WOOD RESEARCH
51 (3): 2006
1-10

QUALITATIVE AND QUANTITATIVE EVALUATION OF FALSE HEARTWOOD IN BEECH LOGS OF VARIOUS AGE AND QUALITATIVE STRUCTURE.

Vladimír Račko, Igor Čunderlík
Technical University in Zvolen, Slovak Republik

ABSTRACT

Qualitative structure of produced beech logs from seven harvested areas was evaluated. From 114 trees of the age of 60 to 144 years 489 logs different quality were cut according the Slovak standard STN 48 0056. Quality and quantity of false beech heartwood was evaluated.

Approximately 1/3 beech logs contained false heartwood. Occurrence of false heartwood dominates in third quality class and these logs were prepared from older trees. Other results showed, that log diameter was more significant factor for categorizing the logs into lower qualitative classes, but the type and proportion of false heartwood were not restricting factors of these qualitative classes.

KEY WORDS: beech, false heartwood, evalvation, qualitative classes

INTRODUCTION

Beech is the most significant tree species as a permanently renewable raw material for Slovak wood processing industry and in the present it is also a very important raw material for export. For the best valorisation of the raw material it is important to know the quality of produced beech assortments. It is no less important to know the raw wood defects, which influence the most the quality of beech assortments.

Beech assortments of raw material in forest and wood industry are categorised according to STN 480056 standards to six quality classes:

I. quality class – veneer logs
II. quality class – plywood logs
III. quality class – saw logs of III/A and III/B quality
IV. quality class – mine logs
V. quality class – fibrous and other industrial wood
VI. quality class – fire wood

According to Konôpka et al. (2002) in the year 2001 there were 3 044 338 m^3 of hardwood assortments processed by forest enterprises in Slovakia. The most numerous group is composed of assortments of V. quality class with the volume of 1 856 500 m^3 and the proportion of 61% of the whole amount. The second most numerous group is composed by assortments of III/A and III/B

class with the volume of 800 750 m^3 and the proportion of 26.3%. On the other hand the production of the most valuable assortments of the qualitative classes I. and II. is very low. 36 900 m^3 in the II. class, which is 1.2% and 7 482 m^3 in the I. class with the proportion of only 0.25%. The cause of this unfavourable condition in the quality of produced hardwood assortments is that many of the logs of butt parts of a trunk with suitable diameter and without trunk shape defects and knots have a high proportion of false heartwoods. False heartwood therefore seems the main cause of better valorisation of beech raw material.

According to Ťavoda (1993) the main defect during categorisation of beech logs to individual assortments is the false heartwood, while the proportion of the false heartwood significantly increases with increasing tree age. The effectiveness of use of heartwood raw material is very low for the production of dimension timbers, it approaches the limit of profitability of production. It is known that over aged beech forest has a raw material of the lower quality than the younger forest because of the high occurrence of the false heartwood. According to economical analysis (Ťavoda 1993) the highest effectiveness of the round wood utilisation (III.A and III.B quality class) is width group 30 – 39 and 40 – 49 cm. For smaller enterprises the effectiveness of the round wood utilisation is up to 50 cm of width. It The utilisation of the lower quality raw wood of over 50 cm, is though still problematic, its processing for saw wood and sleepers is unprofitable.

According to the theory of false heartwood, the age (connected with a ripe wood formation) and trunk injuries are considered the main causes of its formation. Many authors (Nečesaný 1958, Bosshard 1967, Paclt 1953 and others) agree on the opinion, that primary cause of the false heartwood formation is the trunk injury during its growth. The trunk injury together with the age influences the size and type of false heartwood formed. According to Chovanec (1969, 1974 and 1989) (Nečesaný 1958) the extent of the false heartwood in the trunk depends on the age in which the wound was formed, the extent of the wound and the velocity of wound occlusion. The velocity of the wound occlusion is directly proportional to the width of year increment during the period of wound occlusion. The width of the growth increment is influenced by the tree vitality, sociological status of the tree in the forest, climatic conditions, altitude, pedological and geological conditions and so on.

