Effects of different pressing conditions on properties of spruce plywoods

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ABSTRACT: The paper presents results of an institutional research aimed at assessing the effect of different technological conditions in pressing on physical and mechanical properties of plywood sheets. Spruce plywood sheets of the veneer nominal thickness of 3.0 and 3.5 mm were analyzed. The plywood sheets were produced as five-ply and BAKELITE PF B118 phenol-formaldehyde adhesives were used for there manufacture. In relation to a different pressing temperature 115, 120 and 125°C and a different specific pressure, density, bending strength, MOE in bending and glue-bond strength by a shear test were assessed. The determined values of properties were statistically tested.

Keywords: plywood; plywood density; bending strength; MOE in bending; pressing temperature; statistic analysis

Plied veneered materials overcome largely three crucial drawbacks of solid wood by their construction arrangement: material anisotropy and heterogeneity, insufficient dimensional stability in the course of changes in the moisture content and problems in creating large areas and forms. However, to a certain extent, they maintain original properties of natural wood particularly appearance and favourable relationships of mechanical strength to plywood density. Plied veneered materials are characterized by large-area dimensions, uniform mechanical properties and greater resistance to outside effects. Properties of constructional veneered materials are particularly determined by their structure – construction. The permanent and ingenious study of interrelations between the structure and properties is thus the target point of studying the materials. Improving technological and production methods supposes above all the very detailed degree of knowledge of connections and phenomena under co-operation of effect factors and possibilities of action on processes in such a way to be realized under the most suitable conditions with optimum results (Král, Hrázský 2004).

The density of plied veneered materials is an important evaluation character being in intense correlation with the majority of their properties. Under identical production conditions, these correlation relations can be considered to be constant. The fact can be used in the production of materials with planned physical and mechanical properties.

The construction of plied veneered materials is created by pressing composite sets of veneers single-coated or double-coated by synthetic resins in hot presses under co-operation of the temperature field of various intensity. The process of pressing in a hot press resulting in thickening and creating the density profile is dependent on the extent of resistance of particular plies to pressing. The structure (construction) of material resulting from the profile of their thickness (which is a dimension determining material characteristics) is decisive (Poláčik 1982).

All degrees of the production process participate in the density profile which is created in the course of pressing in a hot press. Effects of an actual production facility on the density profile are dependent on actual operating conditions. The plywood sheet

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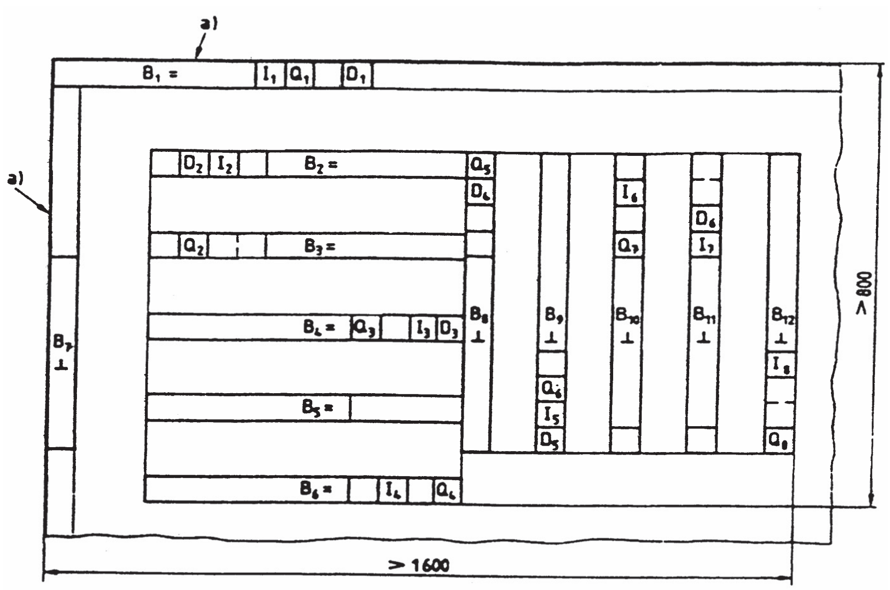

Fig.1. The scheme of sawing for sampling
= longitudinal type of sampling, ⊥ transverse type of sampling, D_1–D_6 density, B_1–B_{12} bending strength, MOE in bending, Q_1–Q_8 humidity, I_1–I_8 glue-bond strength by means of shear strength

construction, the method and the amount of adhesive and pressing parameters are underlying. All these factors are interdependent. Bending stress occurs obviously in the wide scale of technical applications of plied veneered materials. For example, in determining strength properties of constructions of buildings or in using the materials for vehicles the thickness of sheets is dealt with first in relation to their position and requirements posed on them and only then their format is dealt with Matovič (1993).

