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Deformation of beech wood – the sources and their identification before beech logs processing

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Abstract: Longitudinal buckling is a very serious problem in production of solid wood panels assembled of beech lamellae joined alternatively breadthwise and longwise into large-sized blocks. The aim of our work was to identify the main factors causing misshaping of beech dowels in solid wood panels production, with the primary focus on identification of reaction tension wood in dowels and logs.
According to our results, the most common source of longitudinal buckling of beech dowels was the presence and non-uniform distribution of tension wood in them. The tension wood occurrence in logs is possible to predict with a considerable confidence based on eccentric pith presence. The tension wood presence and distribution over the cross section are possible to identify if the cross-cut surface has been milled and its moisture content reduced under FSP. The tension wood can be discerned through its lighter hue and pearlescent-white gloss.

Keywords: beech wood, tension wood, longitudinal buckling, solid wood panels

INTRODUCTION

Beech wood is still keeping a prominent status in wood processing industry, especially furniture making, thanks to a range of favourable properties and to the high presence in the forests of the Carpathian region (BARNA *et al.* 2011). On the other hand, beech wood may exhibit a very diverse quality due to frequent defects (knots, rots, red heartwood, reaction wood, necrosis), and as such it gives rise many problems in processing.

A very serious problem in beech wood products (furniture dowels, railroad sleepers, sawn wood, parquetry, bent elements, veneers and others) is longitudinal buckling (KÚDELA 2002, KÚDELA and ČUNDERLÍK 2012). This issue exerts many difficulties also for producers with long history and rich experience such as, for example, Bučina DDD, Ltd. Zvolen in Slovakia (producer of solid wood panels) and TON Inc. Bystřice pod Hostýnem in the Czech Republic (bent furniture producer).

This problem is also apparent in production of solid wood panels assembled of beech lamellae joined alternatively breadthwise and longwise into large-sized blocks. The high production capacity in this area also means a huge amount of beech raw material wasted and numerous final products devaluated together with human work and energy. The problems associated with longitudinal buckling in wood drying process and plasticization negatively influence of balances of each of the enterprises processing massive beech wood.

The aim of this paper is to identify the main factors causing misshaping of beech dowels in the process of solid wood panels production, with the primary focus on identification of reaction tension wood in dowels and logs.

MATERIAL AND METHODS

Our research ran on two series of beech dowels each consisting of 10 dowels (dimension XX×XX×XX mm). The two sets were sampled from two sets of dried beech material. The beech dowels exhibited excessive curvature, so they did not meet the criteria for making lamellae for solid wood panels of the specified thickness (Fig. 1).

From one end of each observed dowel, there was sawn a 20 mm thick specimen. From each specimen, there were cut two test bodies for reaction wood identification – one from the concave, the other from the convex side (Fig. 1c). Thereafter, the cross surfaces of these bodies were prepared for reaction wood identification by electron scanning microscopy.

Fig. 1 Change of shape after plasticization and drying of beech dowels.

The tension wood (TW) identification in a round wood stock followed the observations by ČUNDERLÍK and KÚDELA (1992). The tension wood was identified on cross surfaces of fresh cut beech round wood with eccentric pith. Our aim was to verify experimentally whether eccentric pith might serve as a reliable identifier of TW occurrence. From the round wood stock, we sampled randomly 15 logs with eccentric pith. From each log, we cut a ca 5 cm thick disk. All disks were milled on one side and placed in a climate chamber for continual drying. The dried-out disks were examined to identify the occurrence pattern of tension wood on their cross cut. On a beech cross surface treated in this way, the tension wood is visible as a lighter pearlescent area versus a brown-creamy area of the opposite wood

About 30 days later, we took samples from another 15 logs and the whole procedure for tension wood identification was repeated.

RESULTS AND DISCUSSION

The beech wood structure examination on cross-surface by electron scanning microscopy confirmed high occurrence of tension wood in the dowels. Tension wood was observed in all selected dowels on their concave side. This reaction wood is easy to identify through the thick G-layer separated from the other cell wood layers due to excessive shrinkage (CHOVANEC *et al* 1989) − Fig. 2a. Conversely, most of the dowels did not exhibit tension wood on their convex sides (Fig. 2b).

In several cases, there were also observed G-fibres on convex sides (Fig. 3). The microscopic observations revealed that both the quantity and quality of G-fibres varied, and so did also the tension wood patterns over the dowels cross-section. The varying tension wood patterns induced longitudinal buckling.

