Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 88, 2014: 297-303
(Ann. WULS - SGGW, For. and Wood Technol. 88, 2014)

# Strengthening of veneers for 3D-forming

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**Abstract:** *Strengthening of veneers for 3D-forming*. 3D – forming of veneers is used only in limited extent. The reasons are wood properties, mainly anisotropy of wood. In this paper, we propose some chosen methods for strengthening of veneers in directions parallel and perpendicular to the grains, with strengthening means such as hotmelt adhesive and glass fibre with adhesive coating. Properties of modified veneers were compared with the properties of reference – untreated veneers. We compared these properties: strength and deformations – extension in tension, strength and deflection in bending, and 3D – formability. From the results, we can conclude that referred treatments resulted in a slight improvement of 3D – formability.

*Key words:* veneer, forming, 3D – formability, strengthening , tension, bend

## INTRODUCTION

Three-dimensional forming of veneers (3D), despite interest, is practically used in very limited extent. The reasons are those wood properties, which are important if wood is under mechanical loading while it is 3D – formed; particularly small deformations and strength properties differing along and across wood grain. The wood strength properties parallel to grain are different from the strength properties perpendicular to grain. By modification of wood – veneers, these properties can be partially changed and so, we assume, formability of veneers can be improved.

Some possibilities for modification of veneers, respectively some other procedures aimed at increasing 3D – formability have been already published by VORREITER (1949). He sees some possibilities to increase the formability in plastification of veneers by chemical methods, in production of veneers from lengthwise compressed wood, or in creation of multi-layered veneer material. Some other authors (WAGENFÜHR et al. 2006, SCHULZ et al. 2012) dealt with improvement of 3D formability by production of veneer from compressed wood, by mutual gluing of veneers, by production of veneers slicing lengthwise, or by application of strap while forming wood.

In recent years, the procedure of f. Reholz (HUBER 2007) is the most succeed; the procedure is based on mechanical cutting of veneer into veneer tapes and subsequent cross linking of the tapes with a fibre.

One of the possibilities for modification of veneer properties, that became an object of our research, is strengthening, i.e. joining of veneer with some other material modifying native veneer properties in order of the objective pursued. This material will be called "strengthening means".

The term "strengthening mean" will be understood as solid material in the form of thread (fibre) or in the form of sheet material, strongly connected with veneer. Such means will be termed as "thread" or "sheet". Their function in relation to 3D forming of veneer is to increase the tensile strength perpendicular to wood grain, alternatively to increase deformations in the given direction.

In our case, the object of our research will be the thread strengthening mean. Properties of veneers with thread will be evaluated in planar, in bending, and in spatial loadings. The aim of the research is to get the knowledge about if the veneer formability can be increased using this kind of modification. Furthermore, the aim is to determine whether the test results for veneer in planar loading and in bending correspond to 3D – formability of the veneer.

## METHODS

Experimental tests were done in beech veneer (*Fagus sylvatica, L*), thickness of 0.56 mm, average moisture content of 8.5 %; veneers were natural (untreated) or modified with strengthening mean. The strengthening mean was a hotmelt adhesive applied in strips (width 2 mm) with spacing of 5 mm in direction perpendicular (alternative A) or parallel (alternative B) to wood grain. The other strengthening mean was glass fibre coated with thermoplastic adhesive (fibre used for splicing veneers), similarly applied on the veneer.

To evaluate the effect of the strengthening means, we chose a comparison principle; we compared examined properties of natural (untreated) veneers with strengthened (modified) veneers. We examined tensile strength and deformations – extension – in tension, the strength and deflection in bending, and deepening and value of force generating 3D forming. The mentioned properties were measured using the test machine Labortech type LabTest 4050. Speed in the tension test was 1 mm/min and in the other tests 10 mm/min.

The strength and deformations in tension were measured in specimens with plane dimensions 60 × 160 mm, bending strength and deflection in specimens 40 × 60 mm, 3D formability in round specimens having a diameter 60 mm. Each set contained 10 test specimens.

In tension test, the test specimen was clamped between the jaws of testing machine in the manner that working part of the specimen had a length of 60 mm. Bending test was done as three-point bending in a preparation where axial distance between the supports was 20 mm and the radiuses of the supports and the load mandrel were 4 mm. The reason for designed parameters of the preparation was to maintain similar conditions as at the proposed test of 3D formability; and thus the same radius of curvature of the supports and the gap size between loading mandrel and the supports (punch and die).

Test of 3D formability was done in the preparation with a circular hole in the matrix with a diameter of 44 mm and a punch with a diameter of 40 mm. The principle was in pushing the punch into the veneer. The maximum value of deepening of veneer before rupture became an indicator of 3D formability. During the test, the test specimen was circumferentially attached, while the distance between the matrix and the holder was defined with the spacer ring. The thickness of the spacer rings corresponded to the average thickness of the specimens after modification; the rings allowed horizontal movement of the specimens during the test and prevented undulation on the periphery of the specimen. Principal schemes of individual tests are illustrated in Figure 1.

