QUANTITATIVE YIELDSFROM THE CUTTING OF THE STEMS OF WHITE PINE (*PINUS SYLVESTRIS* L.), DEPENDING ON THE THICKNESS AND LENGTH OF THE DETAILS AND THEDEFCTS OF THE WOOD

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ABSTRACT

In the current work are presented the results from an experimental procedure for the establishment of quantitative yields and their variation depending on the thickness and length of details, the defects of the wood and the location of the logs in the stems of Scots pine (*Pinus sylvestris* L.). The experimental procedure was performed according to standardized methodology with selected model stems. It has been established the presence, size and number of defects of treated wood by using EN 1927-2 standard. In the normal technological sequence the stems were cut of sections with lengths 1, 2 and 4 m, and from the obtained sections (logs for sawing) according to acute sawing method the boards were cut of details with a thickness of 3, 6 and 9 cm. The obtained results allow drawing analysis and conclusions in relation to quantitative yields and their change depending on the thickness and length of the details. On the basis of these results an analysis can be drawn in relation to the impact of disadvantages of the wood and the importance of the place for harvesting of the logs from the tree stems. The resulting information allows more accurate and objective assessment of the technology and the machines in terms of more efficient wood processing and manufacturing of materials from solid wood.

Key words: Scots pine (*Pinus sylvestris* L.), stems, size-qualitative characteristics, materials from solid wood.

INTRODUCTION

Continued growth of the demand for wood as well as the expansion of its consumption and processing leads to an increased logging in the forests. In parallel, there is a serious contradiction between the growing demand for timber and the need, not only to maintain, but also to expand the forest area. Taking measures that will lead to a reduction in the consumption of forest wood is practically impossible. Logging will continue to rise because the demand will increase. All this requires us to focus our scientific and practical work towards the search for more rational utilization of the wood (Dimitrov 2001).

Globally, there is a continuous increase in the need for different types of wood for the production of lumber. In the future ever more will appear the need for the utilization of thin round wood for the production of lumber with the needed dimensions and quality requirements to meet the market demand.

Both in construction and in the furniture industry in the country is used quite a lot of wood from Scots pine (*Pinus sylvestris* L.), which has great economic significance.

Because of their environmental and societal significance, the woods of Scots pine are subject to various scientific researches. Scots pine forests constitute about 31 % of the total forested area of Europe (Zafirov 2008).

Scots pine has been one of the main tree species used in the creation of forest plantations in the last century. As a result, today the forests of Scots pine form 16 % of the forested area of the country and over 50 % of the territory occupied by coniferous forests (Rafailov 2001).

Some of the main defects of the wood are the presence of knots and rottenness that significantly affect the wood quality. The mechanical properties of wood are especially lowered by decaying and loose knots.

The results of the study of the location and number of knots on the trunks of Scots pine are represented in our other studies (Trichkov N., D. Koinov 2015), but they do not give a complete picture of the internal flaws of the wood. It is important to note that at the top sections of stems are noticed a large number of knots, large degree of tape ring and very small diameter at the thin end of the logs (8–10 cm).

According to BS 767:1989 for the production of lumber for the construction and furniture industries are used round wood assortments of coniferous trees with a diameter of over 14 cm. In most cases, undersized diameter logs are not preferred by consumers due to the fact that their utilization is not sufficiently rational and profitable due to the presence in them of large number of defects in the form of knots, a large percentage of juvenile wood, large degree of tapering and others.

Production companies do not prefer thin logs due to the flaws in the shape of the stem. The quantitative yield of thin diameter logs is much smaller compared to that of the logs with a larger diameter. During the production of lumber from coniferous wood, the percentage of waste in the form of clippings, sawdust, and shrinkage is considerable. Only about 70–80 % of the wood reaching the workshops will end as a finished product (Heräjärvi 2004).

Processing of thin logs smaller than 14 cm, even for lumber with thickness of 10 mm, do not meet the standards for minimum width of 100 mm. This in turn leads to very low market price of the processed assortments and materials. Also the cutting of undersized logs is associated with greater labor intensity and precision, leading to lower profits for producers.

In the future the construction industry will need to create more uniform and cost-competitive wood products with structure that provides more durability and reliability. This can be avoided by removing the faulty wood and trough the restoration of its homogeneous structure.

In this work are presented the results of experimental work on establishing a quantitative yield and its variation depending on the thickness and length of the details, the shortcomings of wood and placement of logs in the trunks of pine (*Pinus sylvestris* L.). The results warrant the making of analyzes and conclusions on quantitative yields and their change depending on the thickness and length of the detail, on the impact of the disadvantages of wood and the importance of the place of extraction of logs from tree trunks. The information obtained allows more accurately and objectively to evaluate the technology and machinery for the more efficient processing of wood and production of wood materials.

