The technology of crushed wood as a factor of environmentally safe forest management

Sergey Dolmatov[1*], *Yana* Makunina[1], *Sergey* Voinash[2], *Ramil* Zagidullin[2], *Adel* Yakushev[2], *Sergey* Ariko[3], and *Andrey* Gordeychik[3]

[1]Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarskii rabochii prospect, Krasnoyarsk, 660037, Russia
[2]Kazan Federal University, 18, Kremlin Street, Kazan, 420008, Russia
[3]Belarusian State Technological University, 13a, Sverdlova street, Minsk, 220006, Republic of Belarus

Abstract. The article considers the prospect of using technologies for processing low-quality, damaged wood and wood waste by grinding in the interests of energy use. The data on the dynamics of the increase in the areas of plantations with impaired and lost stability, the causes of these phenomena on the example of the Krasnoyarsk Territory are presented. Various options for the disposal and use of wood waste, including from logging activities, are described. The main advantages and possible disadvantages of the introduction of technological processes for grinding wood raw materials are also given. The analysis of trends in the production of wood pellets in Russia and the world is carried out. Attention is paid to minimizing the impact of existing wood processing technologies on environmental safety and improving the efficiency of business activities based on the involvement of wood waste in the production process as raw materials for the fuel and energy sector, as well as obtaining new, highly liquid products and materials. The materials of the work can be used in making decisions related to the involvement in industrial production or disposal of low-quality, damaged wood and wood waste.

1 Introduction

Currently, the generally recognized direction of development of the world economy is the concept of sustainable development, which is aimed at a balanced, environmentally safe and socially responsible development of society without critical depletion of natural resources. This concept is fully applicable to activities related to the management of forest resources, logging technology, and wood processing. Forest management is an important branch of the economy, which ensures not only the production of wood resources, but also a high-quality natural environment for the life of many species of animals and plants. However, the constant deforestation leads to the depletion of the natural environment. One of the main factors that contributes to environmentally sound forest management is the lack of modern highly efficient wood processing technology. Outdated equipment and

* Corresponding author: pipinaskus@mail.ru

technologies are used in the processing of roundwood, which leads to significant losses of lumber and inefficient processing of wood waste.

The resources remaining in the cutting areas after logging are completely underutilized. These are the so-called felled residues, low-grade wood. The accumulation of combustible wood waste in logging areas leads to an increase in the burning of forests.

Forest fires have a strong impact on the state of forests and are one of the leading factors in the annual weakening and shrinkage of forests. Damaged by multiple fires, the forest weakens, recovers more slowly, absorbs less carbon dioxide and releases oxygen, which means it does not help slow down climate change. The higher the density of forests, the worse its natural functions, such as climate formation, water and soil protection, will be realized [1]. The above-mentioned factors create prerequisites for environmentally unsafe forest management. They require measures to reduce the harmful effects on the environment. The use of wood shredding technology can be one of the solutions to this problem.

2 Materials and methods

The purpose of the study: to substantiate the prospects for the use of technologies for grinding low-quality and damaged wood, as well as wood waste in the interests of environmentally safe forest management.

Research objectives:

- Determine the places of formation and the amount of resources of low-quality and damaged wood.
- Analyse the available technologies for processing wood raw materials by grinding.
- To consider the directions of use of crushed wood, environmental benefits and economic efficiency of the technology of utilization of designated resources.

3 Results

Let's consider the state of the issue in the designated area using the example of the Krasnoyarsk Territory, which ranks second in the Russian Federation (RF) in terms of forest resources (158,743,269 thousand hectares). The main causes of the weakening and death of forests in the Krasnoyarsk Territory were forest fires and forest pests. The area of forests damaged by these phenomena amounted to 84.7% (625,804.7 ha) of the total area of damaged plantations (738,601.1 ha). The annual growth of the areas of plantations with impaired and lost stability in the Krasnoyarsk Territory is shown in the graph (Figure 1).