The perfect knowledge of strength properties of plied veneered materials for various purposes of use makes possible to create new materials composed to an optimum construction the structure of which to a great extent determines to reach maximum economic effects during their manufacture and thus also their competitiveness. Optimization of the process of pressing ranks among the most effective measures to increase the quality of plied veneered materials with minimum costs.

MATERIAL AND METHODS

Effects of different temperatures during pressing on the physical and chemical properties were assessed in spruce plywood sheets of the veneer nominal thickness 3.0 and 3.5 mm and format dimensions 15 × 1,250 × 2,500 mm. The plywood sheets were produced as five-ply and BAKELITE PF B118 phenol-formaldehyde adhesive (160 g/m^2) was used for their manufacture. The period of pressing was 14 minutes at a specific pressure of 0.9 N/mm^2; 1.1 N/mm^2 and 1.4 N/mm^2. The construction consists of the following plies: SM (spruce) 3.0 mm longitudinal; SM 3.5 mm transverse; SM 3.0 mm central; SM 3.5 mm; SM 3.0 mm.

In sets of plywood sheets pressed using the given specific pressure and pressing temperatures 115, 120 and 125°C, effects were assessed on density, bending strength, MOE in bending and glue-bond strength by means of shear strength. The scheme of sawing for sampling is depicted in Fig. 1.

Sampling and determination of physical and mechanical properties were carried out according to CSN EN standards.

RESULTS AND DISCUSSION

Discussions concerning measured results were aimed at the sample moisture in measuring, density, bending strength, MOE in bending, glue-bond strength in three sets of plywoods pressed at a temperature of 115, 120 and 125°C and specific pressure 0.9, 1.1 and 1.4 N/mm^2. Sets of measured data were tested for normality and after accepting the test the sets were evaluated by descriptive statistics and correlation analysis.

Plywood moisture

Results of the measurement of plywood moisture are given in Fig. 2.

The mean moisture of plywoods ranged from 5.42 to 6.47%. The lowest moisture was found in Set No. 8 and the highest moisture in Set No. 9.

Plywood density

Results of the measurement of plywood properties and correlation analysis of density, strength and modulus of elasticity of the set of plywood sheets are given in Table 1. Correlation analysis gives information on

Table 1. Mean values of moisture (%), density (kg/m³), bending strength and MOE (N/mm²) of analyzed sets of plywoods Nos. 1–9

Plywoods set No.	1	2	3	4	5	6	7	8	9
Moisture	5.47	5.49	5.56	5.55	6.16	5.53	5.70	5.42	6.47
Density	475.99	509.95	488.39	488.92	506.64	525.41	503.10	524.47	547.41
Longitudinal specimens									
Bending strength	38.65	33.15	41.68	54.33	54.85	54.96	49.26	53.87	59.72
MOE	11,777.7	11,393.6	14,583.5	14,904.1	17,364.2	17,621.7	16,472.4	17,867.4	18,024.9
Transverse specimens									
Bending strength	38.37	37.28	35.38	32.87	40.07	42.08	33.56	43.66	44.50
MOE	5,794.1	5,876.1	6,455.0	5,869.6	6,447.5	6,897.5	6,450.2	6,681.6	6,730.6

interrelationships of measured quantities. The sets were tested for normality and met the tests.

Plywood density (Fig. 3) differs from that of natural wood. Higher density is given by pressing the set of veneers being determined by pressing parameters and the content of resin dry matter. The lowest density was reached in the set of sheets No. 1 pressed by the lowest specific pressure 0.9 N/mm² and at a lowest temperature of 110°C, viz 476 kg/m³. The highest mean density was achieved in the set of sheets No. 9, viz 547.4 kg/m³ (pressing power 1.4 N/mm², pressing temperature 125°C). Differences as compared to solid wood range from 25 to 97 kg/m³. Fig. 4 expresses the dependence of density on pressing temperature and Fig. 5 on pressing power.

