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# THE OCCURRENCE AND SIZE OF FALSE HEARTWOOD IN BEECH TIMBER

*The aim of this study was to analyse the occurrence and size of false heartwood in beech timber over the lower and upper log faces. The research was carried out on 350 beech trunks where the presence of false heartwood was found on at least one of the log faces. The research material came from the Jarosław and Lesko Forest District (the Regional Directorate of the State Forests (RDSF) in Krosno) and the Pińczów Forest District (RDSF Radom). The following measurements were taken on selected logs: the mean bottom diameter, the mean upper diameter, the length of the analysed trunks, the maximum diameter of the false heartwood at both ends. As a result of the research, it was found that the maximum diameter of false heartwood on the beech log faces ranges from 30% to 40%, and a statistical test showed no significant difference in the extent of the defect between the lower and the upper face (t = -0.389; df = 612; p-value = 0.697). An analysis of the presence of the examined feature on the log faces showed that there were cases in which false heartwood appeared only over the lower face or only over the upper one. It was also noted that almost half of the examined logs had a larger diameter of the defect over the upper face than over the lower one. This study also examined the existence of a correlation between the diameter of the log face, log length and the percentage of the defect. The statistical test showed no significant correlation for both the lower and the upper face and the log length.*

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**Keywords:** lower log face, upper log face, timber classification, wood defects, red heartwood

## Introduction

In Poland, beech occurs mainly in two climatic zones: the northern coastal zone and the southern Carpathian one. Northern beech stands, growing in a temperate maritime climate, show a small share of light-coloured, healthy false heartwood. On the other hand, southern (mountain) stands show large shares of wood with strongly developed false heartwood, with a high proportion of rot at the stage of advanced decomposition [Krzysik 1974]. False heartwood is characterised by more intense colour visible over log faces and the colour depends on the species of the wood in which it occurs. It is a colour feature typical of heartwood-free diffuse-porous broad-leaved species, appearing only during the life of a tree and caused by oxidation and polymerization of phenolics by chemical or enzymatic processes [Albert et al. 2003]. It is believed that false heartwood may be caused by over 50 different factors, including: air penetrating into the trunk, fungal infestation of the wood, mechanical damage to trees, disturbance of water conditions in the tree, tree age, the presence of trunk bifurcations or large knots [Knoke 2003; Wernsdörfer et al. 2005; Kowalik 2008; Sorz and Hietz 2008; Račko and Čunderlík 2012; Gejdoš et al. 2021]. For most species the wood zone where this feature occurs is more resistant to wood-destroying fungi, but with the aging of the tree some rot can appear, which significantly reduces timber quality. It is believed that false heartwood in beech often takes on a characteristic bottle-like shape over the longitudinal section of the trunk, narrow at the root collar and widening towards the top of the tree [Kimbar 2011]. Others, however, assume that the shape of false heartwood is similar to a spindle: it is widest in the middle part of the trunk and tapering towards trunk ends [Knoke 2002, 2003; Wernsdörfer et al. 2006]. The presence of false heartwood has no significant effect on the mechanical properties of timber. The slight differences in physical and mechanical properties can be explained by the considerable difference in the density of the wood, even from the same trunk, used in the research [Pöhler et al. 2006]. Therefore, in some applications of timber it is not considered a disadvantage, e.g. in veneer wood where its presence is acceptable. False heartwood reduces the susceptibility of wood to saturation because the vessels are clogged with tyloses, which make timber impregnation difficult. This defect also lowers the drying speed of the wood, causes case hardening, increases tangential and radial

shrinkage, and during this process, more frequent defects of sawn timber appear such as cupping and twisting [Shahverdi et al. 2013]. False heartwood also reduces the susceptibility to bending, which is important in the production of bent furniture [Krzysik 1974; Kimbar 2011]. The presence of false heartwood as a different colour visible in the wood can be treated as a defect [Krzysik 1974]. The technical conditions applied in the State Forests specify the allowable sizes of false heartwood in individual timber quality classes: Class WA and WB: up to 1/3 of the butt-end diameter, Class WC: 1/2 of the but-end diameter, Class WD: permissible without limitations [Warunki techniczne 2019a].

