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MOISTURE-INDUCED DISTORTION OF LAMINATED VENEER PRODUCTS

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ABSTRACT

Laminated veneer products consist of veneers bonded together with adhesive into a predetermined shape. Since wood is a hygroscopic material and also anisotropic by nature, laminated veneer products are especially shape-sensitive to changes in moisture content. A deviation from the intended shape is a problem for both the manufacturers and users of the final products and annually such deviations cause great economic losses in the manufacturing industry.

To illustrate the influence of moisture on distortion and shape stability, studies have been performed in industrial conditions and in a laboratory environment. Veneers of beech and birch and a seat shell moulded from these veneers were used in the study. Distortion, i.e. spring-back, position and twist, has been determined directly after moulding and during subsequent moisture and drying cycles.

The distortion follows more or less slavishly the changes in relative humidity around the product. The distortion is generally small directly after moulding but, after the laminates have been exposed to a variation in relative humidity, the distortion increases. Some of the problems of poor shape stability that may arise later in the bending process can be reduced if attention is paid to moisture content and fibre orientation already in the production of the veneer.

To achieve good shape stability of laminated veneer products in practice, the following should be followed by the manufacture industry:

- develop cooperation with suppliers of veneer and set requirements of veneer with regard to deviation of the fibre orientation, and require that the veneer be dried and conditioned to a moisture content consistent with production,
- control incoming veneers with respect to fibre orientation and moisture content,
- plan warehousing of veneers and ensure adequate conditioning, and
- consider the orientation of the veneers and the species.

Key words: thermo-hydro-mechanical processing, shape stability, wood

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INTRODUCTION

Laminated bending or laminated moulding involves the simultanious forming and gluing of veneers, usually without end pressure, against a mould. An elastic spring-back always occurs when the product is unloaded after pressing. Twisting may also occur and this is very troublesome in the production and use of laminated veneer products. When the product is in use and especially when it is exposed to variations in moisture content the distortion of the product may vary (Blomqvist 2013).

The anisotropic and hygroscopic nature of wood causes wood to shrink and swell differently in its principal directions, **Fig. 1**. This is true below the fibre saturation point. This behaviour of wood is important for the behaviour of laminated veneer products as well as for the phenomenon of shape stability.

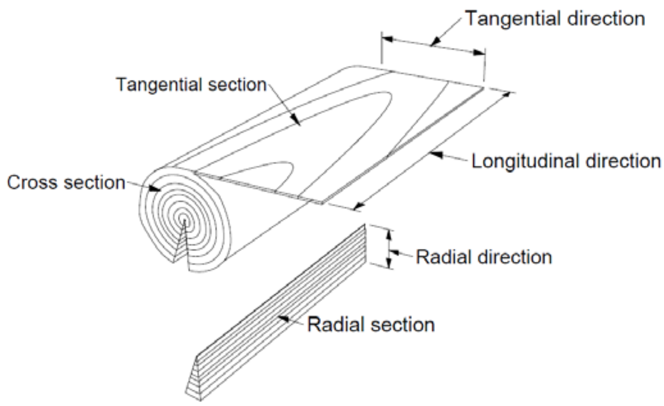

Fig. 1. The principal directions and principal sections of wood.

Table 1 show some basic properties of beech and birch, which are the species studied in this work. Beech has a greater shrinkage than birch in the tangential direction. The difference in E-modulus perpendicular to the fibre results in a need for differences in product design between beech and birch. Rotary cut veneer is the most frequently used type of veneer in laminated bending and it has the LT-direction in the plane of the veneer, Fig. 1. This means that the in-plane shrinkage and swelling of such a veneer is greater than that of a veneer cut in other directions.

Table 1. Some properties of beech and birch (Perem and Thunell 1952). MC – moisture content, FSP – fibre saturation point, parallel to (//) and perpendicular to (⊥) the fibre direction.

