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Integrated recycling of wood waste using recycling technology

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Abstract. The activity of the Russian timber processing industry is inextricably linked to the constant generation of wood waste. The paper considers types of wood waste as well as the possibility of their integrated use in the conditions of wood processing plant. We present the results of experiments on the production of wood fibre boards with the addition of prepared wood waste: bark, sawmill waste, format-cutting waste, trapped fibre and hardwood waste, and determine the optimum percentage of the studied waste in the total wood mass.

1 Introduction

At present, the success of an enterprise directly depends on the application of innovation strategy in its activities, because without the use of scientific and technological progress, the effective operation of the enterprise is impossible. For adequate innovation development, the enterprise should carry out continuous improvement of its activity with application of new technologies or mastering of release of new demanded products, and also aspire to growth of basic economic indicators, such as profit, competitiveness, and efficiency [1].

The main source of economic potential development of woodworking enterprise nowadays is not external factors represented by natural resources, but ideas and innovations based on them.

First of all, it is necessary to note as such a factor the main distinctive feature of the woodworking industry, participation in the processing of waste generated during the production of lumber.

During the process of logging, woodworking enterprises face the formation of a significant amount of waste at all stages of the production of wood semi-finished and finished products. Wood waste is a part of the raw material that does not enter the production of the main product and its amount depends mainly on the logging and wood processing technologies used, the equipment used and the characteristics of the raw material used [2, 3].

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Wood waste is often used as solid fuel for plant needs. However, the use of wood waste for thermal energy generation is inefficient, since the cost of wood waste exceeds the cost of the energy produced in this way.

During logging alone, between 20-37% of wood biomass remains in the form of roots, stumps, twigs, bark, rotten and burnt wood [4-6].

The yield of the finished product in the production of lumber for export purposes is 65% and 35% is waste.

Let's consider the main technological stages of wood processing enterprise within the framework of JSC Lesosibirsk Woodworking Plant No.1. The first technological stage is the preparation of wood raw material, its receipt, sorting, and storage. As a result of loading and unloading with a manipulator there is a waste product in the form of "scrap wood", also at this stage there is a waste product in the form of sorted wood, not suitable for diameter and grade.

The second process stage is the debarking of the raw wood, its sawing, and the production of finished lumber. This phase generates a significant amount of waste in the form of bark, slab and sawdust.

The third technological stage is the production of wood fibre boards. JSC Lesosibirsk Woodworking Plant No. 1 produces wet-processed wood-fibre boards of grade T, group B according to GOST 4598-2018, TO 5536-01-05029043-2018.

In 2018, a new technological line for the production of fuel pellets was launched at the site of Lesosibirsk Woodworking Plant No. 1; the second stage of the fuel pellet production plant was launched in 2020, which increased the total capacity of pellet production (according to Official website of Segezha Group. https://segezha-group.com/product/biofuel/).

In order to ensure the integrated use of wood waste from the wood processing plant, it is advisable to use it in the existing production of wood-fibre boards.

2 Materials and methods

In the course of the research, the types of waste generated at the wood processing plant were analysed. Their preparation and possibility of their further use in wood-fibreboard production on the basis of recycling technology was considered.

The aim of the conducted research is to use recycling technology for the complex processing of waste in the production of wood fibre boards under the conditions of a wood processing company.

Recycling is the process of returning waste, emissions and discharges to production processes, which allows saving on resources by involving secondary raw materials in production, as well as reducing the negative impact on the environment by reducing emissions into the atmosphere and water sources.

Recycling is a relevant technology to recycle wood waste under the conditions of a wood processing plant. For research, waste in the form of bark from log debarking, sawmill waste from the production of export sawn timber, format cutting waste from cutting and trimming of fibreboard, trapped fibre from waste water from fibreboard production, and hardwood waste were used.

The following should be prepared before they can be used in the wood-fibre industry.

After debarking the logs, the bark is dry-cut and then sent for sorting. The fractionation process removes unsuitable particles. Before use, the bark is soaked in water or impregnated with chemical solutions, which are then removed for recovery. The bark is then ready to use in the manufacture of fibreboard.

Waste timber sawing in accordance with GOST 15815-83 [7] is chopped into technological chips, after which the chips obtained can be used in the manufacture of fiberboard.

Waste of format-cutting cutting is subjected to dry shredding before their use in the panel production. Sawmill trimmings are shredded and fed to the mills, the predominance of the desired particle size distribution is controlled by adjusting the milling parameters.

The captured fibres are removed from the water by dispersion flotation, prepared, mixed with the fibreboard, and then used in the production of the fibreboard. The use of the captured fibres has a positive ecological impact on the atmosphere, the soil, and the groundwater [8].

Coniferous wood is processed in the enterprise considered as a raw material; however, the use of hardwood in the production of fibreboard will reduce the cost of raw materials, due to the lower prices per cubic metre, without worsening the physical and mechanical characteristics of the fibreboard.

