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Assessing the effects of thickness of beech veneers on compressibility of plywoods*

Procjena utjecaja debljine bukova furnira na uprešavanje furnirskih ploča

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ABSTRACT • *The assessment of the effect of thickness and thickness tolerances of beech veneers on the value of compressibility in relation to production parameters was carried out on a series of plywood whole-beech sheets of the nominal veneer thickness of 1.5 mm. The plywood sheets were manufactured as seven-ply sheets, and urea-formaldehyde resin DUKOL S was used in their manufacture. The following characteristics were assessed: thickness differences, size of shrinkage and compressibility of veneers. The sheets were pressed using a pressure of 1.5 $N \cdot mm^{-2}$ and 1.7 $N \cdot mm^{-2}$. Values of changes in the thickness of veneers in pressed veneer sheets were then statistically analysed, as well as coefficients of compressibility of particular properties. The basic economic evaluation was made of the effect of compressibility on the level of production costs.*

***Keywords**: plywood, density of plywood, beech veneer, compressibility, shrinking*

SAŽETAK • *Procjena utjecaja debljine i tolerancije debljina bukovih furnira na vrijednosti uprešavanja ploča uzimanjem u obzir parametara proizvodnje obavljena je na skupini uzoraka bukovih furnirskih ploča izrađenih od furnira nominalne debljine 1,5 mm. Furnirske ploče proizvedene su kao sedmeroslojne, a prilikom proizvodnje korištena je ureaformaldehidna smola DUKOL S. Praćene su ove veličine: razlike u debljini furnira, veličine utezanja, uprešavanje furnira. Furnirske su ploče prešane tlakom 1,5 $N \cdot mm^{-2}$ i 1,7 $N \cdot mm^{-2}$. Vrijednosti promjene debljine furnira u prešanim furnirskim pločama i koeficijenti uprešavanja statistički su analizirani. Osnovna ekonomska procjena obavljena je na temelju utjecaja gubitka debljine ploča na troškove proizvodnje.*

***Ključne riječi**: furnirska ploča, gustoća furnirske ploče, bukov furnir, uprešavanje, utezanje*

1 INTRODUCTION
1. UVOD

Plywood materials are manufactured by pressing sets of veneers glued with a synthetic resin in hot presses under pressure.

The strength of plywood is determined by the thickness of veneers. The length and width of plywood can be arbitrarily changed during the design phase (through cutting, setting and special joints). The plywood thickness is of considerable importance for the construction strength. For example, in dealing with

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strength properties of structures or constructions, the thickness of sheets is solved first and only then plans are made related to cutting, placing and forming the sheets. To influence the thickness means to affect physical and mechanical properties of a sheet and thus also a building or other construction.

The effects of thickness loss (compressibility) do not only change density and strength but also other properties related indirectly to the change in density. The preservation of residual stress in wood is a problem occurring after pressing plywood sheets. The stress is the cause of unevenness in these sheets.

In pressing plywood sheets compression of the set of veneers occurs due to the combined effect of pressure, temperature and other factors. Generally, it refers to the compression stress across the wood fibre. Two types of deformations occur during pressing: elastic deformations and permanent deformations (compressibility). The effect of total deformation (i.e. elastic and permanent) is the decrease of thickness of the set of veneers after pressing. With respect to the elastic behaviour of wood, partial spring mounting (cushioning) occurs after pressing, the so-called elastic deformation. Thus, compressibility is the difference between total deformation and elastic deformation of wood.

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

Assessing the effect of production parameters on changes in compressibility and physical and mechanical properties was carried out on the set of plywood whole-beech sheets of veneer thickness of 1.5 mm and dimensions 10×2575×1335 mm. The plywood sheets were manufactured as 7-ply sheets with the use of urea-formaldehyde resin. Thickness differences, shrinkage and compressibility of veneers were assessed.

Within the study, twelve plywood pabels were pressed of specific thickness and of specific physical and mechanical properties. The sheets were pressed using a pressure of 1.5 $N \cdot mm^{-2}$ and 1.7 $N \cdot mm^{-2}$. For the manufacture of experimental plywood sheets, veneers were selected according to special methods. This method of selection was based on measuring the thickness of particular veneers in pre-determined places. The results were statistically ordered from the smallest to the greatest average thickness. Veneers were assembled in such a way as to provide that the first plywood sheet be made of veneers with the smallest thickness tolerance, and veneers with gradually higher thickness tolerances (of higher serial number) were to be used in other plywoods. Thickness measurements were then carried out in these plywoods. The aim of the measurement of veneer thickness was to establish the effects of different thickness of veneers on the tolerance of a pressed plywood sheet.