METHODOLOGY

The experimental work was performed with model stems selected by standardized methodology. The presence, size, number and shape of defects of the wood are established as described in BS EN 1927-2. In the normal production sequence stems are cut into sections with lengths 1, 2 and 4 m.

From the resulting sections (logs for sawing) using the method of acute sawing boards with thickness of 25 mm were obtained, which are subsequently cut into parts with widths 3, 6 and 9 cm.

While preserving the natural location of the boards in the logs and stems, the size and location of the defects in the central and lateral longitudinal sections are defined. With the help of measuring tools for each board are established its size characteristics, then the boards were photographed from a certain distance using a digital camera.

The photographs of the boards are processed by two-coordinate software (Photoshop and CorelDraw). Scheme of the method is shown in Fig.1.

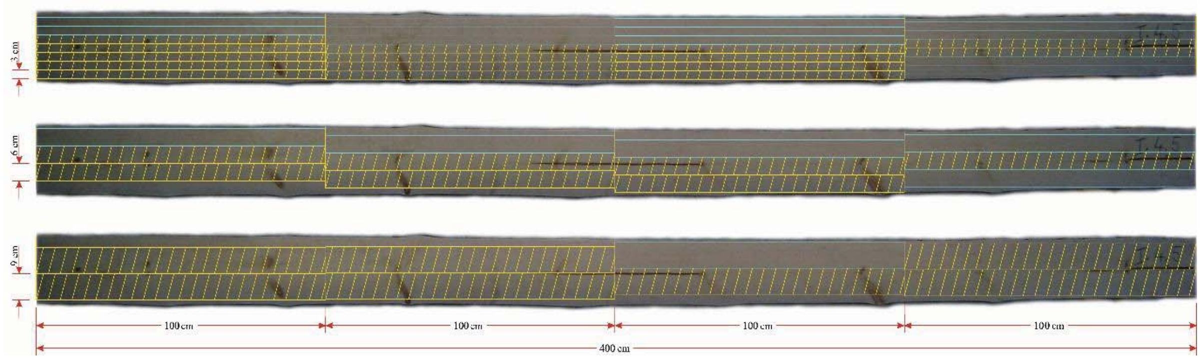


Figure 1: Scheme of the method for determining the wood without flaws

For this purpose, the obtained longitudinal sections are depicted graphically in a way that reflects the natural order of the operations in the technological process. As "unfit" is treated the wood with unacceptable by the standards drawbacks. On figure 2 is shown a graphic model for cutting boards from logs of Scots pine as prisms of different lengths taking into consideration the impact of the defects of the wood on the quantitative yields.

