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Abstract. In the context of the development of the timber industry in Russian Federation the issue of wastes generated in the process of logging is critical. An assessment of the ways of use of logging waste showed that woodfoliage could be used as raw material in the logging industry for the production of granular fuel. In the woodbiorefinery it is used for the manufacture of chlorophyll-carotene paste, sodium chlorophyllin, spruce extract. In agro-industrial production coniferous-vitamin flour is made from wood foliage. Today, fiberboards (Fibreboards) are widely used in house constructions as structural, finishing and insulation materials. The present investigation was performed with the purpose to study the effect of the addition of logging wastes such as flour from coniferous needles on the physical and mechanical parameters of a fiberboard. As a result,the mechanisms of the influence of the percentage of flour in the total amount of wood fiber mass and particle sizes on the physical and mechanical parameters of fiberboard has been revealed. Statistical-mathematical equations and graphical dependencies are obtained that allow the predictionof mechanical properties, density, water absorption and swelling of wood-fiber boards at a given content of ground needles and the size of its particles.

1. Introduction

From the analysis of literature [1-5] it is evident that coniferous wood foliage, having a rich content of biologically active substances such as essential oils, vitamins, carotene, carbohydrates, micronutrients and proteins is a valuable raw material for production of various chemicals. The technology for the production of any type of product from needles includes such operations as the collection of foliage, separation of needles from branches and its chopping [6-7]. At present, about 3-4% of the potential needles resources are used due to the lack of processing technologies for this type of raw material in the conditions of the cutting area. In order to increase the volume of processing and use of coniferous foliage in Lesosibirsk Branch of Reshetnev Siberian State University of Science and Technologyan innovative mobile unit were developed and obtained for copyright certificates. This unit refers to needles processing technology in the cutting area The design of the proposed unit allowsto perform operations of separating and chopping coniferous wood green and subsequent packaging of the resulting product. The unit is able to move around the cutting area. This will allow to receive coniferous semi-finished product of the required fractional composition and save all useful substances. As an analysis of the works of a number of authors [8-12] showed, that one of the possible way of use of semi-finished products from coniferous wood green is adding it to a fiberboard. However, this way has been not sufficiently studied so far. M A Zyryanov and others [13, 14] in a number of works note that when adding wood fiber from logging waste the quality characteristics of fiberboards will not worsen.

2. Methods and Materials

The aim of this work is to identify the patterns of the influence of flour from coniferous wood wastes on the quality characteristics of fiberboard. For the realization of experimental studies a samples of pine foliage was handled on the territory of the cutting areas in the Angara-Yenisei region. Samples of green wood were collected out from normally developed trees taking 2 branches from the lower, middle and upper parts of the crown of young, ripe and overripe stands. At the stage of sample formation, 20 needles were taken from four equidistant parts of the coniferous branch. Thus, a total of 720 needles were involved in each experiment (20 needles of 3 ages, 3 parts of the crown, 4 equidistant parts).

When the selection of pine foliage was completed, the material was hermetically packed in order to preserve moisture. Then it was transported to a laboratory for research. Previously a series of exploratory experiments showed that when more than 16% of particles of needles with sizes less than 0.2 mm and more than 0.8 mm are added to the fiberboard, the quality characteristics of fiberboard deteriorate significantly. Pine wood chopped to a required size was mixed with wood pulp produced at the fiberboard plant of Lesosibirsky Woodworking Plant No. 1 (Lesosibirskiy LDK №1).A wood fiber mat was formed, and 5blocks were pressed for each experiment in a laboratory press using a standard cyclogram. The quality of fiberboards was evaluatedby their physical and mechanical properties in laboratory and under industrial conditions determined by standard methods due to State Standard 4598-86 [15].

To achieve the goal of the study a systematic and integrated approaches have been used. In relation to scientific issues, a complex of modern research methods has been used such as numerical modeling, mathematical planning and statistical analysis.