The aim of this study was to analyse the occurrence and size of false heartwood in beech timber over the lower and upper faces.

## Materials and methods

The research was conducted on 350 randomly selected beech logs, from landings located in the vicinity of the logging area, in which false heartwood occurred in at least one of the faces. The research material came from the Jarosław Forest District (100 samples) and the Lesko Forest District (150 samples) (RDSF Krosno) as well as the Pińczów Forest District (100 samples) (Radom RDSF). The characteristics of the stands from which the beech wood was obtained are presented in Table 1.

**Table 1. The characteristics of the stands**

| RDSF, Forest District, Subdistrict, Compartmen, Geographical coordinates WGS 84 | Area [ha] | Forest site | Stocking index | Species composition | Age | Average breast height diameter (DBH) [cm] | Average stand height [m] | Growing stock [$m^3$/ha] |
|---|---|---|---|---|---|---|---|---|
| Krosno, Jarosław, Korczowa, 237i, N:49.9473, E:23.0656 | 4.88 | Fresh forest | 0.5 | 3 Hornbeam | 113 | 37 | 23 | 50 |
| | | | | 2 Birch | 113 | 43 | 26 | 39 |
| | | | | 2 Oak | 113 | 52 | 24 | 50 |
| | | | | 2 Hornbeam | 73 | 27 | 20 | 16 |
| | | | | 1 Beech | 113 | 50 | 28 | 43 |
| Krosno, Jarosław, Korczowa, 232g, N:49.9543, E:23.0673 | 11.77 | Fresh forest | 0.7 | 4 Oak | 102 | 46 | 26 | 200 |
| | | | | 3 Pine | 102 | 42 | 26 | 110 |
| | | | | 2 Hornbeam | 102 | 30 | 21 | 32 |
| | | | | 1 Beech | 116 | 45 | 26 | 23 |

| RDSF, Forest District, Subdistrict, Compartmen, Geographical coordinates WGS 84 | Area [ha] | Forest site | Stocking index | Species composition | Age | Average breast height diameter (DBH) | Average stand height | Growing stock |
|---|---|---|---|---|---|---|---|---|
| | | | | | | [cm] | [m] | [$m^3$/ha] |
| Krosno, Lesko, Średnie Wielkie, 83a, N: 49.3908, E: 22.2439 | 8.89 | Mountain forest | 1.0 | 7 Beech | 102 | 48 | 33 | 386 |
| | | | | 2 Beech | 77 | 37 | 29 | 92 |
| | | | | 1 Beech | 122 | 53 | 34 | 62 |
| Krosno, Lesko, Średnie Wielkie, 83g, N: 49.3904, E:22.2395 | 12.77 | Mountain forest | 0.9 | 6 Beech | 97 | 44 | 32 | 284 |
| | | | | 2 Beech | 72 | 36 | 27 | 75 |
| | | | | 2 Beech | 122 | 52 | 33 | 96 |
| Krosno, Lesko, Średnie Wielkie, 84a, N:49.3878, E: 22.2404 | 16.08 | Mountain forest | 1.0 | 8 Beech | 102 | 49 | 32 | 446 |
| | | | | 1 Beech | 132 | 57 | 33 | 57 |
| | | | | 1 Beech | 82 | 40 | 28 | 47 |
| Krosno, Lesko, Średnie Wielkie, 108c, N:49.4133, E:22.1828 | 29.2 | Mountain forest | 0.9 | 5 Beech | 77 | 42 | 28 | 194 |
| | | | | 2 Beech | 62 | 34 | 23 | 62 |
| | | | | 2 Pine | 62 | 33 | 26 | 80 |
| | | | | 1 Beech | 47 | 22 | 18 | 19 |
| Krosno, Lesko, Przybyszów, 205f, N:49.4209, E:22.0816 | 7.9 | Mountain forest | 0.5 | 6 Beech | 92 | 42 | 29 | 145 |
| | | | | 3 Beech | 62 | 30 | 26 | 54 |
| | | | | 1 Pine | 92 | 45 | 28 | 22 |
| Krosno, Lesko, Przybyszów, 207f, N:49.4241, E:22.0742 | 4.7 | Mountain forest | 0.2 | 4 Beech | 17 | 3 | 4 | no date |
| | | | | 3 Beech | 27 | 5 | 8 | no date |
| | | | | 2 Fir | 27 | 7 | 8 | no date |
| | | | | 1 Fir | 17 | 4 | 1 | no date |
| | | | | Beech | 102 | 45 | 28 | no date |