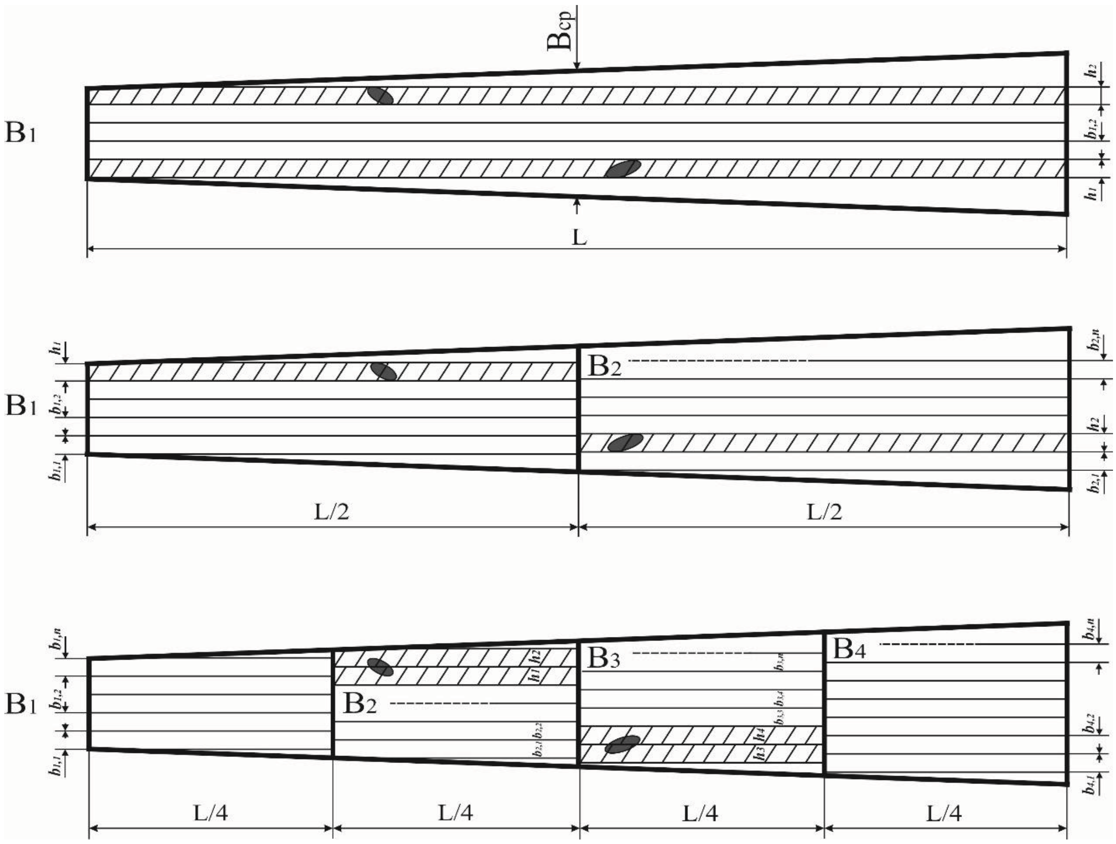


Figure 2: Graphic model of the method for establishing the influence of the defects of the wood on quantitative yields

The aim of this study is to explore the possibilities for utilization of small diameter logs of white pine for the production of glued wood products.

In the absence of flaws, clean processing volume of wood is

$$V = v_1 + v_2 + v_3 + \ldots + v_n = (b_1 + b_2 + b_3 + \ldots + b_n).l.\delta,\ m^3, \qquad (1)$$

where v_i are the volumes of prisms obtained from the non ridged board, m^3;

b_i – widths of the prisms at the narrow end, m;

l – length of the prisms, m;

δ_i – thickness of the prisms, m.

In case of existing inadmissible flaws the usable volume for wood processing will decrease. As seen on figure 2, for constant length and thickness of the prism, the volume of the edible timber is dependent on the width of the prism and can be determined by the formula:

$$V_1 = \sum v_i = (b_1 + b_2 + b_3 + \ldots + b_n - h_1 - h_2 - h_3 - \ldots - h_n).l.\delta,\ m^3, \qquad (2)$$

where h_i are the dimensions of defects measured the width of the prisms, m.

Reducing the volume of the production grade wood for wooden details is expressed through quantitative yield R as calculated by the formula:

$$R = \frac{V_1}{V} = \frac{\sum b_i - \sum h_i}{q}.100,\ \% \qquad (3)$$

where: q is the volume of the trunk, m^3.

RESULTS AND DISCUSSION

The summarized results of the quantitative values for the extraction of wood without flaws R in dependence of the location of the planks in cross-section of the logs and the length of the prisms are shown in Tables 1, 2 and 3.

Table 1: Cutting of the boards of the trunk portions of the stem (up to the 4-th meter in height, $width_{mid}$ = 32 cm), with the widths of the parts 30, 60 and 90 mm

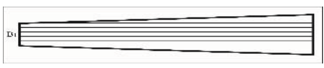
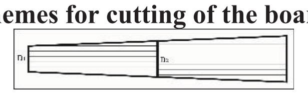
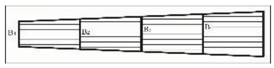
Detail width, [mm]	Schemes for cutting of the boards								
									
	Number of details	Number of clean details	R, clean details, [%]	Number of details	Number of clean details	R, clean details, [%]	Number of details	Number of clean details	R, clean details, [%]
30	55	17	17.05	110	56	26.39	227	152	35.81
60	27	5	9.47	53	20	18.85	106	52	25.92
90	17	1	2.84	35	10	14.14	72	29	20.50

Table 2: Cutting of the boards of the middle part of the stem (between the 8-thand the 12-th meter in height $width_{mid}$ = 25 cm), with the widths of the parts 30, 60 and 90 mm

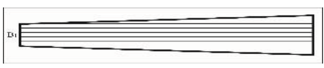
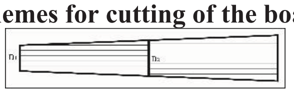
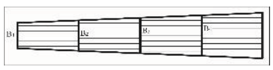
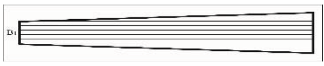
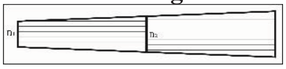
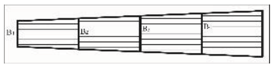
Detail width, [mm]	Schemes for cutting of the boards								
									