It should be noted that over the past 9 years of observations, the area of damaged stands has increased by more than 2 times. The average annual area of plantations with impaired and lost stability during this period is 580,247.9 hectares, while the indicator for 2017 exceeds the annual average by 1.3 times.

The death of forests is uneven over the years and is clearly of a personal nature. Cyclicity, to a greater extent, depends on the weather and climatic conditions associated with the actual burning of forests, as well as on outbreaks of mass reproduction of dangerous stem species (Ussuriysky polygraph, big black spruce barbel) and needle-gnawing pests (Siberian and unpaired silkworm, fir and pine moth).

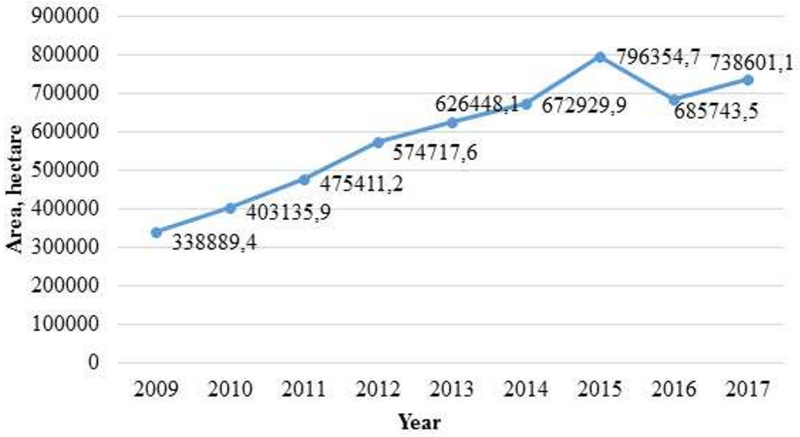


Fig. 1. The areas of plantings in the Krasnoyarsk Territory with impaired and lost stability.

The distribution of the area of plantations with impaired and lost stability for reasons of weakening and death is shown in the diagram (Figure 2). A significant increase in the area of forest plantations with impaired and lost stability in the forests of the Krasnoyarsk Territory in the period from 2009 to 2017 was associated with outbreaks of mass reproduction of the Siberian silk strand, the Ussuri polygraph and large forest fires.

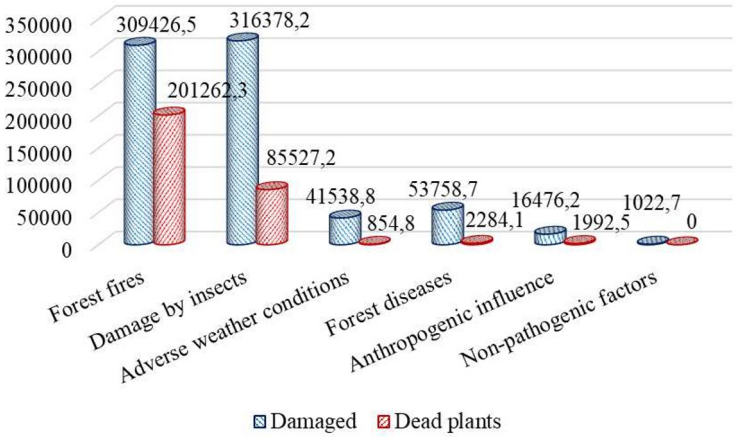


Fig. 2. Distribution of the area of plantations with impaired and lost stability.

Such significant resources require involvement in industrial processing in order to obtain highly profitable, in-demand products. The reduction of the negative impact on forest ecosystems is achieved through the evacuation and processing of designated resources of low-quality wood and wood waste based on the use of wood milling technology. Crushed wood raw materials can be converted, for example, into biofuels or wood-mineral composites (DMCs). The principle of operation of the shredded wood technology is based on the use of special disc or drum type chopping machines. Usually, chopping machines are equipped with knives radially mounted on a massive disk, which carry out direct (chopping) cutting. There are also known designs of shredders, the operation of which is based on the principle of sliding force cutting of wood with a knife in the form of a logarithmic spiral. Such machines have a number of advantages, but have not yet been widely used [2].

