In: Forest Products Society (FPS) 67th International Convention, June 9-11, Austin, Texas, USA

Shape stability of laminated veneer products – How to decrease the negative effects of fibre deviation?

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Abstract

A shortcoming of the laminated bending process is that the products may become distorted after moulding and during use. Annually, significant financial losses have incurred in the furniture and interior design industries as a result of distorted products. In this study, we have examined the influence of deviation of fibre orientation of individual veneers on distortion of a moulded shell to find ways to improve shape stability of laminated veneer products.

Ninety cross-laminated shells, consisting of 7 veneers of Birch (*Betula pubescens* Ehrh.) with a total thickness of 3.6 mm, were studied. The in-plane dimensions of the veneer were 400x660 mm. All the veneers were straight-grained, but to simulate deviation in fibre orientation some of the individual veneers were oriented 7 degrees relative to the main orientation of the other veneers in the laminate. Distortion was determined directly after moulding and after storage in a changing relative humidity.

The results show the well-known fact that deviation of fibre orientation of the veneers in the laminate influences the shape stability of the product. The results from this study, however, also show how the placement of the abnormal veneers in the laminated veneer products influences the degree of distortions. From this basic knowledge some improvements for production of laminated veneer products were suggested.

Keywords: twist, spring-back, moulding, wood, birch, thermo-hydro-mechanical processing

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Introduction

Among the various methods of producing laminated wood, this paper is about the shape stability of veneers formed and laminated simultaneously against a mould. This process is generally called laminated bending and the products are called laminated veneer products.

In laminated bending, veneers are formed and laminated together in such a manner that their relative movements are very limited. In general, the number of veneers is odd in order to give a symmetrical construction. Peeled veneers are the most frequently used in laminated bending and such veneers have their longitudinal and tangential direction in the plane.

Poor shape stability of laminated veneer products can be a significant problem in the manufacture and use of the final assembled product, as poor shape stability may cause problems such that the products fail to meet product requirements.

As mentioned, a shortcoming of the laminated bending process is that the products may become distorted after moulding and during use. The stresses in a newly produced laminated product will, in most cases, tend to reopen the bend, i.e. to increase the radius of curvature, when the product is removed from the mould. This is often referred to as spring-back and this change in shape is normally not as great a problem as other modes of distortion, e.g. twisting, that can occur directly after moulding as a result of elastic deformation, moisture, or heat-induced stress fields (Navi and Sandberg 2012).

In later stages the product may also change shape due to natural changes in the surrounding environment. Moisture content changes can lead to distortion, and the moisture content in the assembly should be kept as constant as possible. Stresses resulting from the deformations introduced during the moulding process can lead to cracking during the formation and also later when the product is exposed to natural climate variations (Hvattum et al. 1978; Lind 1981; Cassens et al. 2003).

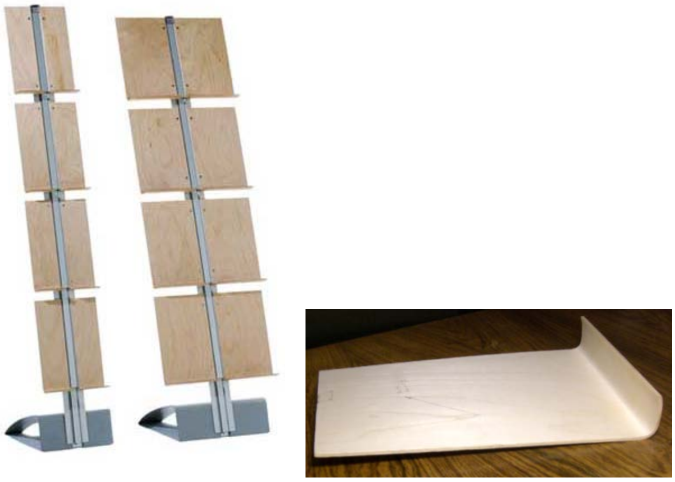
If the fibre orientation of the veneers deviates from the main direction of the veneers there will be a tendency for the laminated assembly to twist as a result of moisture content changes (see e.g., Boulton 1920; Ormarsson and Sandberg 2007). Such distortion can be eliminated by selecting only straight-grained veneers and, above all, by ensuring that all the pieces are conditioned to the same moisture content before moulding. However, trees are not symmetrical cylinders, and this makes it virtually impossible to produce a veneer that is parallel to the grain both on its face and throughout its thickness. The orientation of peeling also plays a role.