Another source of dowel misshaping was that they were taken very close to knots. The dowels did not contain knots, nevertheless, their fibres were deviated due to former knot proximity, and, subsequently, they were cut (Fig. 1b). We found that also these dowels contained tension wood.

Our results indicate that the tension wood occurring in dowels in irregular patterns was the primary and the most frequent source of their misshaping, due to contraction of the tension wood and several times more shrinkage of this wood compared to the normal (ČUNDERLÍK and CHOVANEC 1987, ČUNDERLÍK *et al*. 1992, 1995). The knowledge of tension wood patterns in a dowel facilitates to predict the dowel misshaping (KÚDELA 1993). The last cited work indicates that the maximum dowel deflection can be achieved with a tension wood proportion making one half of the dowel cross section area.

The differences in shrinkage between the tension and normal wood in a dowel result in stress generation (KÚDELA 2005). These differences are caused by structural differences

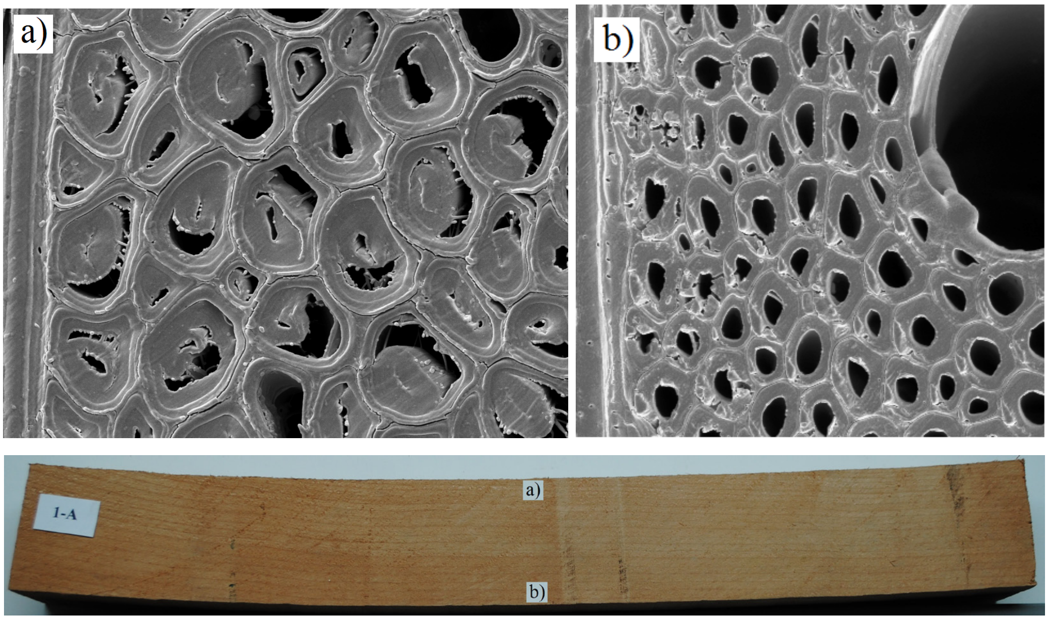

Fig. 2 Misshaped (bent) dowel with tension wood on the convex side (a) and normal wood on the concave side (b).

