 0.001 \times P + 0.081 \times \tau + 0.07 \times T - 0.0925 \times P \times \tau + 0.0325 \times P \times T - 0.0925 \times \tau \times T
\]  

(1)

Further processing of the experiment results allowed us to determine a promising pressing mode: \(P = 1.4\) MPa, \(\tau = 2.5\) min/mm, \(T = 180^\circ\mathrm{C}\).

Another important factor affecting the physical and mechanical properties of the developed plate is the ratio of components. The amount of finely ground bark varied from 20 % to 60 %. With an increase in the content of fine-ground bark mass in the chip mixture, there is an increase in the strength of manufactured samples, but at the same time, the difficulty of selecting the mode of pressing the chip composition increases. This is probably due to a significant increase in the vapor-gas pressure in the chip bag. When the humidity of the mixture is reduced by less than 20 % in order to reduce the vapor-gas pressure, the effect of ”gluing” the chips is reduced. Samples are stratified and lose their shape stability. The static bending strength varies from 0.1 to 0.8 MPa when the material density changes from 220 to 400 kg/m\(^3\). The plates were tested for water absorption by directly submerging the samples in water. With an increase in the amount of fine-grained bark in the material, the water absorption of plates decreases. Fine-grained bark particles have low hygroscopicity and wettability, almost repel water.

The result of the research can be considered the development of pressing modes and component composition for obtaining an eco-friendly chipboard based on finely fine-grained bark with physical and mechanical characteristics comparable to the characteristics of heat-insulating fibrolite or arbolite plates, sufficient for the use of this plate as a thermal insulation material.

4. Conclusion

As a result of the experiments, it was found that the density of the developed thermal insulation material, which provides quality indicators for thermal insulation boards, is from 220 to 400 kg/m\(^3\). The recommended thermal insulation material has the following characteristics: thermal conductivity coefficient from 0.077 to 0.081 W/m\(\cdot\)C\(^\circ\), water absorption in 24 hours – from 46 to 37 %. Optimal indicators of physical and mechanical properties have a material made on the basis of finely fine-grained bark and chips with a component ratio of 40/100.

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