Background

The company that participated in this study had a specific product with major problems of twisting. The product was a 3.6 mm thin moulded shell used as a shelf in a brochure rack, Figure 1.

Aim

The aim of the study was to investigate whether or not and to what degree deviation in fibre orientation in individual veneer sheets affects deformations of the shell.



a) *b)*

Figure 1. a) Brochure rack and b) the moulded shelf that is included in the rack.

Material and method

After moulding and a certain period of interim storage, the shells are normally divided into a number of shelves and manufactured to the final shape in a CNC-machine (various widths exist).

In total, 90 shells were studied after moulding but before processing into the final shape. Figure 2 shows the shell with the different definitions used in this paper. A total of six groups of 15 shells were tested, as seen in Table 1, with different orientations of the veneer.

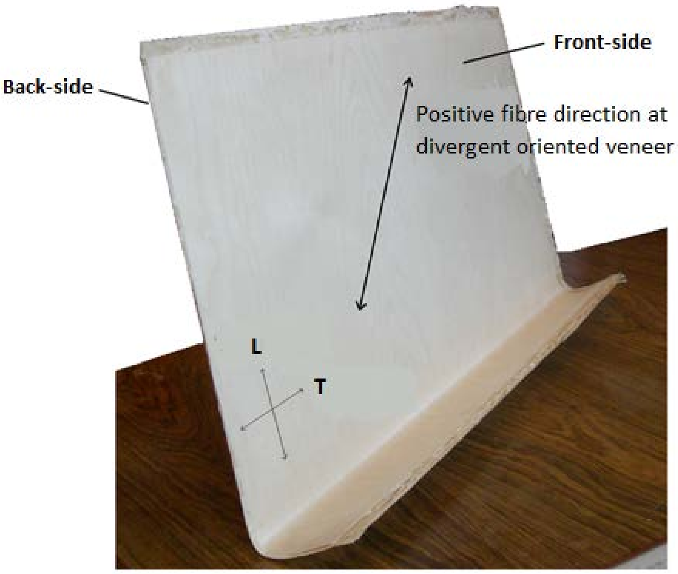


Figure 2. A shell that was studied in this investigation, with the different definitions used in this paper: front- and backside of the shell, positive fibre direction, lengthwise- and transverse direction.

The moulded shell in this study was made of birch (*Betula pubescence* Ehrh.). Veneers were conditioned at 20ºCelcius (C) (=68ºFahrenheit)/20 % relative humidity (RH). The shell consisted of 7 peeled veneers and the surface veneers were sanded. The veneer dimensions were 400 x 660 mm^2. The thicknesses of the sanded veneers were 0.4 mm, while the other five veneers were 0.5 mm thick. All veneers were sorted and cut in such a way that they could be considered straight-grained, except for those chosen to be different. Table 1 shows how the veneers were added together in the various groups.

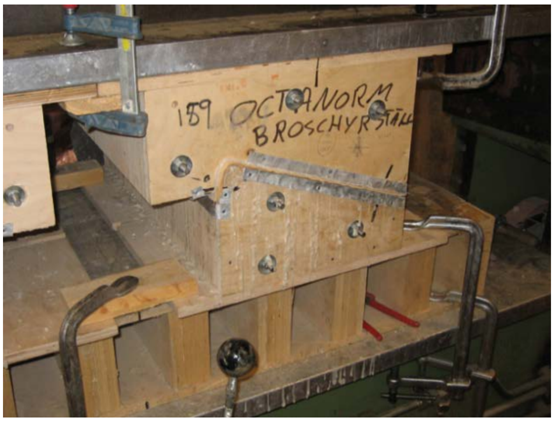
Table 1. Grouping of samples in the tests according to veneer orientation.