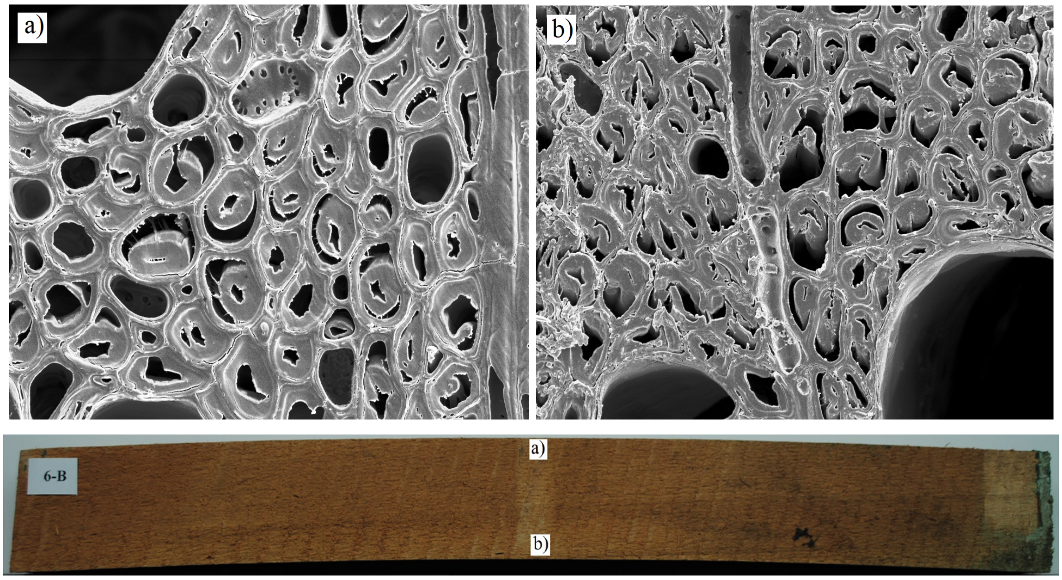

Fig. 3 Misshaped (deflected) dowel with tension wood on the concave side (b) and also the convex side (a).

between the tension wood and the normal wood and they can further be enhanced due to differences in drying between these two wood types (TARMIAN *et al*. 2009).

The stresses generated due to different moisture patterns in tension wood and normal wood can be eliminated to a considerable extent by controlling the drying process through adjustment of the input parameters of the drying medium.

The stresses generated due to different shrinkage of tension wood and normal wood following from their different structures can only be avoided by eliminating tension wood. In presence of this wood, misshaping may occur even under finely-tuned drying regimens. It is also possible to apply mechanic loading in such a way as to prevent dowels buckling.

Our results obtained in the research on tension wood in beech dowels gave us incentives for closer examination of tension wood occurrence in logs. In operating conditions, tension wood in logs is generally not easy to identify directly (MARČOK *et al.* 1996a, b, BARBACCI *et al.* 2008). In freshly cut beech round wood we may suppose tension wood occurrence if the pith in these logs is eccentric or the logs are not straight (ČUNDERLÍK and KÚDELA 1992).

Accordingly, we focussed on logs with eccentric pith. From 30 logs, there were prepared disks for tension wood identification. Tension wood was confirmed in all 30 logs with eccentric pith, in form of a distinctly lighter layer on the cross-cut of milled and dried disks (Fig. 4). Tension wood exhibited varying occurrence frequency and different patterns on different cross-sections (Fig. 4). These results do not allow an unequivocal prediction of tension wood location over the cross-section. Fig. 4 demonstrates three various possibilities of tension wood position: all tension wood concentrated in one part of the log (Fig. 4a), more or less uniformly distributed over the whole cross section (Fig. 4b), present in very small amounts in various parts of the cross-cut of the log (Fig. 4c).

a) b) c)

Fig. 4 Various tension wood patterns on log cross sections.

Our observations show that if these logs are sawn into dowels, the dowels will contain tension wood in various amounts and quality, exhibiting various patterns across the dowel cross sections. Consequently, to suppose the dowel misshaping is reasonable. Therefore, we may propose the asymmetric pith to be an important indicator enabling to predict tension wood occurrence in logs.

CONCLUSION

Our results and their analysis allow us to drive the following conclusions.

The most common source of longitudinal buckling of beech dowels is tension wood present in these dowels and non-uniform distribution of this wood in them.

Another cause may be due to fibre deviation in dowels from the longitudinal axis because of the former knot proximity.

The tension wood occurrence in logs is possible to predict with a considerable confidence based on eccentric pith presence.

The tension wood presence and distribution over the cross section are possible to identify on cross-cuts milled and dried under FSP. The tension wood can be discerned through its lighter hue and pearlescent-white gloss.

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Streszcznie: *Wady kształtu kłód bukowych – źródła i ich identyfikacja przed przerobem.* Wyboczenie jest poważnym problemem w produkcji klejonki bukowej. Celem pracy było określenie głównych czynników powodujących deformację fryzów, ze specjalnym zwróceniem uwagi na drewno napięciowe we fryzach i kłodach. Wykazano , że głównym źródłem deformacji jest obecność niejednorodnej dystrybucji drewna napięciowego. Jego obecność w kłodzie jest możliwa do przewidzenia, na bazie obecności niekoncentrycznego rdzenia. Identyfikacja takiego drewna w przekoju jest możliwa, po rozcięciu i wysuszeniu poniżej wilgotności nasycenia włókien dewno napięciowe różni siębarwą – jest jaśniejsze i posiada perłowy połysk.

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