In this regard, the company can purchase or procure hardwood for further use in the manufacture of fibreboard. In this case, the hardwood must be sorted, chopped and partially mixed with softwood chips for further fibreboard production before it can be used.

3 Results and discussion

In order to study the effect of wood waste on the physical and mechanical characteristics of finished wood-fibre boards at the SibSU branch in Lesosibirsk in accordance with GOST 10633-2018 [9], a number of laboratory experiments, the results of which are presented in Table 1, were conducted.

Table 1. Physical and mechanical properties of fibreboards with wood residues.

Type of waste	Percentage content, %	Indicator name		
		Density, kg/m^3	**Strength, MPa**	**Water absorption, %**
Reclaimed pulp	4	1021	33.8	21.9
	5	1029	32.5	21.2
	7	1040	30	19.9
	8	1049	29	19.6
	10	1061	27	18
Bark	4	917	24.8	33.5
	5	915	28	33
	7	911	31.5	29.5
	8	909	32.5	28.2
	10	906	33.5	26.1
Hardwood waste	10	962	35.5	23.2
	15	963	35.3	23.5
	25	974	34.8	24.1
	30	980	34.7	246
	40	991	34.2	25.1
RDF waste	10	856	41	22.6
	15	891.5	39.6	24.1
	25	986.1	37.3	26.3
	30	942.1	36.1	27.8
	40	905.2	33.8	31.3
Sawmill waste	10	840	40	29
	15	844	42	27
	25	860	46	24

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	30	856	45	28
	40	842	42	32

The conformity of the physical and mechanical properties of the obtained fibreboards using wood waste was carried out for wood-fibre boards of T grade, group B according to GOST 4598-2018 "Wood-fibre boards of wet process".

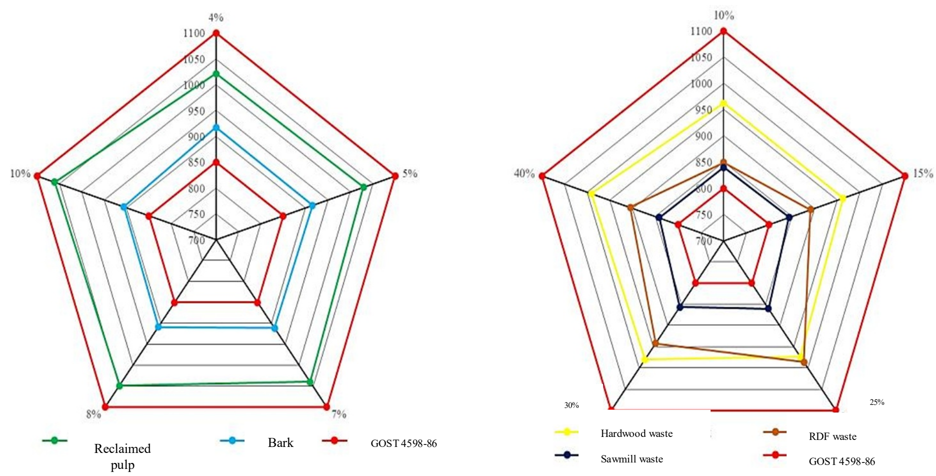

Fig. 1. Dependence of fibreboard density on the percentage of wood waste in the total mass

Figure 1 shows the graphs showing the density values of fibreboards using wood waste. As can be seen from the graph, the captured fibre and bark meet the requirements of GOST and are within the specified limits of 800-1100 kg/m3, but the waste in the form of captured fibre has a higher density value than the bark. Waste hardwoods meet the established density limits.

The RDF waste also meets the requirements, and when added 25% to the total mass has a higher density than the rest of the waste. Sawmill waste meets the GOST density requirements, but has the lowest density at all the percentages listed in the total mass.

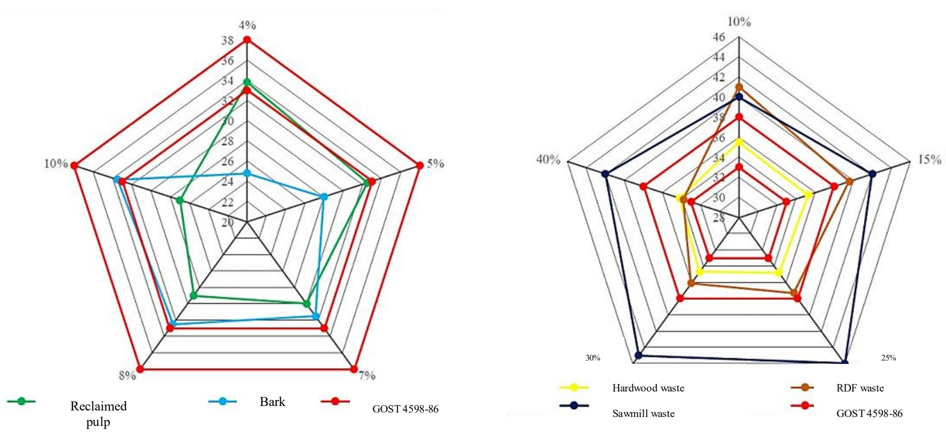

Fig. 2. Dependence of fibreboard strength on the percentage of wood waste in the total mass

Based on the experiments carried out, graphs showing the strength values of wet-processed wood fibreboards using wood waste are presented (Figure 2).