| RDSF, Forest District, Subdistrict, Compartmen, Geographical coordinates WGS 84 | Area [ha] | Forest site | Stocking index | Species composition | Age | Average breast height diameter (DBH) [cm] | Average stand height [m] | Growing stock [$m^3$/ha] |
|---|---|---|---|---|---|---|---|---|
| Krosno, Lesko, Myczków, 160a, N:49.4178, E:22.3992 | 17.9 | Mountain forest | 0.7 | 8 Beech | 107 | 44 | 32 | 271 |
| | | | | 1 Beech | 152 | 60 | 34 | 62 |
| | | | | 1 Beech | 82 | 32 | 29 | 31 |
| Krosno, Lesko, Myczków, 170c, N:49.40938, E:22.3864 | 8.45 | Mountain forest | 0.7 | 6 Beech | 92 | 39 | 29 | 183 |
| | | | | 3 Beech | 112 | 49 | 31 | 99 |
| | | | | 1 Beech | 72 | 28 | 27 | 27 |
| Radom, Pińczów, Góry, 113h, N:50.4766, E:20.3909 | 1.62 | Fresh forest | 0.5 | 6 Pine | 131 | 39 | 26 | 104 |
| | | | | 3 Beech | 131 | 46 | 29 | 58 |
| | | | | 1 Beech | 78 | 33 | 24 | 19 |
| Radom, Pińczów, Góry, 214b, N:50.5430, E:20.2128 | 8.82 | Fresh forest | 0.7 | 4 Fir | 88 | 37 | 28 | 245 |
| | | | | 3 Beech | 98 | 44 | 31 | 127 |
| | | | | 1 Fir | 108 | 45 | 28 | 67 |
| | | | | 1 Fir | 73 | 29 | 25 | 37 |
| | | | | 1 Oak | 88 | 48 | 29 | 35 |

Explanations: Fresh forest - the habitat is fertile and very fertile, fresh; occurs most often in brown soils, Mountain forest - the habitat is fertile, fresh; occurs in the mountains up to about 600 m above sea level most often in brown soils

The following measurements were made on selected logs:
the measurement of the mean lower diameter without the bark [cm] ($D_l$); two measurements were made: at the largest and the smallest end diameter, after which the mean was calculated. The measurements were taken with the accuracy of 1 mm [Warunki techniczne 2019b];

- the measurement of the mean upper diameter without the bark [cm] ($D_{top}$); the measurement was performed in the same way as the lower diameter;
- the measurement of the length of each examined item, i.e. log [m];

- the measurement of false heartwood size. The maximum diameter of the zone in which the false heartwood was present, was measured. The measurement was made with an accuracy of 1 mm. The shape of the false heartwood was not taken into account. The measured dimension was divided by the mean diameter of the butt-end and the result was given in %. The measurements were taken on each of the log faces with the defect [EN 1309-3:2018; Warunki techniczne 2019b].

The obtained measurements were compiled in spreadsheet and Statistica ver. 12. Due to the fact that the Shapiro-Wilk test showed a normal distribution, the t-test was used to analyse the significance of differences, and the Pearson correlation test was applied to determine the relationship between the features [Kot et al. 2007].