The authors have adopted an active experiment as the main method for obtaining a statistical and mathematical description of the process under study [13].

Input factors: the percentage of ground needles in the total mass (q), the particle size of the needles (f).

Output parameters: density (P), wood ultimate static bending strength (Pr), water absorption (N), swelling (R) of a fiberboard.

The selection of the main characteristics of the models according to the experimental research program is presented in the form of a functional dependence:

$$\mathrm{Pr},\ \mathrm{P},\ \mathrm{N},\ \mathrm{R} = \mathrm{f}\left(q,\ f\right), \tag{1}$$

Ranges of variation of the input parameters of the studied process: $(0.2 \pm 0.01) \le f \le (0.8 \pm 0.03)$ mm, $(4 \pm 0.1) \le q \le (16 \pm 0,3)$ mm.

3. Results and Discussion

Because of processing experimental data using a modern experimental and laboratory measuring base at the appropriate level of metrological support for research, equations have been obtained. They describe the dependences of physical and mechanical parameters on the percentage of ground needles in the total mass and particle size.

$$\mathrm{Pr} = 1580.13 - 16.85 \cdot q + 50.07 \cdot f + 0.08 \cdot \mathrm{q} \cdot \mathrm{f} - 0.03 \cdot q^2 + 0.34 \cdot f^2, \tag{2}$$

$$\mathrm{P} = 23742.05 - 186.87 \cdot q - 642.22 \cdot f + 1.71 \cdot q \cdot f + 1.05 \cdot q^2 + 3.22 \cdot f^2, \tag{3}$$

$$\mathrm{N} = -35749.2 + 127.01 \cdot q + 965.86 \cdot \mathrm{f} - 1.24 \cdot q \cdot f + 0.08 \cdot q^2 - 4.66 \cdot f^2, \tag{4}$$

$$\mathrm{R} = -16327.4 + 10.12 \cdot q + 453.49 \cdot f - 0.18 \cdot \mathrm{q} \cdot \mathrm{f} + 0.56 \cdot q^2 - 2.22 \cdot f^2, \tag{5}$$

The calculations confirmed that all the coefficients of the regression equations are significant.

There are response surfaces based on to equations 2-5 to demonstrate the influence of the studied factors on the physical and mechanical parameters of a fiberboard. Theresponse surfaces give a more complete demonstration of the dependence of the physical and mechanical parameters of a fiberboard on the percentage of ground needles in the total mass and the size of its particles.

The graphical dependence in figure 1and equation (2) demonstrates the value of the strength index of the resultingboard increases with an increase of wood green from 2 to 10% in the content. With the addition more than 12% of ground needles wood ultimate static bending strengthindex of the board is significantly reduced. The strength index of the board decreases with increase of the size of the ground needles added to the total mass. With an increase in the particle size of needles from 0.2 mm to 0.8 mm, the value of the strength index slightly decreases and reaches 33-34 MPa.

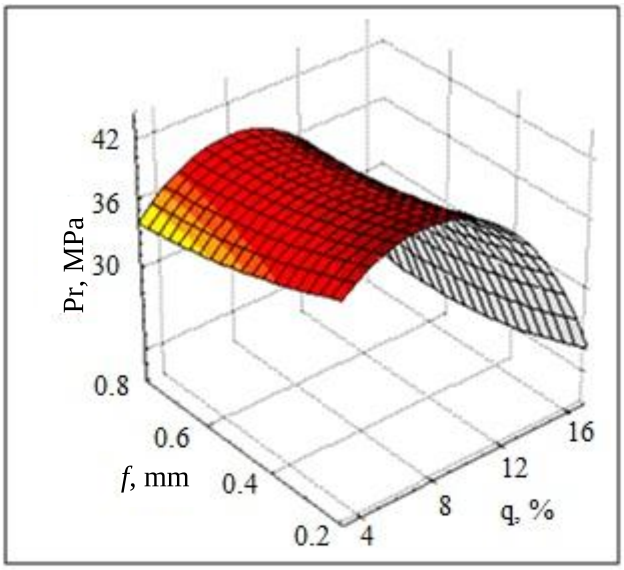


Figure 1. The dependence of the value of the bending strength of the board and the percentage of ground needles in the total mass and particle size of the needles.

