

FEATURES AND PROBLEMS IN CUTTING THIN LOGS

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ABSTRACT

This study examines some of the most common problems associated with cutting thin logs. Information is summarized from various authors regarding some of the characteristic features and difficulties that arise when cutting this type of timber. Several approaches to processing thin logs with different types of primary woodworking machines are presented. The dimensional and qualitative characteristics of this timber are directly related to both the quantitative and assortment gains, as well as to the deficiencies and defects in the final product. The application of technologies for further processing the obtained bonded materials in the production of engineered wood products (EWP) is associated with high labor costs as well as low quantitative and qualitative yields. Nevertheless, research in this area needs to continue due to the increasingly intensive decrease in the diameter of trees, and consequently a decrease in the average and large construction wood.

Key words: disadvantages, defects, solid wood materials, EWP.

INTRODUCTION

On a global scale, there is a continuous increase in the demand for timber, resulting in measures being taken in several main directions to overcome the shortage of timber resources, including: searching for new raw material sources, reducing wood waste during processing, and, last but not least, more rational utilization of waste in obtaining high value-added products (Koynov and Valyova 2022; Koynov *et al.* 2023). One of the directions of each wood processing enterprise is the maximum quantitative and valuable utilization of round timber and closing the cycle in processing wood waste. This direction is considered particularly relevant due to the fact that the increasing wood consumption is related to the processing of large quantities of round timber (FAO 2022). Studies have shown that the average diameter of processed wood has significantly decreased over the past few decades, and this trend continues after future predictions (Nilsson 1991; Kostov 1993; Nabuurs and Paivienen 2001; Kostov and Rafailova 2009; Koynov 2018). At the moment, there are no exact definitions of dimensional characteristics for thin round wood in the processing enterprises. According to the current standards in Bulgaria (BDS EN 765: 1988; BDS EN 766: 1988 and BDS EN 767: 1989), round wood intended for cutting has a minimum diameter at the thin end of 14 cm. Round materials with minimum average diameter without bark of 10 cm are classified into 10 classes based on this size in accordance with BDS EN 1315: 2010. An information provided by wood processing companies in Bulgaria shows that thin logs are considered as round timber with a diameter at the thin end less than 30 cm. This raw material is not particularly preferred according to primary timber processing companies. The reasons why wood processing companies avoid thin logs are due to the pronounced characteristic defects in them, as well as some peculiarities and problems that arise during their cutting. Another reason for their lack of preference is the lack of specialized cutting (sawing) lines for thin logs, low quantitative and qualitative yields, and, last but not least, production with multiple defects

and flaws. Thin round wood in our industry is mainly used as raw material for the production of composite panel materials and in the ligno-cellulosic industry. But as mentioned above, on one hand, the intense pace at which the diameter of trees decreases and on the other hand, the increasing demand for wood, will inevitably lead to more frequent processing of this raw material. In the future, processing thin round wood in the production of solid wood materials will become more and more relevant.

CUTTING OF THIN LOGS

The production of solid wood materials mainly depends on market demands, the quality of the raw material, and the cutting method. The decreasing diameters of raw material resources require opportunities for more rational utilization of these logs (Koynov 2018; Koynov and Valyova 2022). The final quantities obtained are directly related to the dimensional and quality characteristics of the logs, the cutting methods and schemes, as well as market demands. The approach to cutting the raw material is of particular importance, especially for small diameter logs. Processing them with a more suitable, rational, and optimal method will contribute to improving economic results (Koynov *et al.* 2021; Koynov and Valyova 2022; Koynov *et al.* 2023;). Thin logs are not particularly preferred by buyers due to the pronounced disadvantages in the shape, size, and structure of the wood. As a result, the manufactured product is characterized by a relatively low final value. The analysis of the obtained quantitative and qualitative results presents the relationship between the cutting method, the width and length of the details. The information obtained provides a significant insight into the effective processing of wood, as well as a more objective assessment of the technology used in the production of solid wood materials obtained from thin logs (Koynov 2018; Koynov 2019). To achieve high quantities and optimize the cutting methods for thin logs, a significant number of authors have focused their research in this area (Hamner *et al.* 2002; Levinsky and Levinskaya 2002; Heräjärvi 2004; Hernandez *et al.* 2005; Hamner *et al.* 2006; Levinskaya 2012; Rongrong *et al.* 2015). Different approaches and methods for cutting thin logs have been examined, with some of the most commonly used primary woodworking machines in the industry. The results obtained from their research can be summarized and presented depending on the considered log diameter and cutting technology.