## Results and discussion

The research revealed that the size of false heartwood on the of beech log faces ranges from 30% to 40%, both on the lower and upper faces (Fig. 1). However, it can be noticed that on the upper face ($D_{top}$), after exceeding the diameter of about 40 cm, the share of false heartwood on the cross-section decreases. A similar tendency is also observed on the lower face ($D_l$), but in the thickest trees, above 70 cm in lower diameter, the size of false heartwood increases and it reaches 50% on the lower face.

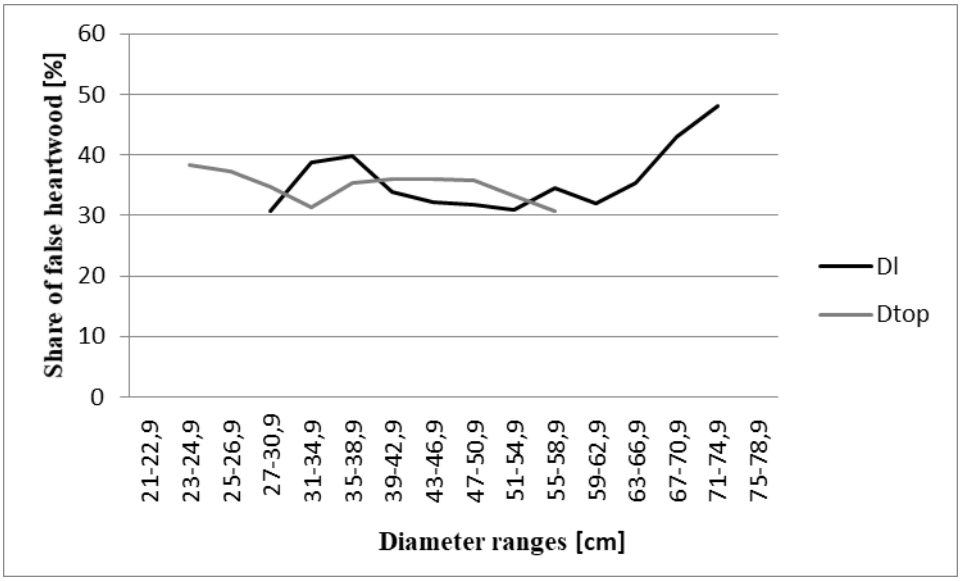


**Fig. 1. The size of false heartwood depending on the butt-end diameter. ($D_l$)- lower log face; ($D_{top}$)- upper log face**

On average, the share of false heartwood on both faces (lower, upper) was very similar (Table 2, Fig. 2). This was also confirmed by a statistical test, which showed no significant difference in the size of the defect on the lower and upper faces (t = -0.389; df = 612; p-value = 0.697).

**Table 2. Statistical characteristics for the share of false heartwood on the examined logs**

| | $D_l$ [%] | $D_{top}$ [%] |
|---|---|---|
| Average | 34.5 | 35.0 |
| Min | 0.0 | 0.0 |
| Max | 83.3 | 82.2 |
| Standard deviation | 15.2 | 15.6 |
| Coefficient of variation | 43.9 | 44.6 |