The aim of this article is to analyze quality and quantity of false beech heartwood in logs of different age structure in I. to V. quality classes.

MATERIAL AND METHODS

Material for investigation was obtained on the area of the forest Technical University in Zvolen. Characteristics of chosen research areas are shown in the Tab. 1.

Tab. 1: Characteristics of the research areas (according to Forest management plan)

Forest district	Môťová			Kováčová	Sekier		
Locality	Kráľová	Kráľová	Podzámčok	Budča	Sekier	Sekier	Sekier
Research area No.	381	432	1102	603	305	312	313
Growth age [year] (*)	110	165	110	110	70	80	80
Research area [ha]	5,03	5,21	9,3	8,35	15,3	12,99	10,41
Beech representation	45 %	98 %	93 %	90%	50 %	100 %	80 %
Altitude	660	690	600	600	550	600	600
Growth exposition	Western	North - western	North	South - western	Eastern	North	South - eastern
Bonity - Bk	32	26	34	30	34	30	28
Stand density	0,7	0,7	0,7	0,7	0,7	0,7	0,7
Slope gradient [%]	30	40	35	35	45	40	55

Trees were chosen by random in natural sociological structure (dominant, co-dominant and subdominant). Harvested trunks were cut into logs at log conversion deport. Timber assortment was done by trained deposit employee on the basis of the qualitative and quantitative defects evaluation and on the basis of the dimensions. Method of width false heartwood proportion measuring was adapted from the STN 480204 standard. Method of area false heartwood proportion measuring was done according to Račko and Čunderlík (2002).

Tab. 2: Age and no. of trees in analyzed growth areas

Research area no.	Basic statistical characteristics					
	Average age [years]	Minimal age [years]	Maximal age [years]	Standard deviation	Variation coefficient [%]	Number of trees sampled
305	66,3	61	73	2,92	4,4	17
312	93,9	75	122	11,41	12,2	18
313	90,8	75	98	5,98	6,6	17
381	105,4	96	119	5,83	5,5	20
432	109,9	72	144	16,75	15,2	11
603	119,8	102	129	6,57	5,5	15
1102	115,6	107	123	3,67	3,2	16
Total	101,0	61	144	18,65	18,5	114

RESULTS AND DISCUSSION

There were 114 beech trunks analyzed in total. From these 489 logs of I. to V. qualitative class were cut, taking into consideration dimensional and qualitative characteristics (diameter of the log, length of the log, wood defects). If we concentrate on false heartwood as on one of the main qualitative characteristics of beech round wood, there were 30.7% logs (150) with false heartwood, 69.3% of the logs without heartwood in the analyzed set.

Individual proportions of all the logs in individual age groups and qualitative classes are on the Fig. 1 and 2.

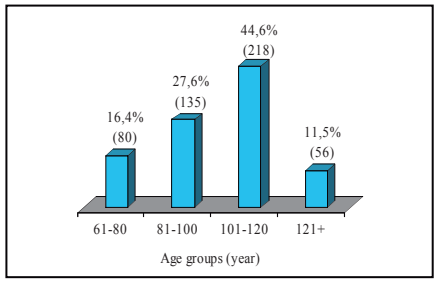

Fig. 1: Proportion of logs in age group

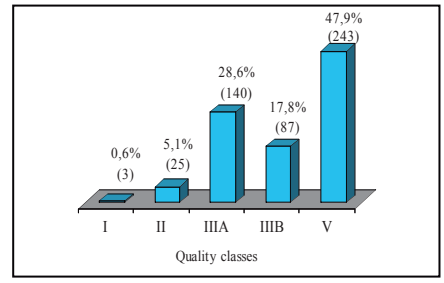

Fig. 2: Proportion of logs in qualitative classes

Proportions of logs categorized in individual classes (Fig. 2) shows great differences. In the I. class only three logs were categorized. The highest number of the logs was categorized in the qualitative class V. (243 pieces). The proportion of heartwood logs (Fig. 3) in the

qualitative class I. was 33.3% and in class II. 36 %, in III.A 47.9 %, in the class III.B 46 % and in the class V. 14.1 %.