The measurement of thickness was carried out both in wet newly peeled veneers and in veneers after drying. Within the study, the shrinkage of veneers was determined during the technological flow. Differences in the thickness of veneers represent the radial shrinkage of beech wood. The thickness of a plywoods was measured in total at seven points of measurement (Fig. 1).

3 RESULTS AND DISCUSSION
3. REZULTATI I DISKUSIJA

Mean changes in the thickness of veneers for particular pressed plywoods and mean values of coefficients of compressibility are given in Tab. 1. Fig. 2 presents mean coefficients of compressibility of pressed plywood sheets.

Plywood sheets Nos. 1, 2 and 3 (set A) and plywood sheets 7, 8 and 9 (set C) were pressed using a pressure of 1.5 N.mm-2. Plywood sheets 4, 5 and 6 (set B) and plywood sheets 10, 11 and 12 (set D) were pressed using

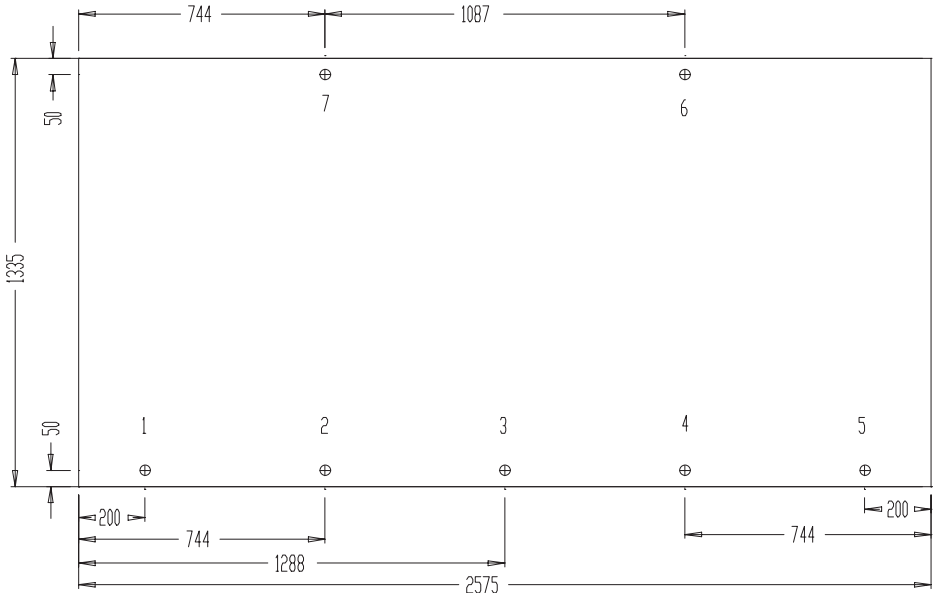

Figure 1 Points of measurement of veneer thickness
Slika 1. Mjesta mjerenja debljine furnira

Table 1. Mean values of coefficients of compressibility and mean changes in the thickness of veneers for particular pressed plywoods
Tablica 1. Srednje vrijednosti koeficijenata uprešanja i srednje promjene debljine furnira za pojedine prešane furnirske ploče

Plywood sheet No. *Broj furnirske ploče*	**Pressing pressure** *Tlak prešanja* N·mm^{-2}	**Mean change in thickness** *Srednja promjena u debljini* mm	**Mean values of coefficients of compressibility** *Srednje vrijednosti koeficijenata uprešavanja* %
1	1.5	0.112	7.15
Set A 2	1.5	0.120	7.57
3	1.5	0.129	8.12
Mean value *Srednja vrijednost*		0.120	7.61
4	1.7	0.140	8.79
Set B 5	1.7	0.145	9.04
6	1.7	0.136	8.44
Mean value *Srednja vrijednost*		0.140	8.76
7	1.5	0.138	8.52
Set C 8	1.5	0.151	9.24
9	1.5	0.160	9.77
Mean value *Srednja vrijednost*		0.150	9.24
10	1.7	0.182	11.09
Set D 11	1.7	0.176	10.70
12	1.7	0.186	11.21
Mean value *Srednja vrijednost*		0.181	11.00

a pressure of 1.7 N.mm-2. Plywood sheets of the set A show identical tolerances as plywood sheets of the set B.

The mean value of shrinkage of peeled beech veneers amounted to 6.99 %, minimum 4.61 % and maximum 10.42 %. Fig. 3 presents the values of shrinkage of particular beech veneers.