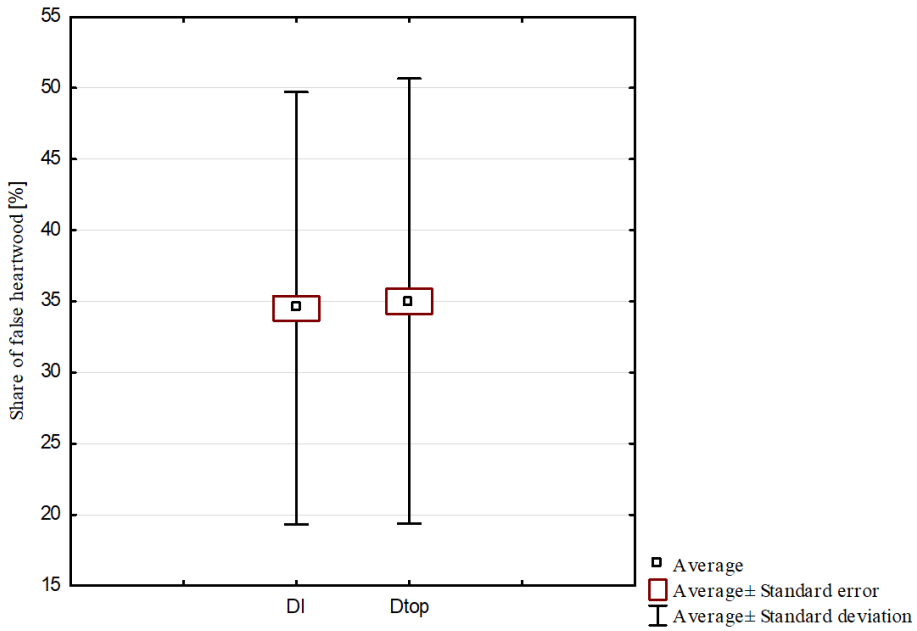


**Fig. 2. Share of false heartwoodon the lower face ($D_1$) and upper face ($D_{top}$)**

When analysing the presence of the examined feature on the log faces, it was found that there were cases where false heartwood appeared only over the lower face (41 samples – 11.8%), or only over the upper face (39 samples – 11.2%). It should be noted that in 190 samples (53.9%) the size of false heartwood on the upper face was smaller than on the lower one, while in 160 samples (46.1%) the trend was reversed. The present study also examined the existence of a correlation between log face diameter and the percentage of the defect on the examined face. The statistical test showed no significant correlation for either the lower (p-value = 0.865) or the upper (p-value = 0.808) face. The share of false heartwood on the upper face was also analysed depending on the length of the examined logs (Fig. 3). Also in this case there was no significant correlation (p-value = 0.301). It can be observed that in logs with the length of about 10 meters the share of false heartwood increases, while in logs over 10 meters it begins to decrease.

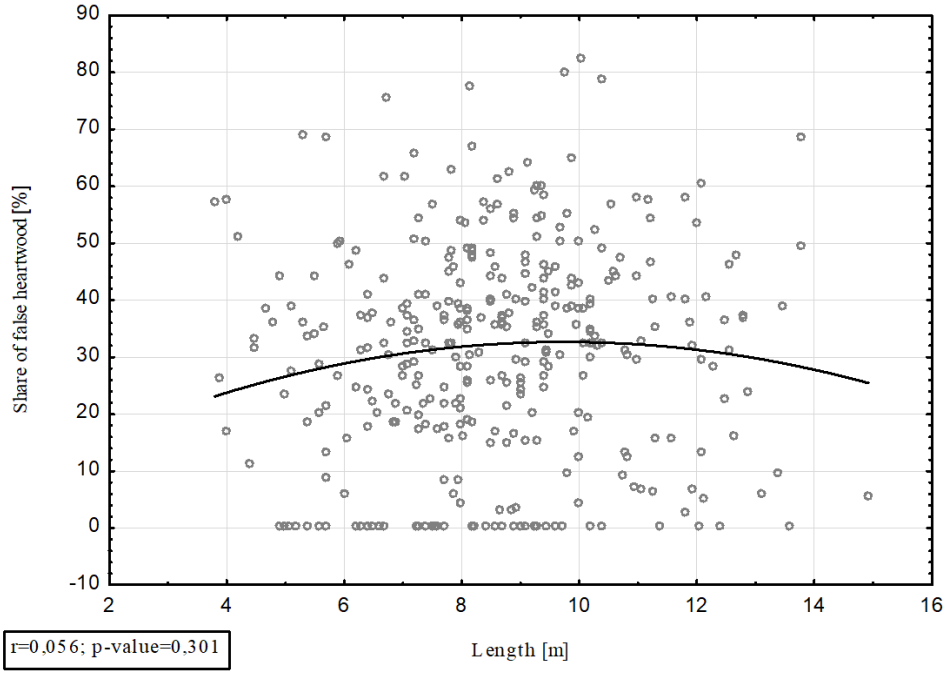


**Fig. 3. Share of false heartwoodon the upper face depending on the length of the logs**

Some authors [Kurek 2011; Račko and Čunderlík 2012] point out that the size of false heartwood may increase in the middle parts of the trunk (along the length of the trunks from 2.8 m to 5.6 m), while on the lower or upper face of the log, the size of the defect may be small. In this study, almost half (approx. 46%) of the examined logs showed a higher share of false heartwood on the upper face

