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Effect of sawn zone on the quality of lumber in the evaluation of selected pine wood defects

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Abstract: *Effect of sawn zone on the quality of lumber in the evaluation of selected pine wood defects***.**
In the course of research on the sawn pine raw material with defined distribution of the defects, a variable level of change in the presence of knots was assessed. Initially, the experimental material was classified in terms of the general-purpose timber, and then the strength classes of wood for structural applications were assigned. The proportion of sound knots increased in case of wood obtained from the middle and top zones. In the case of butt-end logs, an increase in the share of the rotten knots having an average diameter of 2-4 cm was observed. The intensity of the defect's occurrence corresponded with the zone of origin along the large-sized roundwood length.

Keywords: scots pine, sawn timber, classification, knots

INTRODUCTION

The State Forests National Forest Holding remain the main supplier of wood for sawmills in Poland. Wood processing is the result of activities related to the harvest and transport of raw material from the forest areas to the customer's company. The reception and the adjustment of the form of material are included as an element of a technological process which can affect the rational use of raw material. The form of the wood delivered to the purchaser usually follows the dimensional requirements of sawing program. The basic forest-forming species in Poland is Scots pine (*Pinus sylvestris* L.) which usually forms the solid stands (Brzeziecki 2002; Sławski 2007) located mainly in the northern and north-eastern part of Europe. The representatives of this species usually reach a height of 30-40 m. In the early years, the arrangement of branches forming the tree's crown resemble a cone, however, as the time goes on it starts to take on an umbrella-like form (Valinger 1992; Dominguez et al. 2006).

Knots are the remains of dead branches which negatively affect the quality of wood causing a decrease in mechanical strength. The quality of the Scots pine wood is usually determined by the occurrence of knots. Depending on the location, the knots can be characterized by a different degree of soundness, various shapes such as round or oval and the much darker color than the surrounding wood tissue. In case of Scots pine the diameter of knots increases from the butt-end zone to the top of the trunk. The remaining defects, including secondary defects (e.g. blue stain), influence the obtained timber quality to a lesser extent. According to the PN-EN 13556 (2005) this species has a code designation abbreviated as PNSY. It is the main source of raw material in North-Eastern Europe (Borysiuk et al. 2019; Olofsson et al. 2019).

Taking into account the knot occurrence which significantly affects the quality classification of the sawn timber produced from the round wood, it is necessary to identify the sound knots and the rotten ones (both the soundness of the knots, their size and the number can affect the attributed class of wood). Only the sound, single knots up to 10 mm are not decisive for assigning a quality class to a given piece of sawn timber. Generally, it can be assumed that not only the condition of wood defects (which is usually on a similar level in wood) affects the

timber quality. Their distribution along the log has the greatest impact on the qualitative classification of the manufactured sawn materials (Paschalis 1980; Chiorescu and Gronlund 2003; Mirski et al. 2019, 2021).

The aim of the study was to determine the effect of knots occurrence as a factor shaping the qualitative classification of sawn timber intended to general and special applications. The pine raw material was subjected to a qualitative assessment (verification of the knots distribution) and technological processes consisting in the division of large-sized roundwood in order to determine the efficiency indicators on individual lengths for timber of specific quality and strength classes.

MATERIALS AND METHODS

Considering the variability of the raw material base in Poland which manifest itself in different qualities of the stands (Kubiak and Laurow 1994), pine wood was obtained from specific part of the country. The raw material has been selected in terms of the age and the size to be representative of the large-sized roundwood usually chosen for sawmill purposes. 82 years old pine wood of the 4th age class from a mixed forest habitat was selected to perform the investigations. The selected logs represented the Baltic nature and forest area – Kalisz Pomorski Forest Disctrict (RDLP Piła).

The initial stage of the research consisted of sorting the logs taking into account their origin from the different lengths of the large-sized roundwood in accordance with the assumptions of PN-D-95017:1992. According to Hruzik (1993), Krzosek (2009) and Wieruszewski et al. (2012; 2013) the following factors have the greatest impact on the technological features of the log: their thickness and the origin from the trunk height. The obtained logs were sorted into three groups according to their location: butt-end logs, middle logs and top logs. The individual logs with the length of 3 m were manipulated from the pine raw material. Each log was subjected to the further processing to obtain the edged timber characterized by the thickness of 32 mm and the length of 3 m. In order to compare the classification results of the timber from different zones established along the trunk length and to evaluate the common features, the following assumptions were made:

- processing defects were not taken into consideration during the wood classification,
- some defects which occurred in roundwood and which could have appeared on sawn timber during the storage e.g. a discoloration was omitted,
- the defects which were not found in both roundwood and timber such as e.g. insect holes were omitted.