Cutting of thin logs with gang saws

Even when cutting thin logs on modern high-speed gang saws, where the feeding can reach up to 40 mm per a revolution, the productivity of the machines is relatively low (Levinsky and Levinskaya 2002; Tambi 2010; Levinskaya 2012). The weak link in the technological process is the pre-sawing mechanization – loading, centering, feeding for cutting, etc. It should also be noted that the low cutting speeds and the limited number of teeth involved in the cutting process compared to other woodworking machines are prerequisites for the presence of surfaces with a lower roughness class, and hence a deteriorated quality of the finished product (Vetsheva *et al.* 1982; Hamner *et al.* 2002; Hamner *et al.* 2006). The schemes presented in Fig. 1 are for cutting thin logs with the resulting solid wood materials being further processed to achieve maximum quantitative yield. Processing this raw material is recommended to be done with gang saws.

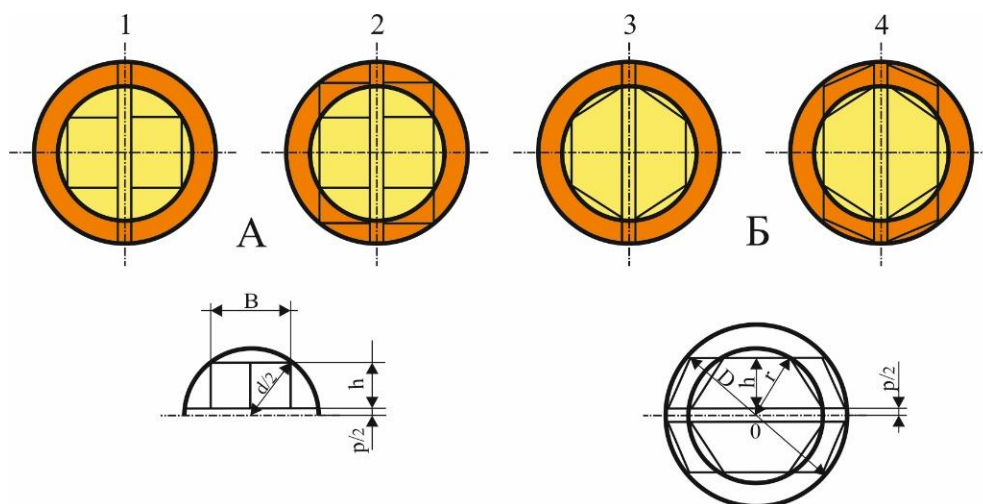


Figure 1: Schemes for cutting thin logs with gang saws (Levinsky and Levinskaya 2002)

Levinsky and Levinskaya (2002) examined several cutting schemes (Figure 1) for thin logs with a diameter from 8 to 18 cm. Sharp sawing was applied in all schemes, aiming to obtain two prisms with a section maximally inscribed in half of the log. In the first variant (position A), the resulting prisms are grooved with rectangular cross-sections. The difference is that in position A – 1, the prisms are grooved along the axis with a constant rectangular cross-section, while in position A – 2, they are grooved along the diagonal, but with a variable rectangular cross-section. In the second variant B, the authors considered the grooving of prisms with a trapezoidal cross-section in order to obtain maximum quantitative yield. In position B – 3 (Figure 2), the materials are grooved along the axis, and in B – 4 along the diagonal, but again with a variable trapezoidal cross-section. Levinsky and Levinskaya (2002) demonstrated that the resulting solid wood materials have very small cross-section dimensions, especially for logs with a diameter at the thin end from 8 to 12 cm. The quantitative yields for these logs are hard to exceed 50 – 60%, even when the prisms have trapezoidal cross-sections. The quantitative yields increase with increasing log diameter and when the prisms are grooved with a trapezoidal cross-section along the diagonal ($d = 14 - 18$ cm, $R = 61 - 78\%$). The authors also proposed a sectoral cutting method, presenting results of quantitative yields. The results show limited use of the obtained materials due to their small sections, despite the calculations made.

Cutting of thin logs with circular saws

In the woodworking industry in countries such as the USA, Norway, Sweden, etc., it has been established that the accuracy and quality of the finished product largely depend on the qualifications of the workers. This is particularly evident in cutting small diameter logs (Sobolev 1960; Stanford 1993; Gerge *et al.* 2020; Forghani *et al.* 2024). Several technological schemes and sequences for cutting thin logs with a single-blade circular saw are shown in Fig. 2.