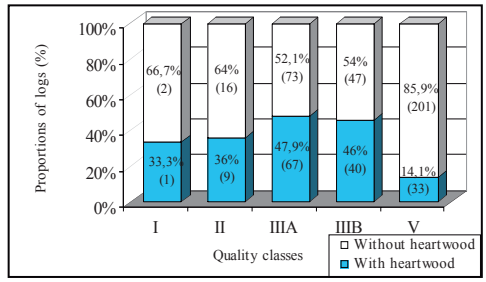

Fig. 3: Proportion of heartwood logs in individual qualitative classes

Average diameters of all logs in the I. class are the greatest and they decrease with gradually decreasing class. Average diameters of logs without heartwood (Fig. 4a) are in all cases lower than the average values of logs with heartwood (Fig. 4b)

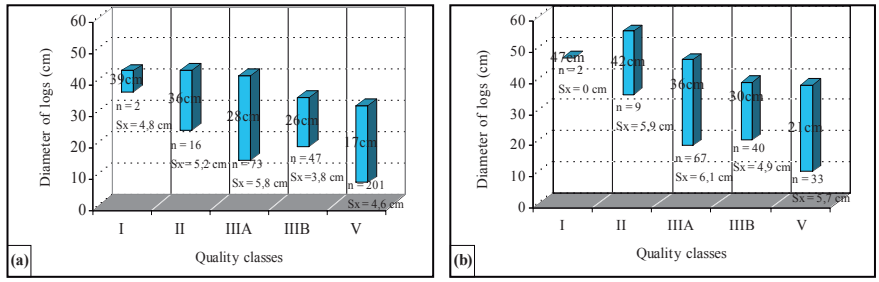

Fig. 4: Average diameters of logs without heartwood (a) and logs with heartwood (b)

Average width proportion of heartwood (Fig. 5) is low in the I. qualitative class, but this cannot be considered statistically significant because of low number of logs categorized in this qualitative class. From the class II. up to the class V. the average width proportion of heartwood varies from 37 – 42 % and variability of heartwood width proportion is approximately the same in the classes II. – V.

In the class II. the maximal value did not exceed 66,6% of the width proportion and the minimal value was less than 33.3% of the proportion of the false wood. By deeper analysis we found out that in this class there were 5 round shaped false heartwoods (Fig. 6) with variation range of 34.7-49 % and 4 flames shaped ones with variation range of 11-34.7 %.

The most numerous is the qualitative class III.A (Fig. 5). The STN standard allows unrestricted size of healthy round shaped false heartwood, but does not allow flame shaped and star shaped ones.

From the Fig. 6 we can see, that the most numerous in all qualitative classes are the logs with round shaped false heartwood. Although the STN standard does not allow the occurrence of flame and star shaped false heartwoods in the class III.A, there were 11 logs of this type here, of which 5 were with star shaped false heartwood with variation range of 16.1 – 49.3 % and 6 were with flame shaped heartwood with variation range of 17.2 - 41 %. The STN standard also

allows a 60% occurrence of round mosaic shaped false heartwood. The occurrence of mosaic shaped heartwoods is restricted to an older age, when the multitude of branch and trunk injuries is high. Taking into account the average age of 100 years, the mosaic shaped heartwoods did not occur in our selective set.

The qualitative class III.B does not significantly vary in the requirements on the heartwood size from the class III.A. The size of round shaped and round mosaic shaped false heartwoods is not restricted by the STN standard. It limits only the occurrence of flame and star shaped heartwoods at cross cut diameter of over 60 cm, which cannot be higher than 66.6%. Taking into consideration the age of selected research areas, logs with diameter over 60 cm did not occur in our selection. The most logs in this class did contain round shaped heartwood. There was also a small amount of logs with flame and star shaped heartwood. When categorising logs in this class mainly other defects were taken into consideration (tolerable occurrence of knots, curvature, cracks and others).