Group No.	Definitions	Variation in orientation of veneer (fibre deviation)	Orientation of veneer front to back*
1	Lengthwise veneer (L)	0°	L–T–L–T–L– T–L
	Transverse veneer (T)	0°	
2	Lengthwise veneer (L)	Surface veneer: L_7=+7°	L–T–L–T–L– T– **L_7**
	Transverse veneer (T)	0°	
3	Lengthwise veneer (L)	Surface veneers: L_1=-7°, L_7=+7°	**L_1**–T–L–T–L– T–**L_7**
	Transverse veneer (T)	0°	
4	Lengthwise veneer (L)	Surface veneers: L_1=+7°, L_7=+7°	**L_1**–T–L–T–L– T– **L_7**
	Transverse veneer (T)	0°	
5	Lengthwise veneer (L)	Veneer: : L_5=+7°	L–T–L –T– **L_5**– T–L
	Transverse veneer (T)	0°	
6	Lengthwise veneer (L)	0°	L–T –L–T–L– **T_6**–L
	Transverse veneer (T)	Faner: : T_6=+7°	

*The veneers that have different fibre deviation are in bold. Veneers are lengthwise (L) or transverse (T) oriented in the assembly. Adhesive is spread on both sides of the transverse veneers. Definitions can be found in Figure 2.

Moulding

A urea formaldehyde adhesive from Casco Adhesives, Inc., Sweden, was used (adhesive Cascorit 1274 and hardener 2584). High frequency (HF) heating was used and was switched on for 1 minute. Total press time was 4 minutes and 10 seconds. However, sometimes the shell stayed in the residual heat longer from the mould. Pressing of the samples was performed in less than two days. The press had two moulds for the shell but only one of them (the right, Figure 3a) was used for moulding samples for this study. The mean value of the applied surface pressure was 0.5 MPa. After the pressing, the shells were placed in a stance to be cooled down uniformly, Figure 3b.



a) *b)*

Figure 3. a) Mould where the shell was laminated, and b) stance for newly pressed shells.

Measurement of the shape

The measurements of the shells were performed in a gauge with 10 measurement points, Figure 4.

Position was calculated as the average distance between the shell and the gauges, measurement points 1 and 5. The first measures at day zero were comparable to what is usually called spring-back. The distance between point 1 and 5 was 567 mm. The height of measuring points 1 and 5 was 255.5 mm.

Twist was calculated as the difference in distances between the shell and the gauge measurement points 1 and 5. Positive (+) values are counter clockwise and negative (-) values are clockwise, as seen from the side measurements.

Cupping was calculated as the distance between the calculated straight line between measuring points 1 and 5 and measuring point 3. Positive (+) values are values beyond the line and negative (-) values are inside the line, as seen from the side of measurement.

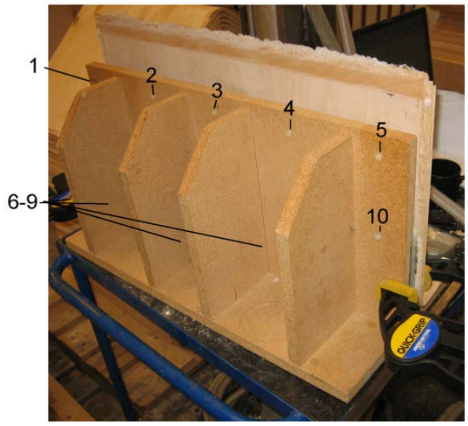


Figure 4. *Gauge for measuring of shape. The numbers in the image indicates measuring the positions and designations.*

After moulding and measuring, the shells were moved to a climate chamber, where they were exposed to climate cycling, Table 2

Table 2. *Measurement occasions and climate during the test.*

No.	No. of days after the press	Test site	Climate before measurement (moisture content)	Time in the respective climate * (days)
1	0	Production	-	0
2	41	Climate chamber	20°C/20 % RH (4.5 %)	41
3	89	Climate chamber	20°C/90 % RH (21 %)	48
4	103	Climate chamber	20°C/20 % RH (4.5 %)	14

* Number of days in respective climate before respective measurement.