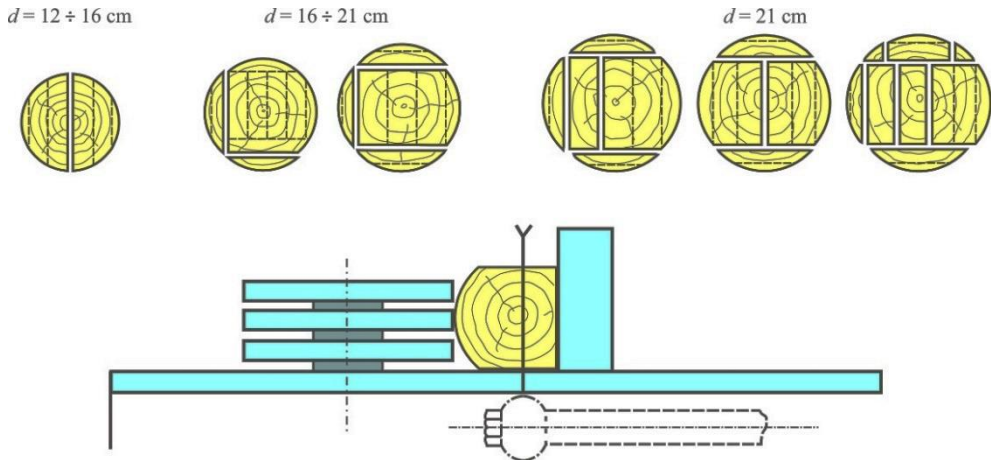


Figure 2: Schemes for cutting thin logs with a single-blade circular saw (Sobolev 1960)

The methods examined for cutting thin logs show limited use of the obtained materials. The authors concluded that the resulting solid wood materials (beams and boards) have very small cross-section dimensions and are irregular in shape due to inaccurate centering. These results are particularly evident in logs with diameters from 12 to 16 cm. The presented schemes (Figure 2) clearly show that the thinnest logs are initially split into two halves, and then each of them is further cut into boards of a specific thickness. For logs with diameters from 16 to 21 cm, two caps are initially separated to form a prism with double walls, which is then cut into boards with specific thickness. One more board is separated from the covers if possible, but with minimum dimensions.

According to the presented information, in all cutting schemes with single-blade circular saws, splitting thin logs is associated with large labor costs, a large number of operations, and a significant amount of waste in the form of caps, trimmings, and sawdust.

Cutting of thin logs with milling-prism aggregates

This type of technology is mainly applied in countries with significant forest resources such as Canada, Finland, etc. These lines can process logs up to 6.2 m in length with a feed rate of 180 m.min⁻¹. The productivity of these machines is very high and is mainly used for splitting logs with diameters from 18 to 21 cm (Campbell 2013). The cutting sequence for thin logs with diameters in the thin range of 21 cm, with milling-prism aggregates, is shown in Figure 3.

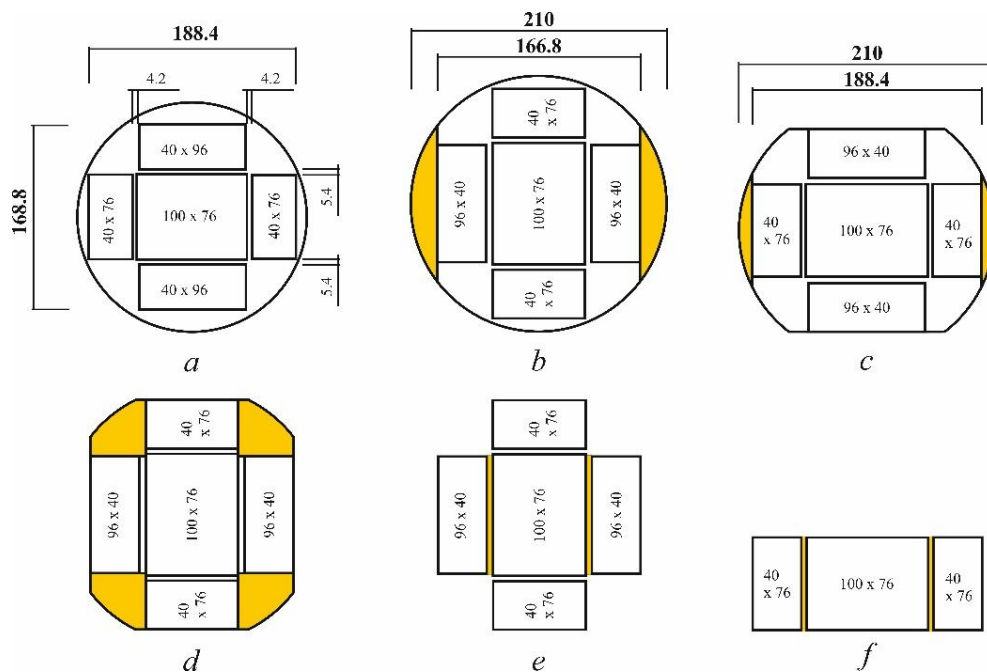


Figure 3: Cutting sequence with milling-prism machines (Campbell 2013)