than on the lower one, and in approx. 11% of the logs, this defect occurred only on the upper face. A similar relationship was also found by Karaszewski et al. [2013a]. They observed that the largest volume was recorded in logs which were downgraded as a result of red heartwood. Moreover, cross sections taken from the face of the beech tree, revealed red heartwood with a smaller surface area in comparison to cross sections taken from the same log, but 6 to 9 m higher. Similar results were obtained by Knoke [2003], who found that regular (classic) false heartwood, of a larger size, is more common on the upper face (67% of the examined logs) than on the lower face (43%). On the other hand, false heartwood of irregular shape (star-shaped, fracture-shaped, etc.) is more common on the lower face. The star shape of the false heartwood on the lower butt-end is often caused by fungal infections. They cause the false heartwood to enlarge and its shape to morph from cloud-like to star-shaped forms [Arač et al. 2021]. False heartwood also frequently takes the shape of a spindle inside the trunks [Wernsdörfer et al. 2006]. It is the widest in the central part of the trunk and tapers towards the base of the trunk and its top, ending mostly at the crown base. In the present research, such a tendency was also noted, but it was insignificant. This can be of fundamental importance in the classification of large-sized timber produced in shorter sections. While analysing beech timber quality, Karaszewski et al. [2013b], indicated that about 22% of the wood volume was of a lower quality class due to the presence of false heartwood. Similar results were obtained by Prka et al. [2009], who noted that, in timber quality class A, about 14% of timber volume had lower quality when taking into account the presence of false heartwood, while in class B about 15%. The largest decrease in timber value is observed in stands that are over 110 years old [Trenčiansky et al. 2017]. Unfortunately, even when one has all the information on the conditions of tree growth, it is impossible to avoid the formation of false heartwood in beech wood and obtain timber that is free from this defect [Knoke 2002]. Only constant research on the formation and development of false heartwood in growing trees would allow healthy trees to be bred by removing trees with a developing defect. Unfortunately, neither in practice nor with the use of available research methods (non-invasive methods of wood quality testing) can this be achieved. According to Knoke [2003], however, it is possible to predict the possibility of the occurrence of false heartwood in older stands. He believes that the risk of false heartwood occurrence is mainly related to tree age, diameter at breast height and the occurrence of major damage and trunk bifurcation. If at the age of 80 or 90 the trees are damaged and forked there is a very high probability of false heartwood development in their trunks in the future. Therefore, he recommends removing such trees during intermediate cuttings and leaving the trees without such features.

## Conclusions

1. The shares of false heartwood on the lower and upper faces did not differ significantly.

2. Among the examined logs there were such where false heartwood was present on only one of the faces: the lower or the upper one.

3. Almost half of the examined logs had a larger size of the defect on the upper face than on the lower one. Therefore, when evaluating the presence of this feature in beech wood, both faces should be analysed. This is especially important during timber classification, when the maximum diameter of the zone with the false heartwood present on both faces plays a crucial role in the classification.

4. No correlation was found between the diameters of log faces and the size of false heartwood, and its share remained at a similar level, regardless of the diameter.

5. No significant relationship was found between the length of the logs and the size of false heartwood over the upper face.

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## List of standards

**EN 1309-3:2018** Round and sawn timber - Methods of measurements - Part 3: Features and biological degradations. CEN, Brussels

**Warunki techniczne. 2019a.** Drewno wielkowymiarowe liściaste. Załącznik nr 6 do Zarządzenia nr 51 DGLP z dnia 30 września 2019 r. [Technical conditions. 2019a. Large-sized deciduous timber. Appendix No. 6 to Regulation No. 51 of the General Directorate of State Forests, of 30 September 2019]

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