The qualitative class V. does not restrict neither size nor type of the heartwood. At the same time it allows very small diameter logs. The average width proportion of the heartwood and also the variation range and a number of the log occurrence is similar to the class III/B. On the other hand in this class flame shaped heartwood prevails. Also round heartwoods occurred here in the smaller amount, star shaped heartwoods were missing. In this class mainly logs obtained from the upper parts of the trunk of older trees were categorized.

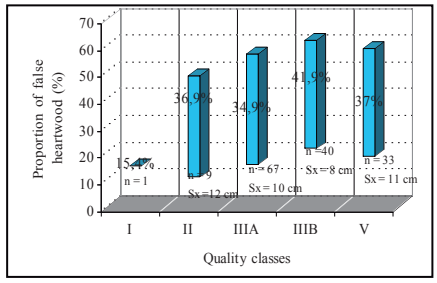

Fig. 5: Average width proportions of false heartwood in the logs

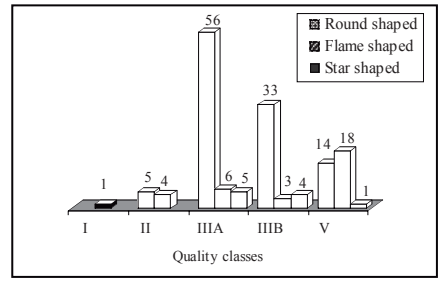

Fig. 6: Number of logs with various types of false heartwood

According to the different authors (Hillis 1987, Vasiljevič 1974, Chattaway 1952) heartwood in beech trunks is not formed until 50-80 years of age, which is connected with absence of ripe heartwood in the trunk. When local colouring occurs, it is connected with formation of side-drought in the proximity of a trunk injury occurrence. The formation of defects (knots, wounds …) in the older age of the tree, when the ripe wood is already formed in the central part of the trunk, causes the false heartwood spreading along the length and width of a great part of the trunk. The older tree is, the higher is the proportion of the false heartwood and also the number of its occurrence. Racz et. al. (1961) found the occurrence of 20 % false heartwood proportion among 80-year-old beech trees, the occurrence of 55 % false heartwood proportion among 120-year-old beech trees and occurrence of up to 80 % false heartwood proportion among 150-year-old beech trees. According to our findings the proportion of heartwood logs among trees of the average age of 100 years was 30.7% (Tab. 2).

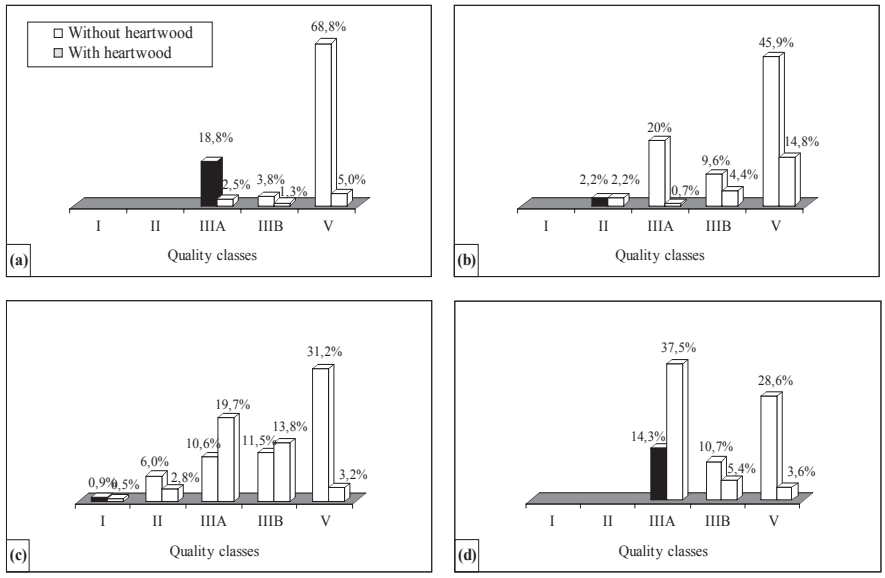

Fig. 7: Proportions of logs without false heartwood and logs with false heartwood. Age group 61–80 years (a), age group 81–100 years (b), age group 101–120 years (c) and age group over 120 years (d)