Result – fibre orientation in the veneers

Figure 5 shows the mean values of position for the different test groups. Group 3, which had crossed oriented surface veneer, was the most mobile during the climate cycling.

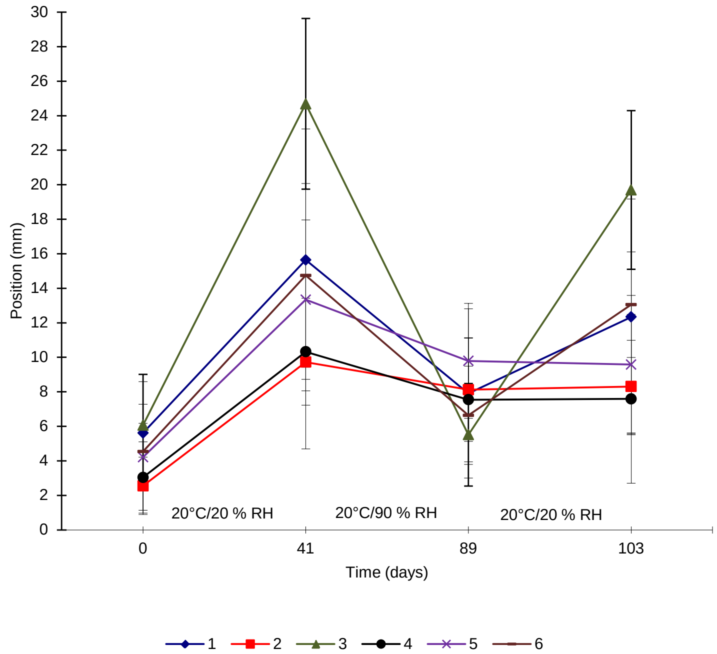


Figure 5. *Mean position in shells manufactured with veneers with different fibre orientations. Test groups 1-6 according to Table 1.*

Figure 6 shows the mean values of twist for the different test groups. The least twisted was group 1, which could be considered as the reference because group 1 does not have any divergent fibre orientation. Regarding twist, group 4 was almost as shape stable as group 1, followed by groups 6, 5, 2, and 3. Again, group 3 showed the poorest shape stability.

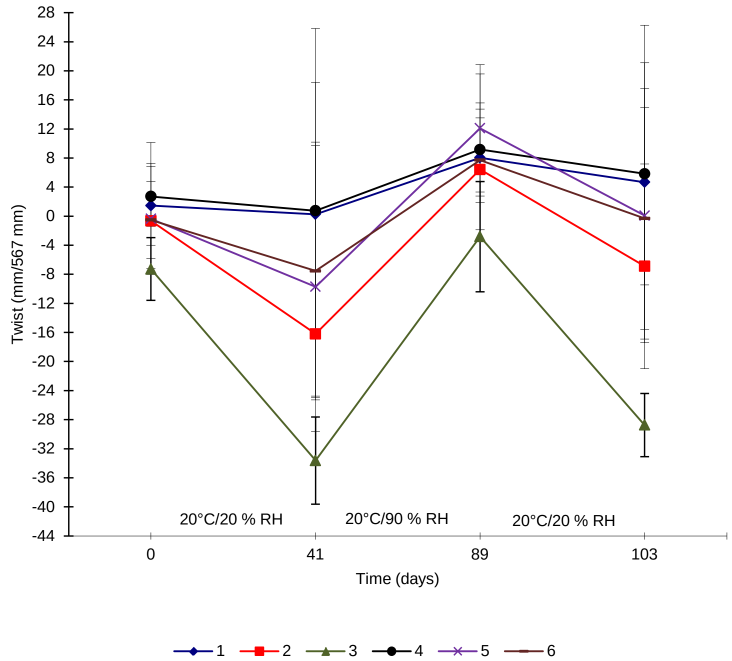


Figure 6. *Mean twist in shells manufactured with veneers with different fibre orientations. Test*

groups 1-6 according to Table 1.