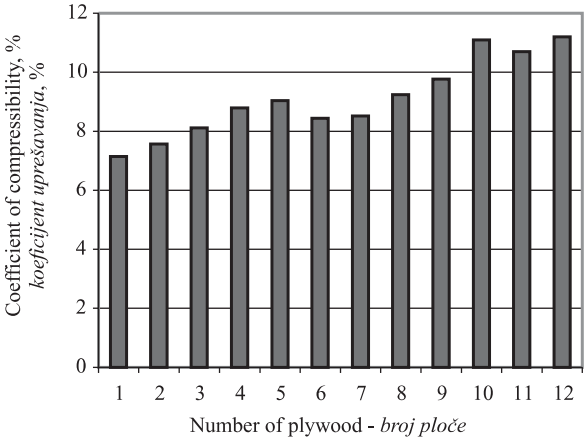

Figure 2 Mean coefficients of compressibility of plywoods Nos. 1 – 12
Slika 2. Srednje vrijednosti koeficijenata uprešavanja furnirskih ploča 1 – 12

4 CONCLUSION
4. ZAKLJUČAK

This paper summarizes the results of the institutional research in the field of evaluation of properties of wood-based composite materials. The objective of the paper was to analyse the thickness of rotary-cut beech veneers in wet condition and after drying, thickness tolerances and the rate of their dimensional reduction expressed as the coefficient of compressibility after their pressing to plywood sheets as well as the extent of shrinkage of particular veneers. For this purpose, twelve plywood sheets of specific composition and thickness were manufactured under operational conditions. Sets of veneers were assembled in such a way as to provide that the first plywood sheet be manufactured from the thinnest veneers and the last one from the thickest veneers. Thus, the thickness-variable set was analysed and statistically evaluated.

Compressibility is made possible by free cell spaces, which are filled with air. Due to the effect of pressure, cell walls recede into these spaces. The space changed in this way shows higher density and strength. Effects of pressure do not only change density and strength but also other properties related indirectly to the change in density. The preservation of residual stress in wood is a problem occurring after pressing

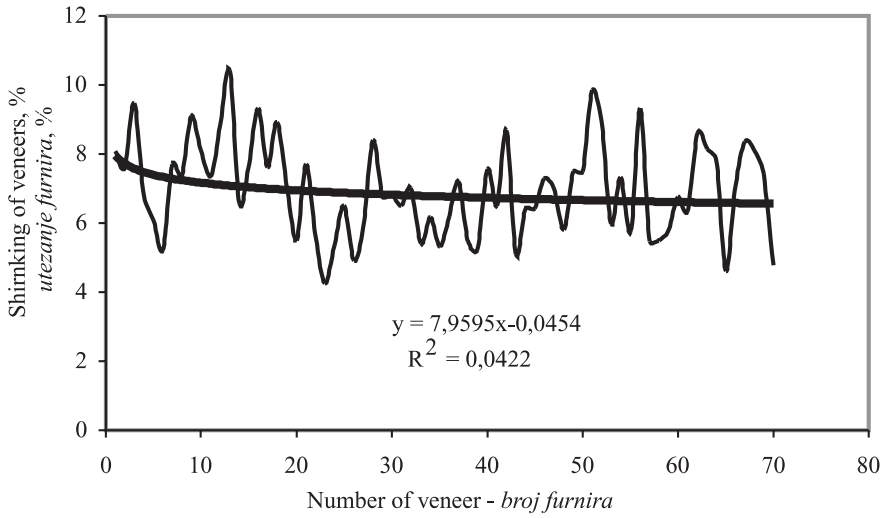

Figure 3 Extent of shrinkage of peeled beech veneers
Slika 3. Utezanje ljuštenog bukova furnira

plywood sheets. The stress is the cause of additional unevenness in these sheets. Based on properties of analysed plywoods, it was established that they showed various behaviour under various types of stress.

Tests proved that the coefficient of compressibility increased with decreasing thickness of veneers in a plywood sheet. Using the higher pressing pressures of 1.7 $N \cdot mm^{-2}$, the coefficient of compressibility increased by 6.29 %, as compared with standard pressing pressures of 1.5 $N \cdot mm^{-2}$. The coefficient of compressibility ranges from 7.15 to 11.21 %. The thickness of particular veneers was reduced on average by 0.112 - 0.186 mm (Tab. 1). Among particular sheets, an average difference in thickness amounted to 0.095 mm. Veneers of the smallest thickness were used in sheet No 1 and those of the highest thickness in sheet No 12. Thus, the smallest mean thickness is in sheet No 1, viz 1.56 mm and the greatest one in sheet No 12, viz 1.66 mm.

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