The graphical dependence in figure 2 and equation (3) show the value of the density index of the resultingboard increases with increasing content of ground needles and the size of its particles. The density index reaches its maximum value of 980-990 kg/m^3 when 15-16% of ground needles of 0.7-0.8 mm in size are added to the total mass.

The graphical dependences in figures 3, 4 and equations (3) and (4) show that water absorption and swelling of fiberboard are improved by adding ground needles. The value of the indicator of water absorption and swelling of the resulting boards increases with an increase of ground needles in the total mass of more than 8% and the size of its particles. The values of water absorption and swelling of fiberboard reach their maximum values of 33-34% and 22-23%, respectively, when 15-16% of ground needle.

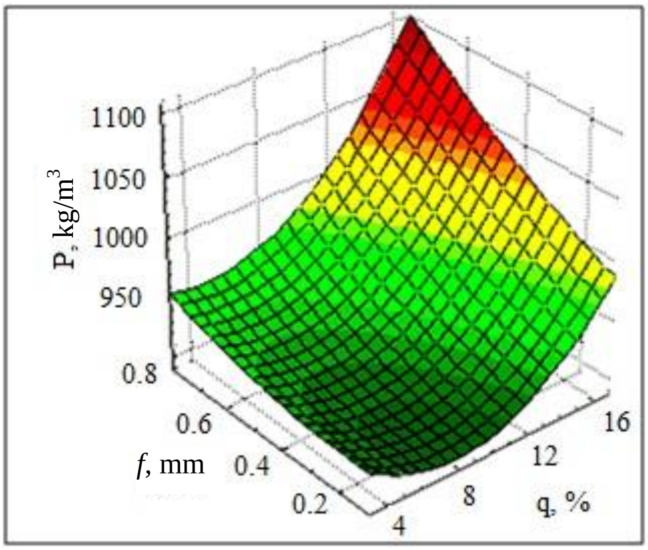


Figure 2. The dependence of the value of the density index of the board on the percentage of ground needles in the total mass and particle size of the needles.

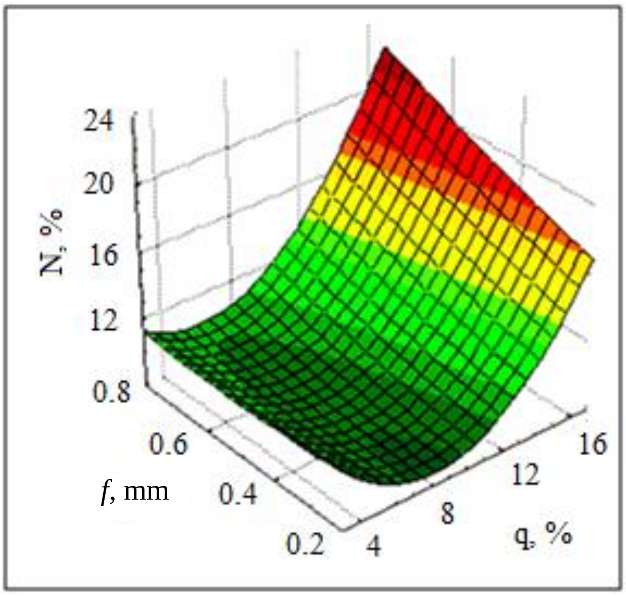


Figure 3. The dependence of the value of the indicator of water absorption of the board on the percentage of ground needles in the total mass and particle size of the needles.