Figure 7 shows the mean values of cupping for the different test groups. Groups 1, 4, and 5 behaved similarly. Group 2 was a little more cupped than the already mentioned groups. In addition, group 2 had a negative direction in the dry climate in contrast to the other groups. Group 3 was more cupped than group 2. The most cupped was group 6, which had a significantly larger cupping than the other groups. The difference between group 6 and the other groups was that group 6 had a veneer with divergent fibre orientation in the transverse direction.

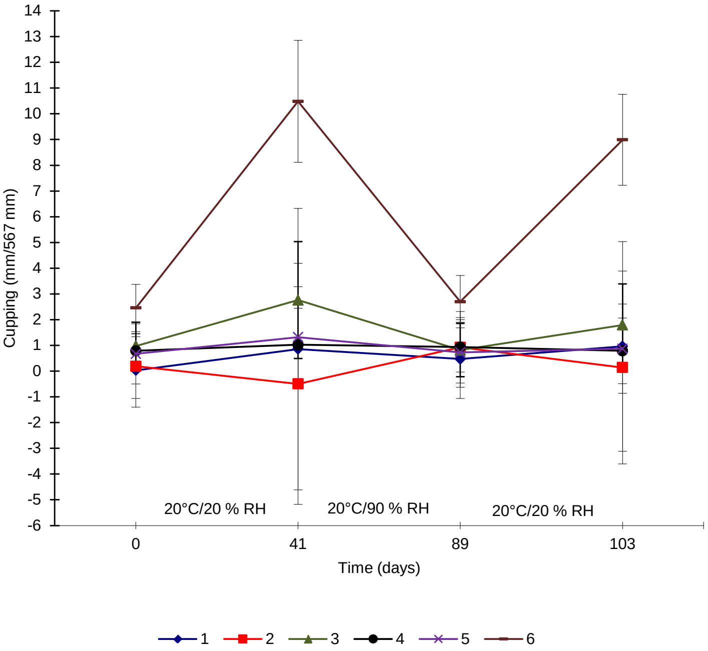


Figure 7. Mean cupping in shells manufactured with veneers with different fibre orientations. Test groups 1-6 according to Table 1.

Conclusion

In a perpendicular laminated veneer product the best option is to orient every second veneer by exactly 90º to each other, which is known from the literature.

Symmetry is always desirable, as evidenced by similarly divergent oriented surface veneers. Otherwise perfectly oriented veneers have the next best shape stability in this study.

Divergent fibre orientation in a lengthwise oriented veneer in the assembly is not as bad as divergent orientation in a surface veneer.

Crosswise divergent orientations of the surface veneers are much worse than divergent orientation of just one surface veneer.

Divergent orientation of a transverse veneer affects cupping more than any other option in this test.

Reference

Boulton, B. C. (1920). The manufacture and use of plywood & glue. (London, New York: Sir Isaac Pitman & Sons Ltd).

Cassens, D., Leng, Y. and McCabe, G. (2003). Face check development in veneered furniture panels. Forest Products Journal, 53, 79–86.

Hvattum, O., Lind, P. and Osvik, H. (1978). Springback of laminated bends. Norsk Treteknisk Institut (NTI, Norway), Technical Report 16.

Lind, P. (1981). Corner joints and laminated bends – movements causes by moisture changes. Norsk Treteknisk Institut (NTI, Norway), Technical Report 26.

Navi, P. and D. Sandberg (2012). Thermo-hydro-mechanical processing of wood. Lausanne, EPFL Press.

Ormarsson, S. and Sandberg, D. (2007). Numerical simulation of hot-pressed veneer products: moulding – spring-back – distortion. Wood Material Science and Engineering, 2, 130-137.