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THE YIELD OF BEECH RAW MATERIAL (Fagus Sylvatica L.) FOR STRUCTURAL TIMBER IN THE PROCESSING PROCESS

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Abstract

Beech wood (Fagus sylvatica, L.) has a wide range of uses. Because of its specific properties, areas of woodworking industry for its application are limited. Is necessary to evaluate the beech structural timber for application in timber constructions not only according to mechanical properties, but also according to the technological processing. Grading parameters, mainly edgewise and flatwise shrinkage affect its qualitative yield. Paper analyse qualitative and quantitative yield of beech wood in timber conversion and processing process. Tested material consist of 15 tree trunks (21 m^{-3}), each was cut into two logs (total 30 logs) further 247 boards (7,4 m^{-3}). After processing by planning was boards adjusted to dimension of 50/150 x 3100 mm. Quantitative yield of trunks/boards was 35%. In next step was boards qualitatively graded according to STN 49 1531/Z1, 2006. Of the total number of boards n = 247, 118 boards was proved as construction timber, (3,5 m^{-3}). Qualitative yield of boards/structural timber was 48%. Total yield of trunks/structural timber was 17%.

Key words: *Beech structural timber, processing process, visual grading, quantitative yield, qualitative yield*

INTRODUCTION

Beech wood (*Fagus sylvatica* L.) is and going to be the most widespread wood in Slovakia as well as throughout Central Europe. Beech wood has a high density and excellent mechanical properties, but it has a volatile nature and is less resistant to wood decay factors as fungi or insect. The great potential of beech wood can be the use of structural timber in wooden constructions. In order to be able to use the beech safely and efficiently, it is necessary to know its properties set on the real size specimens commonly used in wooden constructions. Qualitative grading of structural timber into strength classes is required. Yield of the beech raw material in the processing process is an important factor. Qualitative and quantitative yield of raw material from tree trunks, logs and structural timber boards represents effectiveness of beech wood usage in wooden constructions.

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MATERIAL AND METHODS

As a tested material was chosen beech wood (*Fagus sylvatica* L.) from cadastral area of Ostrá Lúka, district Zvolen (Slovakia). Average height of beech stands in the locality is 30 m, thickness 38 cm, bonita 28, volume of tree trunks 1,57, phenotype category is rated as valuable. The selection of 15 trees was done individually on an area about 200 x 200 m. Two logs in the length 3300 -3500 ware cut of each tree trunks, and identified by number of log and tree (1/1 – 1/2). Crosscuts of logs were secured against checks cracks by MPC plates. Before main cutting operation were logs trimmed into length of 3100 mm. Some logs contain false heartwood. Wood was healthy, without any damages and possibilities of visual identification of insect or fungi wood decay. Quality of log was rate as very valuable. The quality class of logs was determined according to STN 48 0056, 2007 standard as quality level III.A or II.
Segmental log-sawing pattern (Fig.1) was used for sawing. Logs were saw by the MEBOR 900 horizontal belt band sawmill. Two segments with thickness of 160 mm were cut out from each log. These were then cut on single board with a thickness of 60 mm.

The hatch refers to the side and centre timber as well as the cutting edge

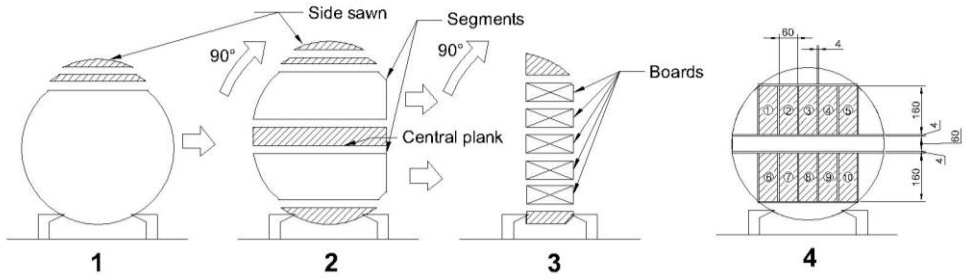

Fig. 1 Method and procedure of segment cut on a belt band saw (Bajza 2018)
1-align of surface, 2 –90° rotation and cut-out of two segments, centre and side timber 3 – 90° rotation of segments and its cutting to single board 4 – cutting schema

The total number of boards is n = 247 pcs. Identifies species and number of individual assortments is set in Table 1.

Table 1 Labeling, frequency and cubature of cutting assortments (Bajza 2018)

Material (*Fagus sylvatica L.*)		Labelling			(n)	Volume (m^3)
		Tree trunk	Log	Board		
Tree trunks		1 to 15	N/A	N/A	15	
Logs			1 to 2	N/A	30	
Boards	Structural timber			1 to 12	118	3,51
	Unusuable boards				129	3,84
Overall					247	7,35
Side sawn and dust		N/A				

N/A : not avaliable

Boards were stored into stacks in the exteriors protected timber storage site during 24 months' period. Unplaned boards were visually graded after natural seasoning (drying to w = 15 % ± 2%) according to STN 49 1531 /Z1, 2006 standard.