From the Fig. 7a and 7b we can see, that at the age of 61-80 and 81-100 years logs without false heartwood prevail, especially in the qualitative classes III/A and V. With increasing age decreases the proportion of logs without false heartwood and increases the proportion of logs with heartwood. The highest increase occurs in the qualitative class III/B and V. and in the age group of 81-100 years.

In the age group 101-120 years and over 121 years the logs with false heartwood prevail. This is confirmed by already known fact that with the increasing age increases also the occurrence of false heartwood in beech raw material. Only in the qualitative class V. the proportion of logs without false heartwood is significantly higher. This is caused by logs from upper parts of the trees of higher age, where the false heartwood occurs in smaller extent.

As it was stated above, with increasing age increases the number of logs which contain the false heartwood. This also applies to size of the area proportion of false heartwood. From Tab. 3 we can see, that with increasing age increases also maximum area proportion of false heartwood in the logs, only average proportion in the age over 120 years has slightly decreasing tendency. The variability of values in all age groups is high also.

Tab. 3: Area proportions of false heartwood [%] in individual age groups

Age group	Basic statistical characteristics				
	Simple average	Variation range	Standard deviation	Variation coefficient	Number of logs
61-80 years	6,7	2,5 - 12,1	4,32	64,8	7
81-100 years	10,7	1,2 - 18,2	5,85	54,5	30
101-120 years	12,3	0,3 - 25,8	6,40	52,0	87
121+ years	11,9	2,2 - 28,8	9,28	77,8	26

On the other hand the width proportion of false heartwood does not significantly change with age and it varies in the range of 34 – 38% (Tab. 4).

Tab. 4: Width proportions of false heartwood [%] in individual age groups

Age group	Basic statistical characteristics				
	Simple average	Variation range	Standard deviation	Variation coefficient	Number of logs
61-80 years	36,8	25,4 - 54,8	12,63	34,3	7
81-100 years	37,2	19,0 - 59,0	11,19	30,1	30
101-120 years	38,1	11,0 - 62,4	9,66	25,4	87
121+ years	34,3	16,0 - 57,0	13,45	39,3	26

From the Fig. 8 we can see that average width proportions of false heartwoods in logs of individual age groups vary only a little, but the variation ranges do change more significantly with increasing of age.

In the age of 61-80 and 81-100 years (Fig. 8a and 8b) the logs of the qualitative class I are missing. In the qualitative class II and the age group of 81 – 100 years there were categorized only three logs with low variation range. We can see increasing in the variation range and number of categorized logs towards lower qualitative classes (mainly class V.). In the age of 61-80 years there were only logs with flame shaped false heartwood in all qualitative groups (Tab 5). In the age of 80-100 years there were categorized, in addition to the flame shaped false heartwoods (that formed class V.), also round shaped false heartwoods (class II. III/A. III/B and V.). According to our opinion the final quality in the age group of 61-80 and 81-100 years is a result of not only curvature and higher occurrence of knots but also of the small diameter of logs. In the age group of 60-81 years there were categorized logs produced from trunks originating from the research areas no. 305, 312 and 432 and in the age group of 81-100 years those ones from the research areas no. 312, 313 and 432.