	Density at 0 % MC	Shrinkage (%) from FSP to 0 % MC			E-modulus at 12 % MC (MPa)		Strength at 12 % MC (MPa)				
	(kg/m^3)	R	T	L	//	⊥	Bending	Compression	Tensile		
								//	//	⊥ radial	⊥ tang.
Beech	680	5.8	11.8	0.3	16,000	1,500	105	53	135	7	7
Birch	580	5.3	7.8	0.6	15,000	800	107	53	137	7	7.5

Background

A manufacturer of laminated veneer products had problems with poor shape stability in his products during periods of the year when the climate is characterized by high humidity. The manufacturer re-dried the veneers over this period to ensure dry veneers, but it could take several days after the drying before the veneers were moulded. This study illustrates the consequences of an inappropriate moisture content of veneer and the effects which this can have on the final products. Climate levels and moisture content levels have been selected on the basis of actual climatic variations that may occur in production and an indoor environment during the year in northern Europe.

MATERIAL AND METHODS

In this study, veneer of beech (*Fagus silvatica* L.) or birch (*Betula pubescence* Ehrh.) have been used. The tests have been performed on both single veneers and on veneers laminated to a seat shell. The peeled veneers used in the study were taken from regular production. The veneers were free from knots, cracks or other openings. Unless otherwise stated, the fibre orientation was straight, i.e. parallel to two sides of the veneer laminate, and each veneer was measured with respect to fibre orientation. The in-plane dimensions of the veneers were 1055x500 mm. All the veneers were conditioned to equilibrium moisture content in a climate chamber before the tests and the moisture content was varied in different tests. The orientation of each veneers in the seat shell was perpendicular to that of the adjacent veneer. Three different tests have been performed:

Test 1. Moisture content variation in veneer during storage

The purpose of test 1 was to find out how the moisture content of veneers that are stored in production is affected by humidity changes. The design of the test sought to simulate the circumstances when the veneers are taken from a dryer (low moisture content) and stored in a wet climate before moulding. The veneers were stored in packages consisting of 15 beech or birch veneers, with sticks between each package, and the climate was changed from 18% to 90% relative humidity at a constant temperature of 20°C and back again to the dry climate. Before moistening, the veneers had a moisture content of 4 %.

Test 2. Influence of veneer moisture content variation on distortion

The purpose of test 2 was to see the effect on shape stability of differences in moisture content between individual veneers in a laminate when the veneers where moulded to a seat shell. The levels of moisture content differance were based on the results from test 1. The distortion was measured a) directly after moulding and b) after 13 days storage at the manufacturing site. Position and twist were used to define the distortion of the product, Fig. 2. Position is defined as the *mean distance* between the backrest and the gauge at two measuring points shown in the figure. Position is equal to zero if the seat shell fits snugly against the mould. If the shell is opened up, the position is positive (+) and if it is closed, the position is negative (-). This means that the position when the shell opens up after pressing is equal to what is normally defined as spring-back. Twist was defined as the difference between two points, with a distance of 235 mm from each other. A gauge was constructed to measure the position and twist of the seat shell. The gauge is placed on three reference points in the seat shell seat and measurements were made at two points on the back of the seat shell. A total of 90 seat shells were tested.

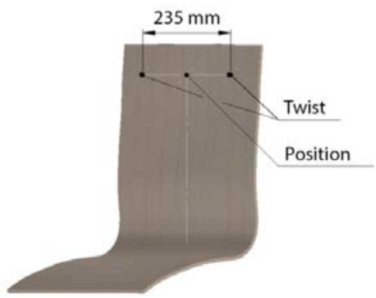

Fig. 2. Definition of distortion of a moulded seat shell.

Test 3. The influence of changing RH on the shape stability of a laminate
The purpose of test 3 was to study how deviations in fibre orientation influence the distortion of the seat shell, and especially to see how distortions are influenced by variations in relative humidity around the product.

