To the question of the possibility of operating sawmill complexes in the conditions of timber terminals

Ivan Maganov[1*], *Evgeny* Tihonov[1], *Albina* Gaiduk[2], *Ilgam* Kiyamov[2], *Linar* Sabitov[2,3], and *Viktoriia* Sokolova[4]

[1]Petrozavodsk State University, Lenin Ave., 33, Republic of Karelia, Petrozavodsk, 185000, Russia
[2]Kazan Federal University, 18, Kremlin Street, Kazan, 420008, Russia
[3]Kazan State Power Engineering University, 51, Krasnoselskaya Street, Kazan, Russia
[4]Saint-Petersburg State University of Industrial Technologies and Design, 18, Bolshaya Morskaya Street, St. Petersburg, 191186, Russia

Abstract. At present, the problem of depletion of forest resources and the associated increase in the export shoulder and the corresponding logistics costs are increasingly felt. Today, as one of the solutions to this issue, the concept of using timber terminals has been applied, when the processing of roundwood into a more appropriate form, including for transportation, is carried out in close proximity to the cutting area. The overall efficiency of timber terminals is affected by the equipment operated on them, in particular, the sawmill. This article discusses the main types of sawmills according to the type of working body: tire, frame, tape and disk, indicating their positive and negative qualities for direct use in timber terminals. The article also formulates tasks aimed at improving the energy sustainability of timber terminals - as production sites for deep processing of timber.

1 Introduction

Due to the depletion of forest resources in places with developed infrastructure, more and more logging areas are located at considerable distances from processing industries and from power lines. The shoulder of roundwood export in some regions is already more than 300 km [1]. In this regard, there is an acute issue of reducing the logistics costs for the transportation of roundwood to the place of processing, the efficiency of which, taking into account the full-wood factor of the wagon, which varies in the range of 0.57 ... 0.67 [2], is quite low. One of the ways to solve this issue is the organization of roundwood processing in close proximity to the cutting area, for which the so-called timber terminals are used [3]. These are production sites where various products are made from roundwood, ranging from sawn timber and semi-finished products to fuel chips and pellets.

One of the key parameters affecting the productivity and efficiency of the timber terminal is the sawmill complex used during its operation, depending on the type of working body. They can be divided into tire, frame, band and circular sawmills.

* Corresponding author: magavan17@mail.ru

2 Materials and methods

The study is based on the application of the method of integrated analysis of the disadvantages and advantages of sawmill complexes, depending on the type of working body used in them.

2.1 Tire sawmills

In the design of a tire sawmill, its working body is a saw bar with a saw chain, which is installed on a power frame with guides for sawing workpieces.

The main advantages of tire sawmills are the simplicity of its design, lightness and the resulting high mobility.

When using these sawmills, a horizontal arrangement of the working body is used, and the possible thickness of the processed workpieces depends solely on the length of the tire used. The work stroke can be performed in both directions. In view of the working body used, there is a significant drawback associated with a sufficiently large cutting width, as well as the need for sharpening or replacing chains, which adversely affects the overall economic efficiency. And it is important that during tire sawing a high degree of waviness is formed on the resulting product, since the tire is rigidly fixed only on one side at its attachment point. This leads to a deterioration in the commercial qualities of the sawing material.

The sawing process with a tire sawmill is shown in Figure 1.

Fig. 1. Tire sawing process.

For sawing along the fibers, it is highly desirable to use special chains that correspond to the task.

2.2 Frame sawmills

This type of sawmill is a pioneer in the field of commercial wood processing and was used even during the use of a water wheel drive.

Immediately, we note that for the installation of a frame sawmill, a prepared platform with a foundation is required, to which it is rigidly attached with the help of studs embedded in it.

The sawing process is carried out by passing the prepared material, fed and pressed by the ruffles, through the saw frame, in which a set of saws with the required range is fixed, performing reciprocating vertical movements.

The sawing process with a frame sawmill is shown in Figure 2.