Prevailing part of logs was categorized in the age group of 101-120 years. At this age only one log with flame shaped false heartwood was categorized in qualitative class I. (Tab. 5) In the classes II. III/A and III/B the variation range is about the same, but the average width proportion of false heartwood increases towards the lower quality. In the class II. there were categorized 2 round shaped and 4 flame shaped heartwoods with lower average width proportion than the round ones. In the classes III/A and III/B there were present all types of false heartwoods (except round mosaic ones). The narrowest variation range with seven logs and all types of heartwoods is in the class V. In this age group there were logs from trees from growths no. 432, 1102, 381 and 603. Within the qualitative classes I.-III/A these were the good quality logs (straight with low occurrence of knots). In the age group of over 120 years the most numerous group was formed by logs of class III/A with relatively low average width proportion of false heartwood, but with wide variation range (Fig. 8d) In this class there were present all types of false heartwoods with a higher average width proportion for the round shaped and the star shaped false heartwoods and the lower for the flame shaped ones (Tab. 4). In the class III/B there were categorized only three logs with the round shaped false heartwood and in the class V. only two logs with the round shaped one. The biggest part of them originated from the research area no. 603 and a smaller part the from research areas no. 432 and 1102. One tree originated from the research area no. 312 with a low average age of 94 years.

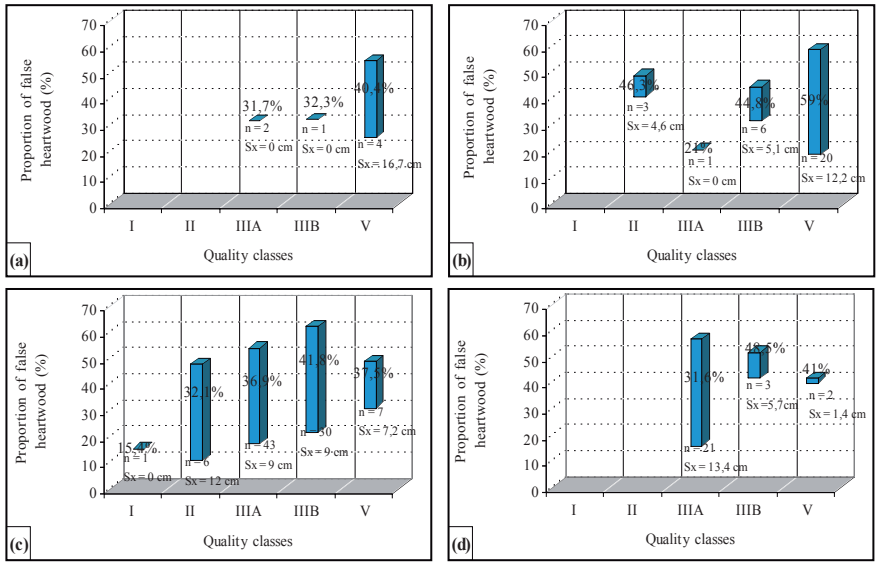

Fig. 8: Average width proportions of false heartwood Age group: 61-80 years (a), 81-100 years (b), 101-120 years (c), over 120 years (d)

Tab. 5: Width proportions of different types of false heartwood

Age	Heartwood type	I			II			IIIA			IIIB			V		
		$\bar{x}$	Min-Max	n	$\bar{x}$	Min-Max	n	$\bar{x}$	Min-Max	n	$\bar{x}$	Min-Max	n	$\bar{x}$	Min-Max	n
61-80 years	Flame shaped							31,7	31,7 - 31,7	2	32,3	32,3 -32,3	1	40,4	25,4 -54,8	4
81-100 years	Round shaped				46,3	41,0 - 49,0	3	21,0	21,0 - 21,0	1	40,4	31,8 - 44,8	6	33,5	21,6 - 44,8	7
	Flame shaped													36,9	19,0 - 59,0	13
101-120 years	Round shaped				41,3	34,7 - 47,8	2	37,2	20,0 - 54,0	37	41,1	28,0 - 54,0	24	36,5	33,0 - 46,3	5
	Star shaped							43,4	30,1 - 49,3	4	48,8	21,7 - 62,4	4	49,0	49,0 - 49,0	1
	Flame shaped	15,4		1	27,6	11,0 - 34,7	4	19,2	17,2 - 21,1	2	37,2	33,0 - 41,4	2	31,0	31,0 - 31,0	1
121+ years	Round shaped							32,5	17,5 - 57,0	18	48,5	41,9 - 52,0	3	41,0	40,0 - 41,9	2
	Star shaped							16,0	16,0 - 16,0	1						
	Flame shaped							30,8	20,6 - 41,0	2						