The seat shell and definitions of distortion were the same as in test 2. The veneers were straight grained and differences in fibre orientation of individual veneers were achived by turning one veneer in relation to the other. The seat shell was measured directly after the moulding and after various periods of storage at different levels of constant relative humidity. The distortion was determined in the same manner as in Test 2. A total of 14 seat shells were tested.

RESULTS AND DISCUSSION

Test 1. Moisture content variation in veneer during storage

Fig. 3 shows the moisture content of individual veneers in the package of fifteen veneers during storage in dry and in wet climates. 24 hours after the climate change from dry to wet (day 14 in Fig. 3) the outermost veneers in the package had a moisture content of about 12 %, compared to 5 % in the veneers in the middle of the package. Both beech and birch behaved similarly.

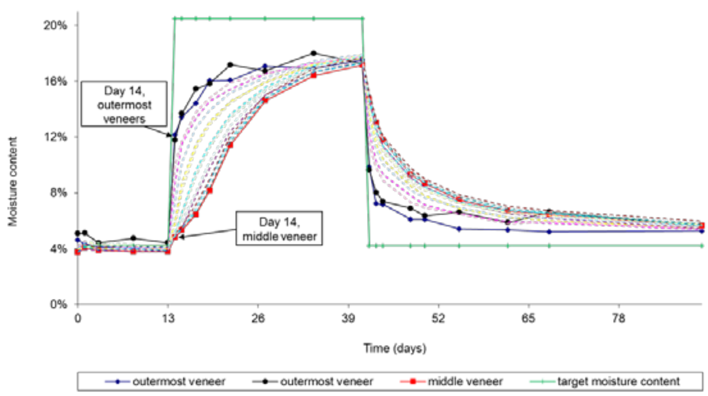

Fig. 3. Moisture content of individual birch veneers in packages of 15 veneers during humidification and drying cycles. Solid lines are the outermost veneers in the package and the middle veneer. The behaviour of the other veneers in the package is marked with dashed lines. The target moisture content corresponded to relative humidities of 18 % and 90 % at 20°C.

Test 2. Influence of veneer moisture content differences on distortion

Fig. 4 shows the position and twist for seat shells of birch with different moisture contents in some of the veneers in the laminate. Immediately after moulding, there were only small differences in position and twist for the different groups. After 13 days, the seat shells which had the most asymmetric moisture content profile exhibited a substantial reduction in position and increase in twist, i.e. poor shape stability. The shells with all the veneers at the same moisture content or with only one or both of the outermost veneers at a higher moisture content showed only a moderate change in shape during storage. The results indicate that, if the veneers are well-conditioned before moulding, the distortion of the moulded assembly in use is reduced, and that a high moisture content in several of the veneers in the assembly can lead to considerable distortion after moulding, especially when the moisture is asymmetrically distributed in the assembly.