The quality of timber for general purpose was determined in accordance with PN-D-96000:1975. Based on the obtained results, the criterion characterizing the appropriate quality level of the timber was determined. The applied qualitative classification of the coniferous wood (acc. to PN-D-96000:1975) defined a four quality classes of the edged pieces of timber. For each piece of the sawn material an acceptable wood defects had to be assessed, in particular their type, number and size. During the edged timber classification both the surface and the side characterized by a worse quality should be evaluated. The exception is the case when the better surface is completely defects-free, and the worse surface qualifies for class II, then this piece of timber can be classified as class I. If the timber cannot be assigned to a particular class only on the basis of one defect, that defect can be omitted (excluding the wane). For the requirements concerning the knots, a 1 m section with the greatest defects is taken into account. The knots can be divided into: sound knots, rotten knots, punk knots, intergrown knots and dead knots having a round, oval, elongated and winged shape. For timber, the sound, intergrown knots having round or oval shape are classified together, another group are the elongated or winged

shaped sound and intergrown knots, next the partially rotten or partially intergrown of all shapes and at the end the rotten and punk ones of all shapes.

Pieces of obtained timber were visually sorted (acc. to PN-D-94021:2013) into three classes: KW (the best class), KS (middle class), KG (the worst class). Each piece of timber must undergo the quality assessment taking into account the following features: knots, slop of grains, cracks, processing defects, rot etc (Krzosek 2009). The most important and the most common criterion is the knots occurrence and it was the basis of applied classification with the omission of other defects. The worst surface was considered during the assessments. All knots except those with a diameter lower than 10 mm were included. They indicate the weakest points in given piece of timber and determine the possibility of use as the material for structural applications (Kozakiewicz and Krzosek, 2013; Sikora and Krzosek 2014).

RESULTS AND DISCUSSION

Among the defects listed in the standard, the identified knots mostly affected the qualitative classification of timber taking into account the zone from which the piece was obtained. As the height of the zone along the trunk increased, the share of knots also increased (Table 1).

The increase in the amount of low-quality timber was the result of both an increase in the share of knot area (reduction of quality class assigned according to PN-D-96000:1975) and a slight share of the sound knots responsible for the major share of class IV timber.

Table. 1 The role of knots as a factor affecting the quality class of timber along the trunk length

Amount of timber	Logs		
	Butt-End log	Middle log	Top log
Total (pc)	856	1 250	421
With knots (pc)	642	1 029	397
Share of pieces with knots (%)	75,0	82,3	94,3

During the analysis of the knot impact results, the differences between the zones were noticed. Against the background of analyzed groups, the timber obtained from butt-end sections seems to have had the lowest share of the knots (75%). The outcomes of the impact of knots on the timber classification showed the similar high value in case of remaining zones (Table 1).

When comparing the quality classes of the general-purpose timber classified according to the requirements of Polish standard, it can be seen that the sawn wood had a different share of specific classes depending on the zone established along the large-sized roundwood length. This tendency is particularly visible in Fig. 1 and Tab. 2 where the quality classes for butt-end, middle and top sections are presented. The applied regulations are mostly based on the knot's occurrence. The other defects, including the resinosis, had a marginal effect on a determination of the quality classes for middle and top zones.

When verifying the variability of the distribution of qualitative timber classification with regard to knots, a curvilinear course of function was noticed. It indicated the significant share of the third class as a result of the knots occurrence. Moreover, the influence of this defect increased with the distance from the butt-end zone, which results in the increase in share of sound knots on the surface of the timber. The share of the sound and rotten knots area determining the assignment of wood to the fourth class was similar in butt-end and middle zones. It reached the highest level of approx. 3% in the top zone. In the assessment of the strength properties, the visual method in accordance with the modified requirements of PN/D-94021:2003 were applied. The division into the strength classes is presented in the Table 3.

Table. 2 The structure of the timber quality based on the knots (PN-D-96000:1975)

	Logs											
	Butt-End log				Middle log				Top log			
	Quality class											
	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Number units											
Number of pieces	0	187	450	5	0	66	953	10	0	4	381	12
Share of pieces with knots in individual classes (%)	0,0	29,1	70,1	0,8	0,0	6,5	92,6	1,0	0,0	0,9	96,0	3,0
The effects of knots on the quality class (%)	0,0	21,9	52,5	0,6	0,0	5,3	76,2	0,8	0,0	0,9	90,6	2,9