Grading parameters for visual grading of structural timber:

1. Longitudinal edgewise and flatwise shrinkage (deflection in mm from the plane in the middle of the board)
2. Number and diameter of the knots (right / left side of boards)
3. False heartwood presence: yes / no (right / left side of boards)
4. Presence of bark: yes / no (right / left side of boards)
5. Presence of front or middle clacks: yes / no (right / left side of boards)
6. Other parameters (rot, incest bites, other damage or decay)

The material preparation range that has been used in this research makes possible to track the whole process of timber conversion and processing of beech raw material up to the final product, what mean planned structural timber. This simple yield analysis followed:

- Quantitative yield: $$\boldsymbol{K_m}[\%] = \frac{\boldsymbol{volume\ of\ products\ [m^3]}}{\boldsymbol{volume\ of\ raw\ material\ [m^3]}} \times \mathbf{100}$$

- Qualitative yield: $$\boldsymbol{K_{q.type}} = \frac{\boldsymbol{V_{type}}}{\boldsymbol{V_{board}}} \times 100\ (\%)$$

(DETVAJ, 2003, KRAJČOVIČOVÁ, 2012)

RESULTS

In whole process of beech structural timber processing have been observed few parameters: type, number and volume of individual assortments, as well as the factors directly affecting the yield. Of the total number of boards n = 247 was used after the visual grading for structural purposes n = 118. The final size of the boards drying and planing was 150×50×3100 mm.

Table 2 describes the quantitative yield. It defines the percentages of valuable and non-valuable assortments of the total volume of the input log. Total boards yield was 75.3 %. The yield of boards utilized for structural timber was 35.3%. The reach of quantitative yield in the chosen quality focused log-sawing pattern corresponds to the real conditions of processing of the raw beech materials.

Table 2 Quantitative yield of cutting assortments (Bajza 2018)

Quantitative yield analysis								
Assortments			Thickness (mm)	Width (mm)	Volume (m^3)	%	Volume (m^3)	%
Valuable products	Boards	Timber	**60**	**160**	**7,35**	**35,3**	15,67	**75,3**
		central planks	60	≈	4,33	20,8		
	Side boards		32	≈	3,99	19,2		
Non valuable products	Sawn waste		≈	≈	1,64	7,9	5,13	**24,7**
	Length allowance		≈	≈	1,11	5,3		
	Wood dust and chips		4	≈	2,38	11,5		
Tree trunks			≈	≈	20,8	100	20,8	100

≈ symbolizes different parameters values, each piece was measured separately

Qualitative yield analyses of cutting products as tree trunks / logs / structural timber (Table 2.). Of the total number of boards (n = 247), only 118 qualitatively suited to structural timber purposes what mean 47.8%. Unusable assortments accounted of 52.2%. Final qualitative yield of structural timber in relation to the volume of the input tree trunks is

16.88%, while in the unusable boards it is slightly higher (18.5%). The qualitative yield of structural timber from tree trunks was negatively affected mainly by drying deformations – shrinkage caused by reaction wood. Altogether, up to 107 boards (43.3%) were excluded.

Table 3 Quantitaive yield of cutting assortments (tree trunks/boards/structural timber) (Bajza 2018)

Qualitative yield analysis											
Assortments					(n)	Volume V (m^3)		V_{type} / V_{board} (%)		V_{board} / $V_{trunks.}$ (%)	
Name	Dimension	Type									
Boards	160 x 60 x 3100 (mm)	Structural timber			**118**	**3,5**		**47,8**		**16,88**	
		Unusuable	Couse of exclusion	Deformation	107	3,2	**3,8**	43,3	**52,2**	15,3	**18,5**
				Knots	2	0,1		0,8		0,3	
				Splits & shakes	9	0,3		3,6		1,3	
				Other	11	0,3		4,5		1,6	
		Overall			**247**	**7,4**		**100,0**		**35,34**	
Tree trunks volume						**20,80**					

DISCUSSION

Analysis of yield affected factors:
- Dimensions of tree trunks / logs. Average diameter of logs was ø 516 mm, length 3100mm. Yield increase directly with the logs diameter, on the contrary indirectly decreases with the length of the log.
- Conversion of timber technology (band saws MEBOR 900 with sawing belt thick 4mm). Hydraulic drive fixing and centralization mechanism provide efficient alignment of log in band saw. What reduce the effect of the deviation of the parallelism ot the tear surface ot the stem with sawing gap. Technology of timber conversion used in research affect yield positively.
- Dimension and assortment of timber conversion product set optimal log-sawing pattern and number of single cut. That affect volume of chips and wood dust productions. The segment log-sawing pattern was chosen efficiently to considering yield.
- Operator of technology was hig qualified. Volume capacity per work shift was below average, but the operator could focus on the qualitative aspect of the cut. (positive affect on yield)
- Natural seasoning process and its impact on the qualitative yield: Natural seasoning (drying) is a slow drying process, which in a properly chosen process eliminates the deformation sufficiently (TREBULA, 1997). The procedure and the method of natural beech drying were carried out according to recommendations (TREBULA, 1997). Excessive deformations were not caused by improper drying but was probably caused by presence of tensile reaction wood and large internal stresses. (VILKOVSKA et. al. 2018). Unusable boards with excessive deformations reach 43,3 % (n = 107) of total number of boards (n = 247). In the case of effective diagnostics of reaction wood in logs, we could expect increasing of yield.
- Quality of the beech structural timber (strength class). STN 49 1531 / Z1 standard is applied for visual grading of structural timber used in timber construction. Grading parameters defined by this standard fit more to coniferous wood species. This standard is almost unusable for beech wood. For example, character of knots what the main grading parameters in coniferous wood species is very different in deciduous wood species. Grading methodology ignore existence of ring-porous and diffuse-porous woods.

CONCLUSIONS

Requirement of beech wood applications in timber constructions such as building is not only knowledge of its properties but also the economic evaluation of the processing and timber conversion process. Analysis of the quantitative and qualitative yield of structural timber from logs and tree trunks predicts the efficiency of the use of pillar raw material in the products. Yield of timber various with every single wood species. Beech wood is characterized by unpredictable deformations, low resistance to wood decay factors, which affects the yield. Quantitative yield of boards made of logs were 35,3% (n = 247). The qualitative yield of the structural timber from boards was 47.8% (n = 118), from logs only 16.88%. Determining the causes of low quantitative yield of structural timber from logs requires further research and verification.

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