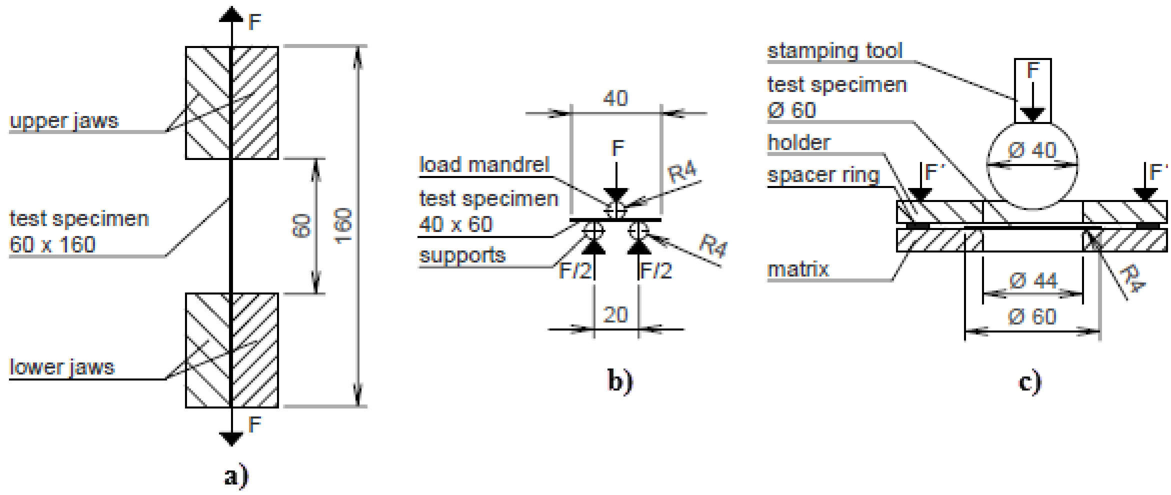


**Figure 1.** Principal schemes of individual tests
a) tensile strength test, b) bending strength test, c) test of 3D formability – the stamping tool with a spherical curvature – circumferentially attached specimen

## RESULTS AND DISCUSSION

The value of measured deformation was chosen as the basic indicator for evaluation of 2D and 3D formability. In tension, the indicator was the value of the extension; at bending test the value of deflection, and in test of formability the value of deepening. Other indicators, which helped us to evaluate the influence of types of modification on formability, were the value of necessary applied force and also the strength.

Measured values, obtained on the base of above mentioned methodology, were evaluated by multi-factorial analysis of variance using the program STATISTICA 10. The results of these analyses are shown in graphs.

Tension test was done in two directions considering wood fibres (parallel and perpendicular to grain), while strengthening means were always oriented in direction of loading. At tension test perpendicular to wood grain, we found a slight increase in extension in treated – strengthened veneer specimens when compared with reference specimens; while the more pronounced effect was demonstrated in specimens modified with the fibre (Figure 2). At tension test parallel to grain, the influence of treatment was not seen. The reason why the influence of treatment was seen at tension test perpendicular to wood grain we can see in very low strength of veneer in this direction when compared with parallel direction; whereas the strength and tensibility of strengthening means are not changing, so more significant effect was seen at specimens with lower strength. From this perspective, it appears that proposed methods of treatment enable to increase deformation in the direction perpendicular to wood grain, which we consider as one of the reasons of limited formability of veneer. As for the force needed for rupture of specimens, it significantly increased only in strengthening with hotmelt fibre in the direction perpendicular to wood grain.