Initially, the layout for cutting is set (Figure 3 – a). In order to obtain solid wood materials with the desired dimensions, as a first step the surrounding surface of the logs is cut with the help of milling heads (Figure 3 – b). The resulting prism is rotated by 90° and passes through a second pair of milling heads (Figure 2 – c). This is followed by another 90° rotation and removal of the remaining rounded part of the log, using a third pair of milling heads (Figure 3 – d). In this way, a regular polygonal figure is formed Figure 3 – e), from which two prisms with cross-sectional dimensions of 40 x 96 mm are separated by means of aggregates of two-saw circular machines with a saw thickness of 5.4 mm (Figure 3 – e). The resulting prism is again rotated 90° and further cut on a second pair of two-saw circular machines with a saw thickness of 4.2 mm, obtaining a total of three prisms, two of which measure 40 x 76 mm and one – 76 x 100 mm (Figure 3 – f).

It can be seen that the round wood passes through multiple operations to obtain solid wood materials with desired final cross-sectional dimensions. Calculations for quantitative use of round wood show that quantitative yields can hardly exceed 51-54% with this cutting method. A significant amount of raw material is lost in the form of technological chips and shavings, and the resulting materials have limited cross-sectional dimensions. Last but not least, the logs must be sorted very precisely to ensure the intended specification of the solid wood materials.

Cutting of thin logs with band saws

Cutting thin logs with a band saw with wagon feed is rarely used due to low productivity, resulting from the reciprocating movements of the carriage at each subsequent cut. The productivity is similar to that of single-blade circular saw machines. For cutting thin logs, it is recommended to use two to three or more pairs of vertical and horizontal band saws (paired or quadruple) with small diameter band wheels. Some of the most common methods and schemes for cutting thin logs are shown in Figure 4.