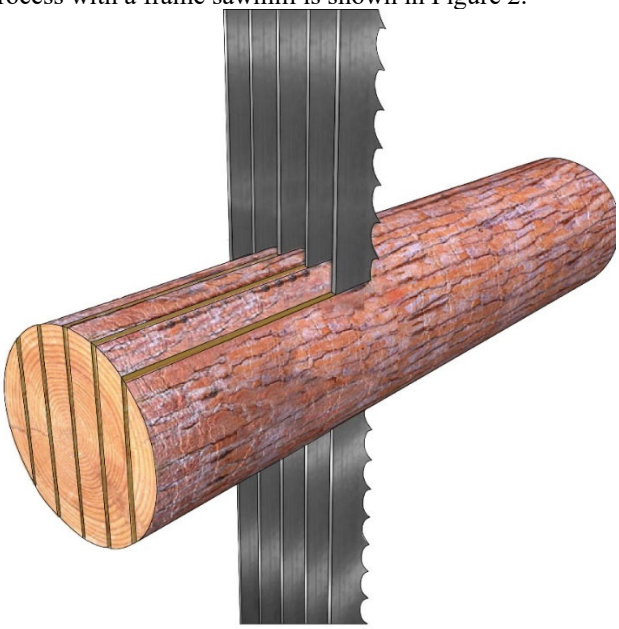

Fig. 2. The process of sawing with a frame sawmill.

From the main indicators of the work of frame sawmills, one can single out a fairly high productivity, since the feed material is sawn all in one pass. However, at the same time, there is also a disadvantage associated with the fact that if it is necessary to change the dimensions of the resulting lumber in terms of thickness, it is necessary to stop work and rearrange the saws with a new range. The width of the cut relative to other schemes is at an average level and depends on the saws used during operation and the angle of the teeth.

Sawing is carried out in the vertical plane of the processed material. In this case, moving saws up is idle, and moving down, respectively, is working.

A significant disadvantage is the large mass of the entire structure, the features of the crank mechanism, and, consequently, large vibrations and the resulting need for a capital foundation [4]. And we should not forget about the problem of the frequency of saw sharpening, since this requirement directly affects the productivity of the entire sawmill.

All these operational difficulties and negative factors have led to the fact that today frame sawmills are a thing of the past and are gradually being replaced by disk and tape counterparts.

2.3 Band sawmills

The band sawmill, the share of output from which was about 10% in the last century in Russia [5], is by far the most common in woodworking enterprises. As a working body, it has a metal saw, made in the form of a closed tape [6], hence the name.

Unlike frame sawmills, the material being processed does not move, but is fixed on the frame, along which the carriage with the saw unit moves along the guides.

The sawing process with a band sawmill is shown in Figure 3.

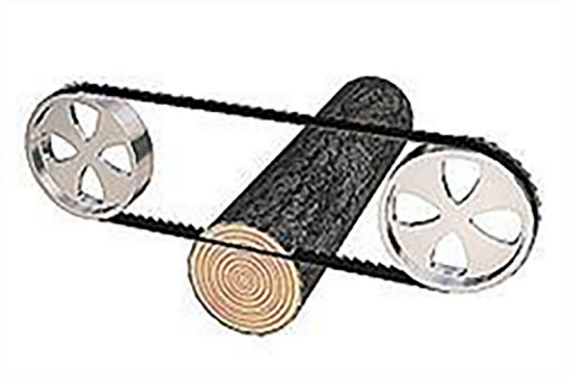

Fig. 3. The process of sawing with a band sawmill.

Sawing can be carried out in two different planes, depending on the type of installation according to the way the working body is located: either horizontally or vertically. Vertical sawmills are also called column sawmills.

Various versions of band sawmills are possible to increase their efficiency in any of the directions.

First of all, these sawmills are divided into narrow-saw or wide-saw. Narrow-saw blades, as the name implies, have a narrow blade width of up to 60 mm and are used when working on soft woods or to obtain lumber of small thickness, while being considered low-productive. Wide-saw blades, as the name implies again, have a blade width of up to 200 mm or more, and can be used to process large-diameter workpieces of any, including hardwood, being considered, respectively, high-performance.

When using saws with double-sided sharpening, sawing of workpieces is possible when the carriage moves in both directions, which has an extremely positive effect on overall productivity due to the absence of idling when the carriage returns to its original position.

It is worth noting a rather rare performance with two tapes on one machine. This scheme allows you to get a four-edged beam with just one turn of the workpiece by 90º. Saws in this case are arranged vertically with a drive from different pulleys in the same plane and performing multidirectional rotation.

Due to the simplicity of their design, low weight and material consumption, band sawmills have high potential mobility, which allows them to be mounted on trailers folded in the stowed position and deployed in the working position.

In addition to its simplicity, the main positive quality of band sawmills is the smallest thickness of cut among all types of their "colleagues" and depends only on the thickness of the saw band used.