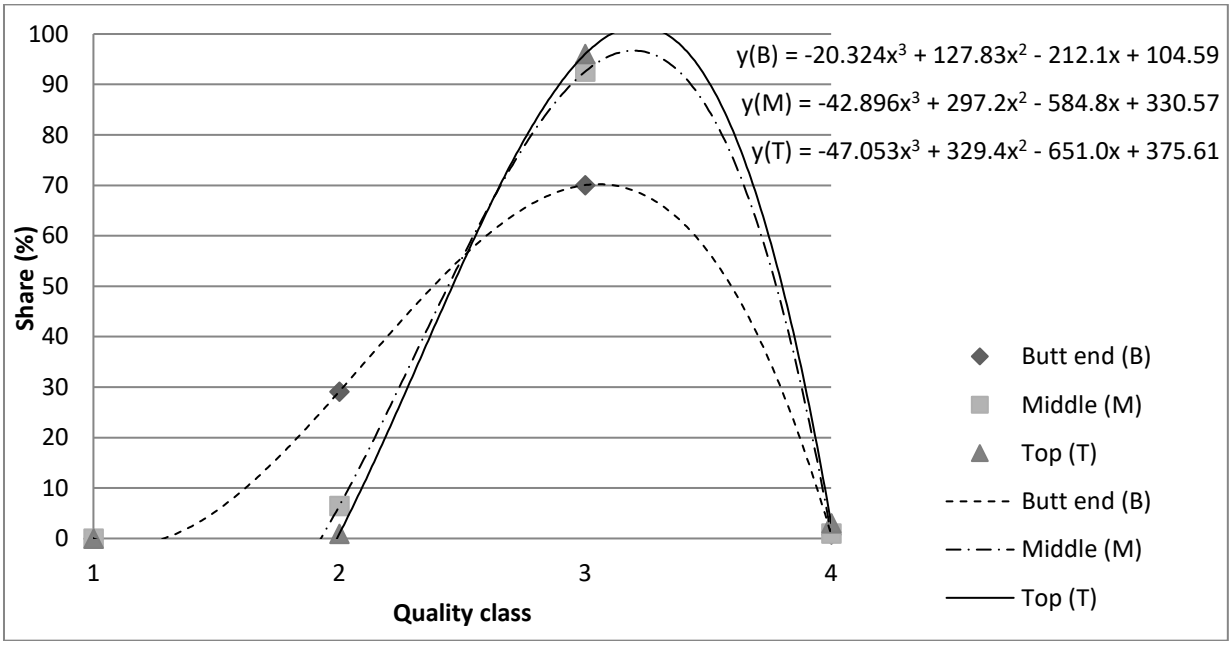

Figure 1. Distribution of the share of timber in the individual quality classes on a significance level of r = 1

The share of higher strength classes (labeled as KW and KS) in the sorted timber obtained from the bottom-end and middle zones confirmed the link between the results of classification and the distribution of knots along the length of the large-sized roundwood. 49% of the evaluated timber pieces were classified as a structural materials. This high proportion probably resulted from the omission of some defect such as cracks and the slop of grains. These results corroborate previous pine lumber results. They indicate a strong influence of knots in the

strength classification of structural lumber. The influence of other defects verified by Krzosek et al. (2009; 2020; 2021) indicates the influence of fiber twist.

Table 3 Number of pieces assigned to the individual strength classes based on knots distribution (PN-D-94021:2013)

	Logs								
	Butt-End logs			Middle logs			Top logs		
Strength class	KW	KS	KG	KW	KS	KG	KW	KS	KG
Number of pieces	138	329	150	65	215	166	0	82	85
Share of the class (%)	5	13	6	3	8	7	0	3	3

CONCLUSIONS

On the basis of the pine timber assessment and the evaluation of knots distribution it can be stated that:

1. The analysis of the qualitative classification confirms the variability in timber quality along the length of the large-sized roundwood.
2. Verification of the regulations in qualitative classification of timber depends on the considered range of acceptability of the defects presence defined by the applied standard.
3. The main group in terms of thickness in the processing of assortments for the structural applications (25%) was wood of the second class, KS.
4. The total efficiency of structural timber obtained in the processing was 49%. The timber classified as KW constituted 8% of the sawn products. It proves the low adjustment of the processing to the high requirements of the visual strength classification.

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Streszczenie: *Wpływ strefy przetarcia na jakość tarcicy w ocenie wybranych wad drewna sosnowego*. W trakcie badań na surowcu tartacznym sosnowym o określonym rozkładzie wad oceniono zmienny poziom występowania sęków. Początkowo materiał doświadczalny sklasyfikowano w kategoriach tarcicy ogólnego przeznaczenia, a następnie przypisano klasy wytrzymałościowe drewna do zastosowań konstrukcyjnych. Udział sęków zdrowych wzrósł w przypadku drewna pozyskanego ze strefy środkowej i górnej. W przypadku kłód odziomkowych zaobserwowano wzrost udziału sęków zepsutych o średniej średnicy 2-4 cm. Intensywność występowania wady tarcicy odpowiadała lokalizacji strefy jej pochodzenia na długości wielkowymiarowej drewna okrągłego.

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