CONCLUSION

By analyzing the occurrence of the false heartwood in the beech raw material extracted from seven research areas with the average age of 101 years (61 – 144 years) we found 30.7 % proportion of the heartwood logs. The lowest proportion of the false heartwood occurred in the logs of the qualitative class V. Restricting factor for this qualitative class is the diameter of the round wood and the other defects. The most of the logs with false heartwood were categorized in the qualitative classes III/A and III/B.

From the analysis performed, it can be stated, that the width proportion and the type of the false beech heartwood in the analyzed set are not the restricting factors for categorized the logs in the higher qualitative classes. Maximum dimensions of false heartwood in most of the logs do not reach the border values of the size given by STN 48 0056 standard. After the implementation of the European standard STN EN 1316-1 the requirements for the tolerable dimension of false heartwoods will become stricter.

ACKNOWLEDGEMENT

This work was supported in part by Slovak Grant Agency for science (Grant No. 1/1357/04).

REFERENCES

1. Bosshard, H. H., 1967: Über die fakultative Farbkernbildung. Holz als Roh und Werkstoff, 25, s. 409 – 416
2. Hillis, W. E., 1987: Heartwood and tree exudates. Springer-Verlag, 268 s.
3. Chattaway, M. M., 1952: The sapwood-heartwood transformation. Austr. For., 16, s. 25-34
4. Chovanec, D., 1969: Povrchové znaky poranenia buka. Lesnícky časopis, 15, s. 372-383
5. Chovanec, D., 1974: Možnosti zábrany vzniku bukového jadra. Lesnícky časopis, 20, s. 339-354
6. Chovanec, D., Čunderlík, I., Válka, J., 1989: Znaky kvality bukových kmeňov. Vedecké a pedagogické aktuality. 1. vydanie, Vydavateľstvo VŠLD, Zvolen, 103s.
7. Nečesaný, V., 1958: Jadro buku. SAV Bratislava, 231 s.
8. Konôpka, J. et. al.: 2002: Správa o lesnom hospodárstve v Slovenskej republike 2002 (Zelená správa). Ministerstvo pôdohospodárstva SR Bratislava, 126s.
9. Paclt, J., 1953: Štúdia o nepravom jadre buka. IV.-V. Biológia Bratislava, 8, s. 255-262
10. Racz, J., Schulz, H., Knigge, W., 1961: Untersuchungen über das Auftreten des Buchenrotkerns., 16, s. 413 - 417
11. Račko, V., Čunderlík, I., 2002: The ripewood and false heartwood proportions at different beech stem levels. In. Wood Structure and Properties ´02. Arbora Publishers, Zvolen, Pp. 39–41
12. STN 48 00 56 Listnaté sortimenty surového dreva. Technické požiadavky
13. STN 480204 Surové drevo. Guľatina. Meranie vád

14. STN EN 1316-1 Listnatá guľatina. Kvalitatívne triedenie. Časť 1: Dub a buk
15. Ťavoda, J., 1993: Hľadanie spoločnej cesty v spracovaní buka. Les, 49, s. 10-11
16. Vasiljevič, J., 1974: Osržavanie bukove na područu Zrinjske Gore. Šumarski list, 98, s. 475-520

Ing. Vladimír Račko, PhD.
Technical University in Zvolen
Faculty of Wood Science and Technology
Masarykova 24
960 53 Zvolen
Slovak Republik

Prof. Ing. Igor Čunderlík, PhD.
Technical University in Zvolen
Faculty of Wood Science and Technology
Masarykova 24
960 53 Zvolen
Slovak Republik