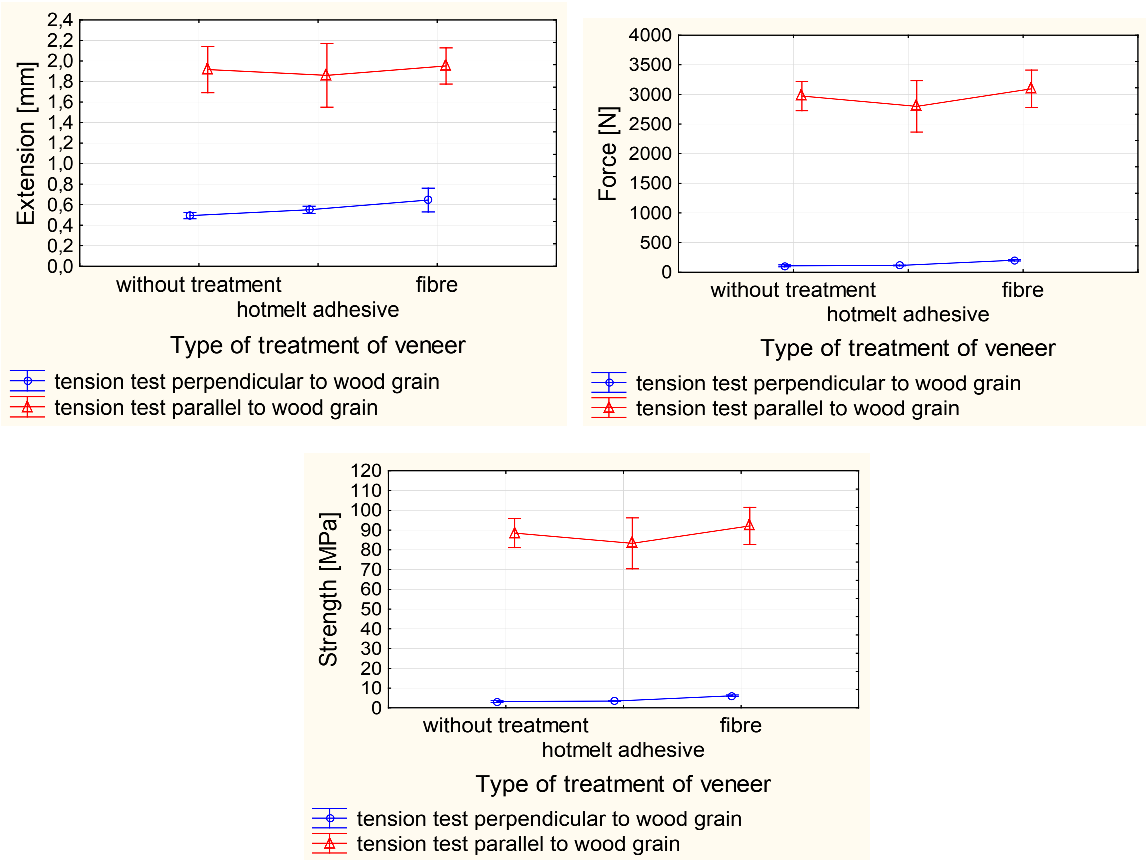


**Figure 2.** Dependence of the extension, force, and strength on type of treatment of veneer in tension test

Bending test was also done in two directions, parallel and perpendicular to the wood grain, while the test specimen was loaded always in a way that strengthening means were held perpendicular to the load mandrel. At the test, in both directions of loading, modified veneers showed greater deflection when compared with untreated ones; while there was significant increase in direction parallel to wood grain (Figure 3). Due to the nature of the bending test in direction parallel to wood grain, value of deflection depends on the ability of wood to deform in direction perpendicular to the wood grain. Comparing the results of this test with results from the bending test perpendicular to the wood grain, we can state that using proposed treatments of veneer we reached significant increase in deflection in the bending test parallel to wood grain and thus significant increase of formability of the veneer in direction perpendicular to wood grain – which we consider as one of the criteria to increase the 3D formability. As for the force applied to form and also the strength, they both increased at modified veneer when compared with untreated ones. Less force needed for forming the veneer and also the lower strength were measured at bending parallel to wood grain.