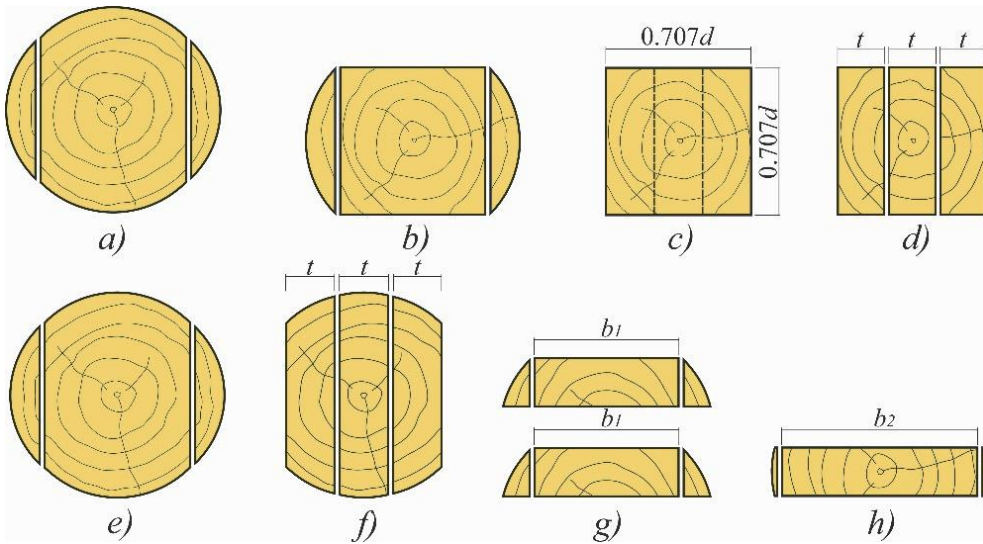


Figure 4: Cutting sequence with paired band saws

The feeding of the round materials in this type of machine is mainly chain-based, which significantly increases the productivity (Wood-Mizer Industries 2013). Similar cutting schemes apply to those with gang saws and double-blade circular saw machines. Two main schemes for cutting thin logs are shown in Figure 4. In one case, only beams are produced if the log diameter is above 14 cm (Figure 4 – c), ensuring that the solid wood materials will have cross-sectional dimensions of 100 x 100 mm. If the logs are smaller than the specified diameter, the prisms or thick caps are further cut into boards (Figure 4 – d) to obtain smaller assortments sought by consumers. For the second option (Figure 4 – f), after the first pair of paired band saws, a second pair of paired band saws is placed, where the prism is directly cut into boards. The resulting solid wood materials then undergo a subsequent technological operation – grooving (Figure 4 – g) or cutting to precise widths (Figure 4 – h). Narrowband technology is used to reduce production costs that are not directly related to the breaking process. This technology does not require the construction of expensive concrete foundations. In current dynamic market conditions, the ability to react quickly depending on market demand and supply is necessary. Lines of this type are designed to be flexible, modular, and mobile at the same time. When cutting thin logs, the quantitative yield is very low, but thin bands are used to obtain at least one more board or strip from each log, thus reducing raw material consumption.

APPLICATION OF MATERIALS OBTAINED FROM THIN WOOD

As mentioned, the processing of thin logs is associated with a number of technological operations that reduce both the quantitative yields and the productivity of the main wood-cutting machines. There are also large losses of wood in the form of caps, clippings and shavings. It should be noted that the processing of this raw material is associated with both a significant limitation of the assortment structure of the enterprise and low-quality yields.

After cutting the thin logs, a large proportion of the resulting solid wood materials have smaller than standard cross-sectional dimensions. All this is directly dependent on the size and quality characteristics of this raw material. It is necessary to note that there is a large presence of

juvenile wood in this thin round wood (Barbour 1999; Ayarkwa and Addae-Mensah 1999; Barbour *et al.* 2003; Hernandez *et al.* 2005; Blaskova 2005, 2009), which significantly lowers the physical and mechanical indicators of the production. It has also been established (Srpčič *et al.* 2000; Koynov 2019) that after drying the obtained solid wood materials, numerous defects appear in them, including buckling, twisting, cracking and warping of materials. As a result of all of the above, the application of the final product is currently very limited. This necessitates looking for opportunities for more rational utilization of these solid wood materials, in obtaining products with a higher value added.

Many authors have focused their research (Loginova 1999; Levinsky and Levinskaya 2002; Starkova 2004; Hernandez *et al.* 2005; Campbell 2013; Stängle 2016; Rongrong *et al.* 2015; Koynov *et al.* 2021; Koynov and Valyova 2022; Koynov *et al.* 2023) in this direction, namely towards the complete and optimal utilization of this raw material in glued wood products (EWP). Not a small number of sawmills for the primary processing of round wood are looking for opportunities to implement technologies for finger jointing and glued solid wood with smaller dimensions, in the production of panel materials or the processing of waste (Barbour *et al.* 2003; Hernandez *et al.* 2005; Lyhykainen *et al.* 2009). A large part of small-diameter logs in some European countries is used for furniture production, assembled beams and table tops, as well as for making wooden houses from logs and assembled beams, yard fences, decks, pergolas, sheds, and more (Heräjärvi 2004; Campbell 2013). However, a large part of this woody material is for construction and packaging purposes, due to its specific characteristics regarding the quality of the wood.

Thin round wood, which is obtained from the top parts of tree stems, has a number of disadvantages such as: the presence of a large number of knots, a higher relative share of juvenile wood, lower physical and mechanical indicators (Koynov 2018). This raw material is mainly used for general purpose materials and a limited assortment of structures – beams, sleepers, thin boards for panelling, packaging, etc. due to its characteristics.

CONCLUSION

Based on the above, the following important conclusions and recommendations can be made:

The cutting of the thin logs is associated with high labor intensity and a precise sorting by dimensional and quality characteristics, the construction of specialized lines to ensure productivity, dimensions, and quality of the final product, and a large number of operations involved in the processing of this raw material.

The use of lines with milling-sawing aggregates, gang saws, gatekeepers and two-shaft circular machines is appropriate only when this raw material is in significantly large quantities, due to their high productivity.

The presence of numerous defects and imperfections in thin logs significantly limits the manufacturing of products with desired dimensional and quality characteristics.

Research shows that a significant amount of wood is wasted in the form of the caps, offcuts and shavings.

Due to the listed characteristics and the low economic indicators associated with its processing, this raw material is often avoided by woodworking enterprises.

Since the cross-sectional dimensions of solid wood materials are directly dependent on the diameter of the logs, it is recommended that the obtained materials be combined to manufacture products made of glued solid wood (EWP). In this way, a rational utilization of this thin round wood is guaranteed in products with a higher added value. However, this approach is not always feasible, as it largely depends on the production program of the enterprise.

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