To increase the degree of automation of the sawing process, it is possible to use a tilter. With the help of it, after the cut, the workpiece is turned over to the required degree without the use of manual labor.

However, despite the obvious advantages, there are also pronounced disadvantages, namely, a high degree of waviness of the resulting products due to the working body used

and the exactingness of timely and very frequent sharpening of the saw blade for the same reason.

The performance of band sawmills varies from model to model and the level of their technological capabilities, such as the use of double-sided sharpening and the presence of two bands, but in general is at a stable solid average level, all other things being equal.

2.4 Circular sawmills

And the last type of sawmill under consideration by the type of working bodies, but by no means in terms of efficiency and quality of the products obtained, is a sawmill. Sawing on this type of sawmill is carried out using rotating saw blades. Just like the previous type of equipment, it got its name from the type of working body used.

By analogy with band sawmills, the processed material on sawmills does not move either, but is fixed on a frame, along which a carriage with a saw unit moves along the guides. It is possible to perform with an idle stroke, when the carriage returns to its original position without cutting, and when sawing is carried out during movement in both directions, which, of course, has a positive effect on productivity.

Just like with band sawmills, sawing can be carried out in two different planes, depending on the type of installation, according to the way the working body is located: either horizontally or vertically. However, there are other variations besides this.

The sawing process with a sawmill is shown in Figure 4.

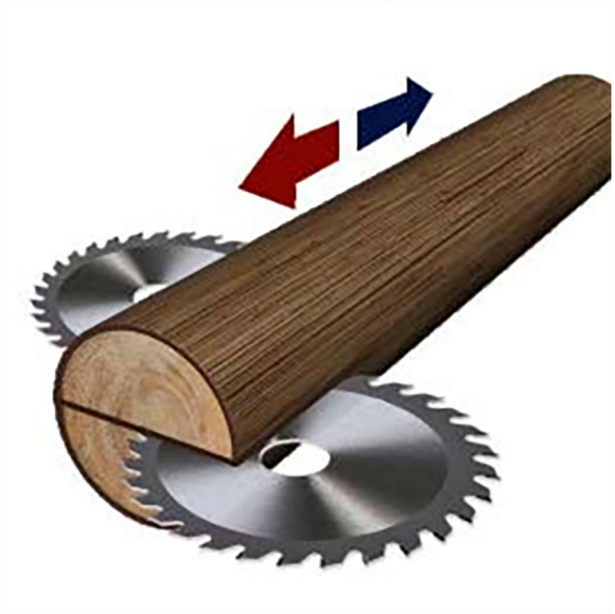

Fig. 4. The process of sawing with a sawmill.

To increase the degree of automation of the sawing process, it is also possible to use a tilter to turn the workpiece to the required degree without the use of manual labor.

For processing small-sized workpieces, sawmills with one saw blade are used, and for sawing large diameters of processed wood, sawmills with two discs are used, which are in the same plane, which allows to increase the width of the grip.

There is a variety of circular sawmills in operation with an installed edge cutter, which reduces the required number of passes to obtain, for example, timber and edged boards, allowing you to process three sides of the workpiece at once without the need for tilting.

We should also highlight the so-called corner sawmill, which is the most technologically advanced in its class. In this case, sawing is carried out by two saw blades located at right angles to each other immediately in two planes - vertical and horizontal, respectively. One of the discs is somewhat ahead of its companion in the horizontal plane.

The sawing process with an angle sawmill is shown in Figure 5.

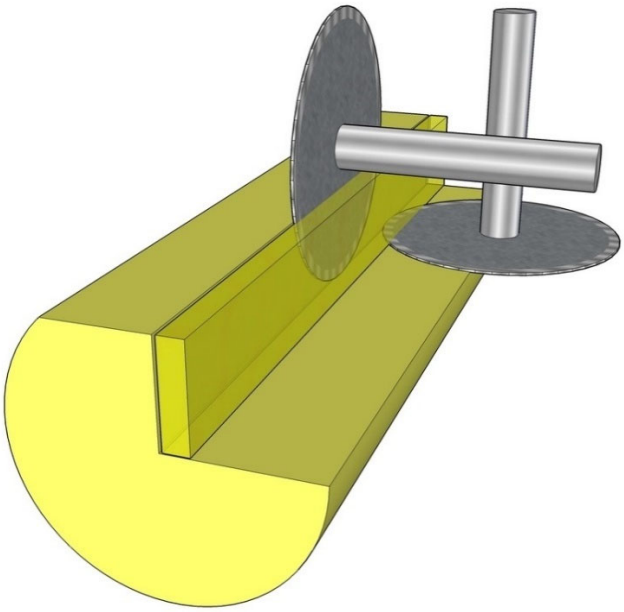

Fig. 5. The process of sawing with an angle sawmill.