As we can see from the diagram, when catch fibres of 4 % are used, the requirements of State Standard are fulfilled, when 5 % are used, the discrepancy is 0.5 MPa, further increasing of catch fibres in total mass up to 10 %, the strength index does not meet the requirements and is not within the defined limits of 33-38 MPa. The index of durability at use of a bark in size of 4-7 % doesn't meet requirements of GOST, at the content in total weight of 8 % the index less on 0.5 MPa, at use of 9-10 % values of the index come within the established limits on durability.

Waste hardwoods meet the requirements of GOST, strength index when they are added is within the range 33-38 MPa. With the use of 25-40% of the FOR wastes GOST requirements are met, and the addition of 10-20% of waste exceeds the required indicators. The addition of sawmill waste in the amount of 10-40% increases the strength of fibreboards, while the GOST requirements are exceeded.

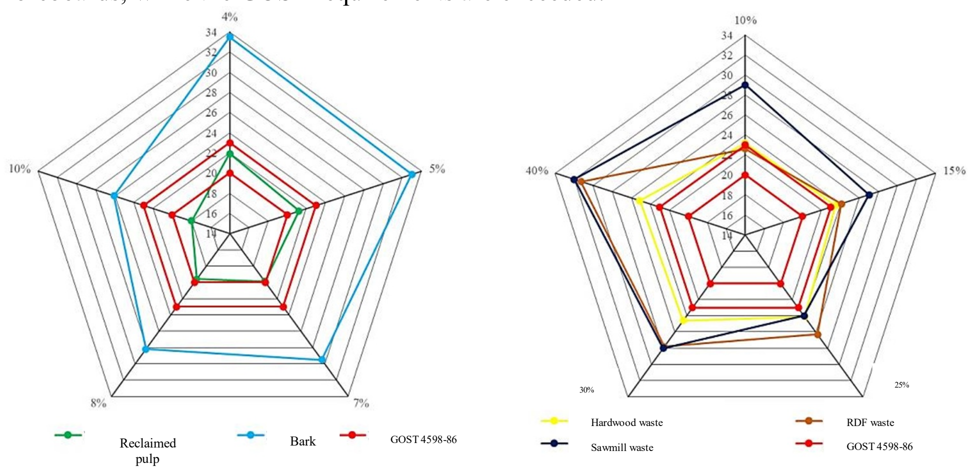

Fig. 3. Dependence of water absorption of fibreboard on the percentage of wood waste in the total mass

Adding wood waste also affects the water absorption of fibreboards, the extent of the effect depending on the type of waste, its structure and percentage of the total mass. Figure 3 shows graphs showing the water absorption values of fibreboards using wood waste.

It is seen from the graph in picture 3, that the water absorption of fibreboards containing 4-6% of captured fibres meets the GOST requirements and the values fall within the limit 20-23%, addition of 7% of captured fibres decreases the index by 0,1%, further addition of 10% fibres will decrease the water absorption of boards and the total mass of the board will be 18%. The use of 4-10% of bark does not comply with GOST requirements and exceeds the admissible values.

Water absorption figures in picture 3 are in accordance with GOST requirements when 10 % of iron ore wastes are used, when 15 % of wastes are used, the figure is higher than the established value by 1,1 %, use of 10-20 % of deciduous wood in total mass does not meet the requirements by 0,2-0,7 % correspondingly. The addition of these types of waste in the remaining percentage contents, as well as sawmill waste from 10% to 40% shows significant deviations from the established GOST limits for water absorption.

4 Conclusions

Analysing the data obtained, we can conclude that in the conditions of a wood processing plant there is a possibility of complex processing of waste by means of recycling technology. The optimal percentage in the total wood mass for waste in the form of trapped fibre is 4%, and all the indicators studied comply with the GOST requirements. Also 10-15% broadleaved waste is suitable for recycling according to GOST, but with exceeding the water absorption index by 0,2% and 0,5%, respectively. RDF wastes are suitable for use in the amount of 10% of the total wood mass, with a fibreboard strength index value higher than the GOST by 3MPa, and other indicators meet the requirements. When RDF waste is added to the mass in an amount of 25%, the value of water absorption does not meet the requirements of GOST by 1%, but the strength of the board increases by 8 MPa.

The practical significance of the study is that the introduction of recycling technology in wood processing enterprises creates an opportunity to reduce the cost of waste disposal, as well as to benefit from the recycling of wood waste in the production of board products.

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