The main task of any chopping machine is to obtain homogeneous raw materials in the form of a mass of technological chips. The homogeneous mass makes it possible to organize its highly efficient transportation and processing, which is difficult to do in the case of waste of various shapes and sizes with low full-weight coefficients.

The resulting chips are used for the production of biofuels or DMK. The main advantage of this technology is its environmental safety. The use of crushed wood makes it possible to significantly reduce the amount of waste that must be disposed of, which reduces the negative impact on the environment. This technology is a very effective way of processing wood waste, however, the production and sale of biofuels in the form of fuel pellets or DMK have certain competitive advantages and disadvantages. None of the technologies has obvious overwhelming advantages, since any of them has objective limitations.

Professional product management in terms of market positioning, logistics and pricing should become an important factor in the operational implementation of the technology for processing crushed wood [3]. For example, the products of processing crushed wood in the form of Durisol and Velox building blocks, thanks to aggressive management, have taken a stable place in the global market of building materials. Moreover, these products are quite competitive compared to solutions based on aerated concrete or foam concrete.

The use of forest management and wood processing technologies, including stages of partial or complete crushing, provides the opportunity:

- Reduce the amount of waste and reduce the need to take it to landfill. At the same time, expensive waste treatment processes, such as recycling and landfill storage, are becoming less in demand.
- Creating compost or fertilizers based on crushed wood, improves soil quality and increases its fertility.
- Creating new products. Thus, crushed wood can be used as the main material in the production of composite materials or building blocks. This makes it possible to create environmentally friendly products based on natural resources.

The environmental benefits include the ability of biofuels made from crushed wood to replace fossil carbon fuels (oil, gas). This makes it possible to preserve national forest resources, free up oil and gas for the production of other types of products. At the same time, the use of wood pellets for the production of electric energy is more environmentally friendly. Another obvious environmental benefit of shredded wood technology is the reduction of greenhouse gas emissions. Since carbon monoxide emissions from the production of electricity from sawdust are 80-90% lower than when using coal or oil, the use of this technology is one of the simplest and most affordable ways to reduce the negative impact on the environment.

4 Discussion

There is a steady trend in the world towards switching to renewable carbon fuels, including wood-based ones, which is reflected in a significant increase in the volume of consumption of wood and its processed products. The total consumption of wood products in the European Union, according to forecasts obtained using EFI-GTM, will grow from 739 million m^3 in the equivalent of roundwood (ECL) in 2010 to 853 million m^3 in 2030 [4]. Wood-based fuel consumption increases by 1.5% annually [5]. It is assumed that such growth rates in Europe will continue until 2030, therefore, the demand for wood for energy production will increase from 434 million m^3 ECL in 2010 to 585 million m^3 in 2030 [4].

The world community, including Russia, has fixed the postulates of the transition to a green economy based on the principles of sustainable development in the concepts and programs of the United Nations [6]. The growth in the production of fuel pellets meets the

requirements of a gradual transition to the economy of bio-renewable resources, which is becoming especially relevant in the context of the acute global energy crisis at the present time. The production of biofuels, pellets, is currently experiencing a real manufacturing boom. In Figure 3 shows the dynamics of growth in pellet production in the world and Russia [7].