	Number of details	Number of clean details	R, clean details, [%]	Number of details	Number of clean details	R, clean details, [%]	Number of details	Number of clean details	R, clean details, [%]
30	40	1	1.50	82	14	10.59	168	67	25.35
60	19	0	-	38	3	4.54	78	17	12.86
90	12	0	-	24	0	-	48	5	5.68

Table 3: Cutting of the boards from the tip parts of the stem (from the 20-th to 24-th meter in height width$_{mid}$ = 13 cm), with the widths of the parts 30, 60 and 90 mm

Detail width, [mm]	Schemes for cutting of the boards								
									
	Number of details	Number of clean details	R, clean details, [%]	Number of details	Number of clean details	R, clean details, [%]	Number of details	Number of clean details	R, clean details, [%]
30	7	0	-	18	1	2.75	39	7	9.62
60	2	0	-	8	0	-	17	2	5.50
90	2	0	-	6	0	-	9	0	-

From the results presented in table 1 becomes clear that the quantitative yield of the timber without the drawbacks in the ground sections of the stem (up to the 4-th meter in height) has the highest values R = 2, 84–35, 81 %), compared to the sections of the middle and top parts of the stem. This in turn is due to the fact that in this part of the stem knots are least in comparison with other parts of the stem. It is also due to the fact that the width of the non ridged boards obtained after cutting the logs is large, which is a prerequisite for receiving a large number of parts.

Details that are free of knots even in length up to l = 4 m and width up to b = 90 mm can be produced, where the quantitative yield in this case reaches R = 2, 84 %. By reducing the length and the width of the details, the quantitative yield of wood without defects increases as the highest yield is for details with length l = 1m and width b = 30 mm, where R = 35, 81 %. Or slightly more than one third of the volume of the trunk is from the wood without flaws.

By increasing the height of the stem from the 8-th to the 12-th meter the diameter of the log decreases, as well as the width of the boards obtained by cutting them. In table 2 is shown that for the length of the parts l = 4 m in widths – b= 60 and 90 mm, lumber without defects cannot be obtained. By reducing the length, the quantitative yield increases, as again the highest quantitative yield is for length of the details l = 1 m and width b = 30 mm, R = 25, 35 %.

Smallest quantitative yield for defects free wood is obtained at the peak sections of the stem (from 20 to 24 meters in height). The diameter of the logs is very small (d = 8 to 10 cm) and should also be noted that the degree of tapering in these trunks is very high. Also the boards derived from these round assortments are few (3 pcs.) and with many shortcomings (curvatures, knots, there is a large percentage of juvenile wood). Details of a width b = 90 mm and length l = 4 m cannot be obtained. The number of knots is very large, and hence the production of wood without flaws is extremely limited. However, by reducing the width and length of the lumber it is possible to obtain parts free from defects. At length l = 1 m and width b = 30 mm, the quantitative yield reaches R = 9, 62 %. Even for a width of the parts b = 60 mm is possible to obtain a timber without flaws (R = 5, 5 %).

From the results it should be noted that by increasing the height of the stem, the quantitative yield of defects free timber decreases by up to 30 % with the least quantitative yield received in top parts of the trees.

CONCLUSION

The trunk cutting operations are the most important because the quantitative yield depends on them, as well as maximizing the quality areas of the trunk, the dimensions of the lumber and the economic use of raw materials. The studies on the impact of the defects of the wood and the shape the logs of Scots pine, warrant the following recommendations:

1. The quantitative yields of timber without flaws using traditional methods of cutting are very low. The application of these traditional methods, especially at thetop sections of the trunk (18–24 m) is associated with high labor intensity and high wood waste. As a consequence of which their utilization is thus uneconomical. It is therefore necessary to apply specialized technologies for cutting these logs because they are flawed and utilization of quality wood is not rational.
2. The presence of more defects leads to a decrease in the amount of quality wood, especially in the logs with up to 18 cm of diameter (harvested from 18–24 m), as their primary purpose is for use in packaging, for fragmentation into wood particles, chips, etc. In the future, this question will be not so much scientific as it will be of practical manner.
3. Reducing the length and width of the parts leads to an increase in the quantitative yield of the timber without defects. Even from the sections derived from the 20-th to 24-th meter along the height of the stem, where the diameter of the logs in the thin end is very small (d = 8–10 cm) it is possible to produce parts with width b = 60 mm and length l = 1 m. In this case the boards are 2 in number and the quantitative yield is R = 5, 50 %. By reducing the width to b = 30 mm, where the length stays the same l = 1 m, 7 defects free details can be produced and the quantitative yield in this case reaches R = 9, 62 % of the volume of the body.
4. It is recommended that the non ridged boards are cut out to parts in the shape of prisms and details with smaller length and width in order to obtain higher yields of quantitative timber without defects.

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CONTENTS