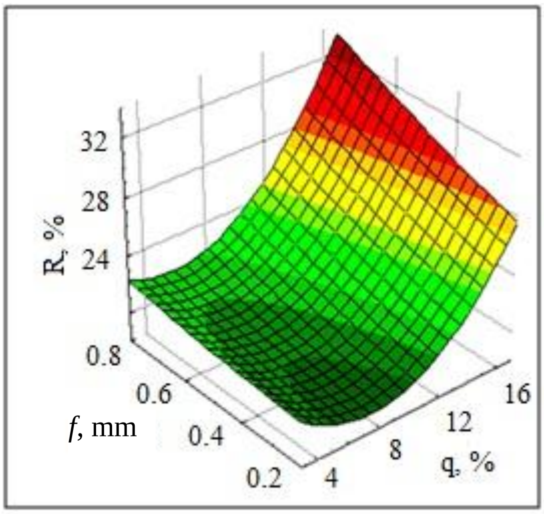
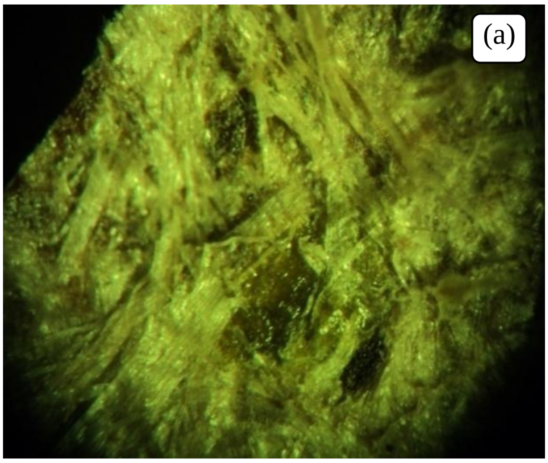


Figure 4. The dependence of the value of the index of swelling of the board on the percentage of ground needles in the total mass and particle size of the needles.

To study the process of forming the body of the board with the addition of ground needles, the analysis of fiberboard was performed using a digital microscope LV-34 with a maximum magnification up to 100 times. Figure 5 presents photographs of a fiberboard with the addition of ground needles that confirm the results of research. Making an analysis of the photographs,we can see that the needles particles not only fill the free space between the wood fibers but also participate in the process of bond formation, creating additional bonds between the large and medium fibers.



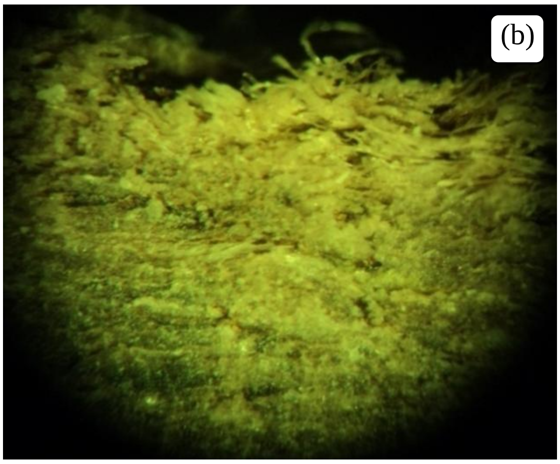


Figure 5. Photographs of the front layer (a) and the arris (b) of the board with the addition of ground needles, magnification by 70 times.

4. Conclusion

Thus, the statistical-mathematical equations, graphical dependencies and photographs obtained during the research describe the production of fiberboard with the addition of ground needles. They make it possible to predict the production of a high-quality board depending on the percentage of ground needles in the total mass and particle sizes. The analysis of the research results shows that the values of the physical and mechanical parameters of the fiberboard correspond to group B according to State Standard 4598-86 with the addition of 10-12% of ground needles in the total mass with a particle size of 0.2-0.5 mm. The use of needles in the production of fiberboard will reduce the amount of logging residues. In addition, it will maintain the quality indicators of the board, solving a number of problems in the field of environmental and fire safety.

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