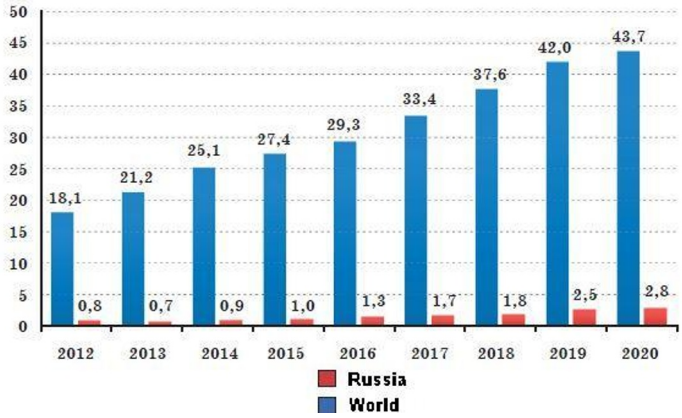
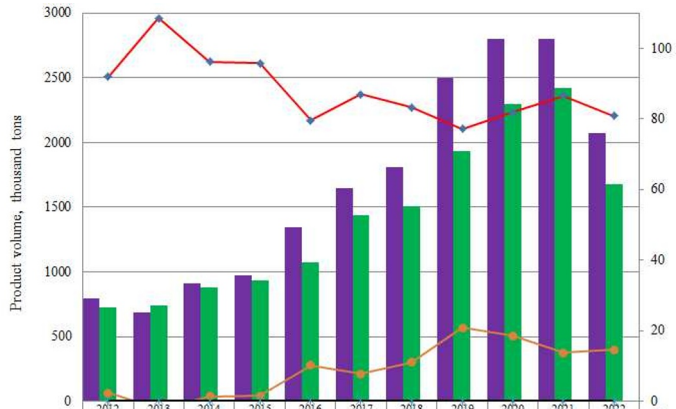


Fig. 3. The dynamics of growth in pellet production in the world and Russia.

Significant efforts on the part of States were required to obtain such dynamics indicators. Since the end of the 20th century, economically developed countries have begun to pursue a policy of using renewable energy sources. The European Union has set a course to build low-carbon energy by 2050 within the framework of the concept of "climate neutrality" [8].

Russian producers have generally caught the global trend of switching to bio-renewable energy resources in the form of pellets. In 10 years, the volume of pellet production increased from 791 thousand tons to 2,800 thousand tons, or 3.5 times (Figure 4) [9]. Up to 80...85% of the pellet output is exported.



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
production, thousand tons	791,0	683,0	913,0	974,0	1345,0	1650,0	1810,0	2500,0	2800,0	2800,0	2073,0
export, thousand tons	729,00	744,00	879,00	935,00	1073,00	1439,00	1511,00	1933,00	2294,00	2425,00	1677,00
import, thousand tons	1,11	1,46	1,34	2,17	2,80	4,88	2,09	2,09	2,09	2,09	2,09
внутр. потреб, тыс.тонн	63,11	-59,54	35,34	41,17	274,80	215,88	301,09	569,09	508,09	377,09	398,09
export share, %	92,03	108,70	96,13	95,78	79,61	86,95	83,38	77,26	81,87	86,54	80,82
import share, %	0,14	0,21	0,15	0,22	0,21	0,29	0,12	0,08	0,07	0,07	0,10

Fig. 4. Dynamics of production, export, import and domestic consumption of pellets (Russia).

The sharp rise in the level of pellet production in Russia and significant amounts of investment in pellet production in 2022 faced new and very serious problems, which

include difficulties in logistics and marketing of finished products in traditional markets in the European Union. Due to the massive refusal of the EU countries to buy pellets produced in Russia, in the near future a situation of warehouse shortage and an oversupply of pellets in the domestic market of the Russian Federation will be formed. The domestic biofuel market of Russia is essentially in its infancy, the volume of consumption of fuel pellets does not exceed 15…20% of their production volume. According to the most favorable forecasts, the total annual consumption within the Russian Federation does not exceed 600...800 thousand tons with production capacities of about 3 million tons. It is obvious that government and industry incentives are required to support pellet producers.

The experience of Germany, where the Klimaschutz programm 2030 was adopted in 2019, is very indicative. The program legally prohibits the installation of liquid fuel heating boilers in residential and public buildings from 2026. At the same time, state support is provided in the form of a subsidy for the replacement of a liquid fuel boiler with a pellet boiler. To date, Germany has more than 6 million liquid carbon fuel boilers, more than 40 million natural gas boilers and only 0.4 million pellet boilers, i.e. the potential market in Germany alone is huge.