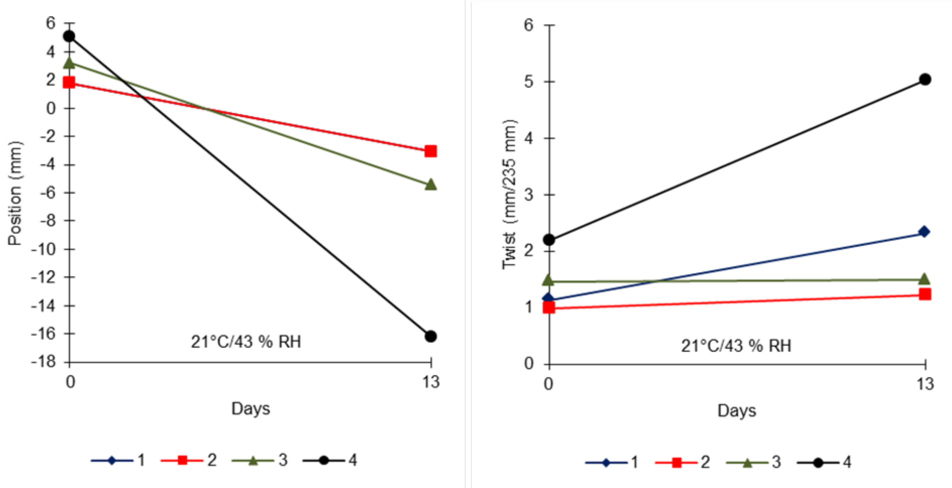

Fig. 4. Mean position and twist in seat shells of birch manufactured with veneers having different moisture contents and exposed to a constant climate: 1) All seven veneers with MC 5 %, 2) 5 veneers with MC 4% and surface veneers with MC 7 %, 3) the veneer closest to the concave side of the seat shell with MC 19 % and the rest of the veneers with MC 5% and 4) 3 veneers with MC 19 % closest to the seat shell concave side and 4 veneers with MC 5%. Groups 1 and 2 have the same position.

Test 3. The influence of changing RH on shape stability

Fig. 5 shows the position and twist for seat shells of beech with different fibre orientations in some of the veneer in the laminate. Distortion was in general small directly after moulding, but after the shells had been subjected to a change in relative humidity, the distortion increased considerably. The results show clearly that deviation in fibre orientation of individual veneers results in an increased spring-back and twist directly after moulding. After exposure to a cyclic relative humidity, there was no clear relation between position and fibre orientation. The influence of a deviation in fibre orientation on twist was clear. The seat shells with no fibre deviation or an irregular fibre structure showed a low twist after moulding and during humidity cycling. The twist that nevertheless occurs in these two groups may be a consequence of a variation in wood properties and the assembly of the veneers, or of an inaccuracy in the deformation measurement. The seat shells with the outer veneers orientated at 5° in opposite directions exhibited a small twist directly after moulding. During the first 48 days of storage, the seat shells dried and exhibited a dramatic increase in twist. When the relative humidity was increased to 90 % RH, the moisture content of the shells increased and the twist decreased and changed direction.

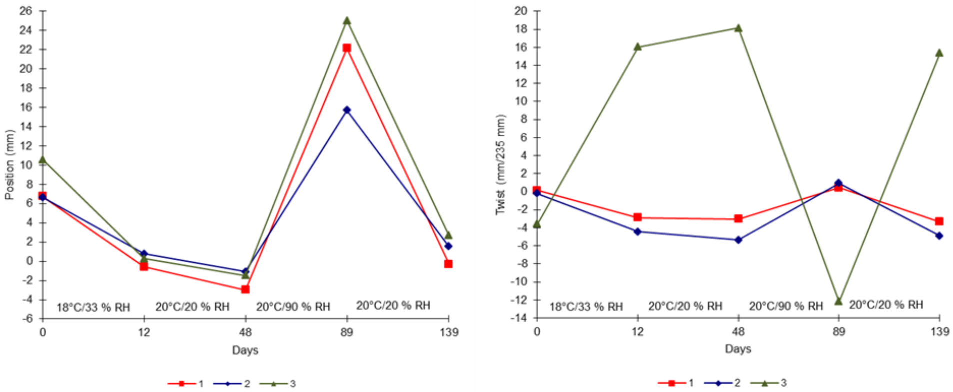

Fig. 5. Mean position and twist in seat shells of beech manufactured with veneers with different fibre orientations: 1) Veneers with no difference in fibre orientation, 2) Irregular fibre structure in transverse veneers and 3) Veneers with different fibre orientations in surface veneers, +5° and -5°

CONCLUSION

Distortion was generally small directly after moulding but, after the laminates had been exposed to a variation in relative humidity, the distortion increased. Position followed the relative humidity changes, i.e. an increase in RH resulted in an increased position. This was not the case with twist.

Problems with poor shape stability that may arise later during the moulding process can be reduced if attention is paid to fibre orientation and moisture content already in the production of the veneers. To achieve a good shape stability of laminated veneer products it is important to have straight grained veneer with an even moisture content at a level adapted to the use of the product.

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