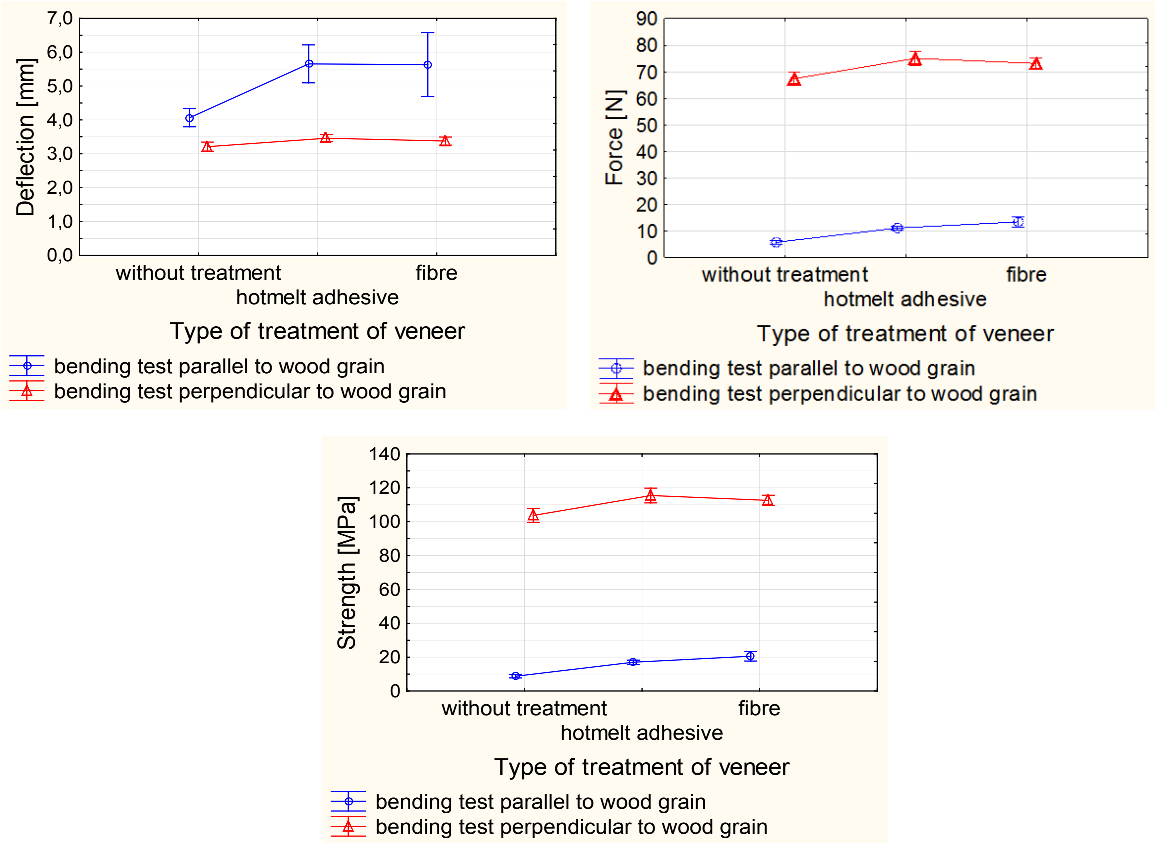


**Figure 3.** Dependence of the deflection, force, and strength on type of treatment of veneer at bending test

In formability test, the influence of strengthening of the veneer was also demonstrated. In comparison with reference specimens, deepening after strengthening with hotmelt adhesive was increased by 18 %. The most significant changes in formability were in specimens strengthened with fibre, where deepening was increased by 61 % (Figure 4). If veneers were strengthened with strengthening mean, the value of force needed for forming was increased; while the greatest force is needed for formation of veneers modified with a fibre.

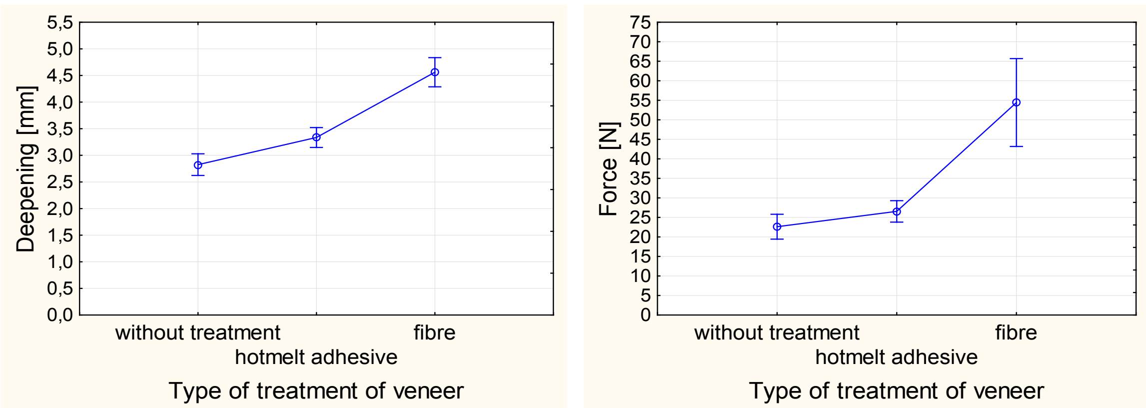


**Figure 4.** Dependence of the deepening and force on type of treatment of veneer at 3D formability test

CONCLUSION

All chosen tests have shown that proposed methods of strengthening of veneer have influenced the examined properties. Based on the results of tension and bending tests, we can conclude that partial information about the influence on 3D formability of veneers is given by the results of deflection at bending test parallel to grain, if strengthening mean is oriented in direction perpendicular to grain.

## Acknowledgment

The paper was supported by the VEGA agency from the project No. 1/0422/12 „Modification of wood properties for the purpose of 3-D compression molding".

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**Streszczenie:** *Wzmacnianie fornirów do formowania 3D.* Forniry charakteryzuje ograniczona formowalność. Przyczyną tego są własności drewna, głównie anizotropia. Praca prezentuje wybrane sposoby wzmacniania fornirów w kierunku poprzecznym i prostopadłym do włókien, za pomocą klejów topliwych i samoprzylepnych mat szklanych. Zbadano własności takich wzmocnionych fornirów z fornirami niemodyfikowanymi. Porównano wytrzymałość i elastyczność w rozciąganiu, zginaniu oraz formowalność 3D.

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