A big plus is also the possibility of creating new jobs due to the development of the sawdust energy production industry. Also, the use of crushed wood technology [10-12] makes it possible to reduce the cost of forest waste disposal and increase the economic potential of the forest industry.

5 Conclusion

The use of crushed wood as a fuel for energy production makes it possible to reduce oil and gas consumption, as well as significantly reduce greenhouse gas emissions. This is especially relevant in light of climate change and the global community's desire to reduce carbon emissions. The technology of crushed wood is an important factor in environmentally safe forest management. This method of processing wood allows the use of forest waste for the production of biofuels or wood-mineral composites, reducing the amount of waste in the landfill. Despite some limitations and disadvantages, the technology of crushed wood continues to develop and improve. In recent years, many new methods and improved equipment for processing forest waste have appeared, which make it possible to improve the efficiency of the process and reduce its negative impact on the environment.

In general, the technology of wood crushing has many advantages compared to traditional forest management methods. It helps to reduce the amount of waste and improve the quality of the soil, allows you to preserve the natural environment and create new products based on wood waste (biofuels, building materials). All this makes wood shredding an important factor in environmentally safe forest use.

Shredded wood technology has significant potential for environmentally sound forest management and can become an important element of a sustainable development strategy. Its successful implementation requires support from government agencies, investors and research centers, as well as wide public awareness of the benefits of this technology, which is one of the most effective and environmentally friendly ways to use forest resources. Due to its advantages, this technology is becoming increasingly popular all over the world.

References

1. S.N. Dolmatov, A.V. Pryanichnikova, E.A. Tikhonov, R.R. Zagidullin, L.S. Sabitov, V.M. Yumagulova, V.A. Sokolova, The potential of unclaimed forest resources of the Krasnoyarsk Territory and the prospects for their use, in IOP Conference Series: Earth

and Environmental Science **1154**, 012075 (2023) DOI:10.1088/1755-1315/1154/1/012075

2. S.N. Orlovskiy, Forest Magazine **5**, 135-150 (2018) DOI: 10.17238/issn0536-1036.2018.5.135
3. S.N. Dolmatov, A.V. Nikonchuk, S.V. Gorbunova, Competition and management of wood-cement compositions among light concretes in the market of construction materials, in IOP Conference Series: Materials Science and Engineering **822**, 012001 (2020) DOI: 10.1088/1757-899X/822/1/012001
4. A. Duhovnik, Y. Balabanova, M. Lushpaeva, A. Gaiduk, and A. Nurullin, Analysis of promising methods for felling for forest care by multi-operation systems of machines, in AGRITECH-VIII 2023, E3S Web of Conferences 390, 07043 (2023) DOI: 10.1051/e3sconf/202339007043
5. F. Steierer, Energy use (EUwood, Hamburg/Germany, 2010)
6. World Economic Forum. The Global Risk Report 2022, https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf
7. S.A. Karkhova, Journal of Baikal Studies **13(3)**, 23 (2022) DOI 10.17150/2411-6262.2022.13(3).23
8. A.V. Zimakov, World economy and International Relations **64(8)**, 81-90 (2020) DOI: 10.20542/0131-2227-2020-64-8-81-90
9. FAOSTAT, FAO, https://www.fao.org/faostat/en/#data/FO
10. A. Pankratovich, P. Protas, Y. Misuno, N. Chernetskaya, V. Yumagulova, A. Safin, Parameters of optimization of transfer operations of the harvesting process, in AGRITECH-VIII 2023, E3S Web of Conferences **390**, 03026 (2023) DOI: 10.1051/e3sconf/202339003026
11. R. Zabel, J. Morrell, Wood Microbiology (Academic Press, Elsevier Inc., 2020) DOI: 10.1016/C2018-0-05117-8
12. V.D. Eskin, A.I. Krivorotova, Complex processing of wood debarking waste as a factor of environmental safety, in IOP Conf. Series: Earth and Environmental Science **1061**, 012045 (2022) DOI: 10.1088/1755-1315/1061/1/012045