This method also makes it possible to reduce the required number of passes for sawing out certain products and to eliminate the need for tilting the workpiece.

There is also a single-disk sawing scheme through the "corner". In this case, when the carriage moves in one direction, the workpiece is sawn with a saw blade in a horizontal plane, and when moving in the opposite direction, the carriage with the saw blade turns over by 90º and sawing is already carried out in a vertical plane.

The advantages of circular sawmills are their high productivity, reliability, accuracy of material manufacturing, low waviness, no need even for every shift sharpening of the working body due to its strength [7].

But for these positive aspects, you have to pay with a large cutting width, some complexity with the installation and sharpening of saw blades, and the total cost of the sawmill, which reduces the possibility of its widespread and universal use.

3 Results

For ease of perception, we summarize the main characterizing relative indicators of the considered sawmills by the type of working body, including the possibility of obtaining slabs into a single whole in Table 1.

Table 1. Sawmill indicators.

				Kerf size	Performance	Waviness degree	Bidirectional sawing	The frequency of sharpening the working body	The presence of surfacing	Slab	Versatility
Tape	Horizontal	Narrow saw		N	H	VH	-	H	+	+	-
		Wide saw		N	H	H	+	H	+	+	-
	Vertical	Narrow saw		N	H	VH	-	H	+	+	-
		Wide saw	Single tape	N	H	H	+	H	+	+	-
			double tape	N	H	H	+	H	+	+	-
Circular	Horizontal			W	A	L	+	L	+	+	-
	Vertical			W	A	L	+	L	+	+	-
	Corner			W	A	L	+	L	+	-	H
	Swivel			W	A	L	+	L	+	-	H
	with edge cutter			W	A	L	+	L	+	+	A
Frame	Vertical			A	H	H	-	A	-	+	-
Tire	Horizontal			W	L	A	+	H	-	+	-

N – narrow, W – wide, VH – very high, H – high, L – low, A – average.

4 Conclusion

Thus, it can be concluded that the choice between a disk or band sawmill for use in a timber terminal is determined by the requirements for the quality and quantity of lumber produced and the general economic feasibility.

The use of frame sawmills in the conditions of timber terminals is not possible due to their special requirements, mainly for installation.

The use of tire sawmills does not meet the requirements of industrial production.

It should be noted that one of the issues in the operation of timber terminals is their energy independence, since they are located far from developed infrastructure, the equipment used for sawing timber has a high energy intensity [8] and requires energy supply in one form or another [9]. Wood chips [10], obtained during the operation of the timber terminal, can be used as an energy carrier. This aspect requires further study.

References

1. A. A. Tambi, V. V. Shvets, V. S. Sazhin, LesPromInform **8**, 100-103 (2017)

2. I. R. Shegelman, K. V. Polezhaev, A. S. Vasiliev, Global Scientific Potential **9(18)**, 031-033 (2012)
3. O. A. Kunitskaya, Vestnik AGATU **6(2)**, 70-79 (2022)
4. D. A. Kolpashnikova, *Analysis of the work of sawmills*, in Modern problems of mechanical engineering: a collection of scientific papers of the XII International Scientific and Technical Conference, October 28 - November 1, 2019, TPU publishing house, Tomsk, Russia, 47-48 (2019)
5. I. V. Gnatovskaya, Forest Bulletin **5**, 81-86 (2003)
6. O. G. Tarasova, E. M. Tsvetkova, A. V. Krenev, Bulletin of PSTU **4(16)**, 97-108 (2020)
7. Daniel T. Oloruntoba, Patricia Popoola, Engineering Failure Analysis **82**, 835-839 (2017)
8. C. Schmidt, H. -H. Westermann, B. Thorenz, R. Steinhilper, Procedia Manufacturing **25**, 263-270 (2018)
9. O. A. Kunitskaya, A. V. Pomiguev, Bulletin of AGATU **3**, 82-99 (2021)
10. H. J. Pegoretti, L. de Souza, F. Muñoz et al., Renewable Energy **163**, 1802-1816 (2021)