Based on the correlation analysis of data there is the strong correlation dependence of plywood density on pressing temperature. The calculated coefficient of correlation amounted to 0.766.

Density and pressing power show strong correlation dependence (coefficient 0.982).

Bending strength and modulus of elasticity in bending

Mean values of the MOE in bending and bending strength of plywood sets Nos. 1 to 9 are given in Table 1 and Figs. 6 to 9. In relation to various technological conditions two basic types of test samples were assessed, viz a longitudinal type and a transverse type.

Bending strength ranged from 33.15 to 59.72 N/mm² and in the transverse type of samples from 32.87 to 44.50 N/mm².

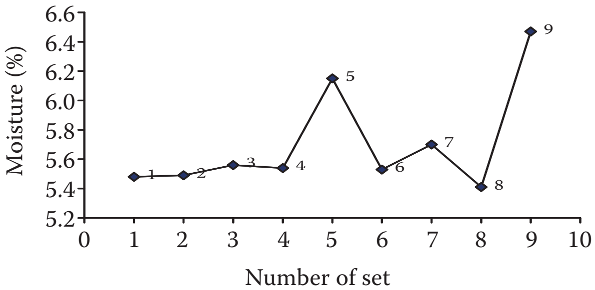

Fig. 2. Plywood moisture

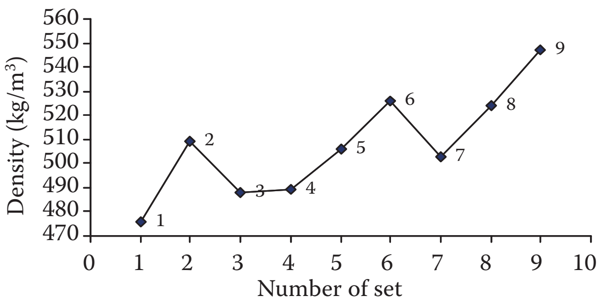

Fig. 3. Plywood density

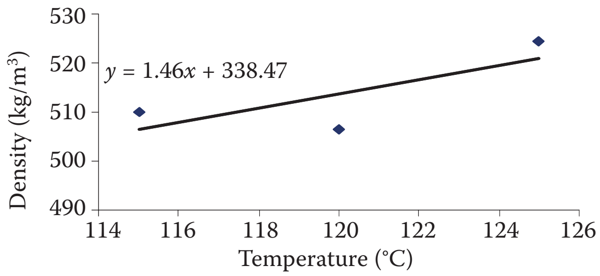

Fig. 4. Determination of the dependence of plywood density on temperature

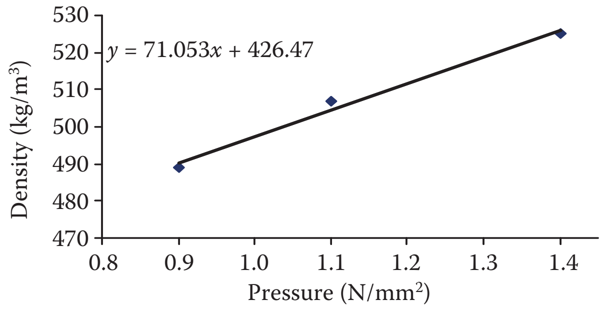

Fig. 5. Determination of the dependence of plywood density on pressure at standard temperature 120°C

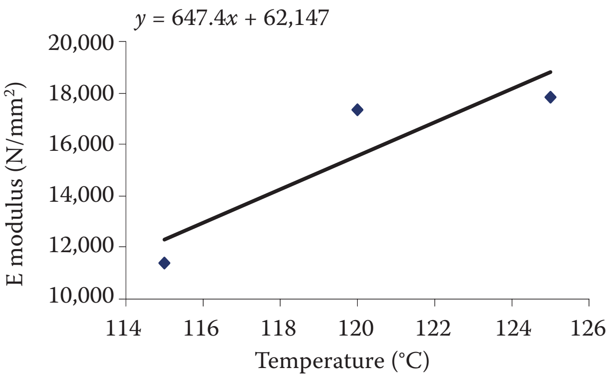

Fig. 6. Determination of the dependence of MOE on temperature at pressure 1.1 N/mm^2

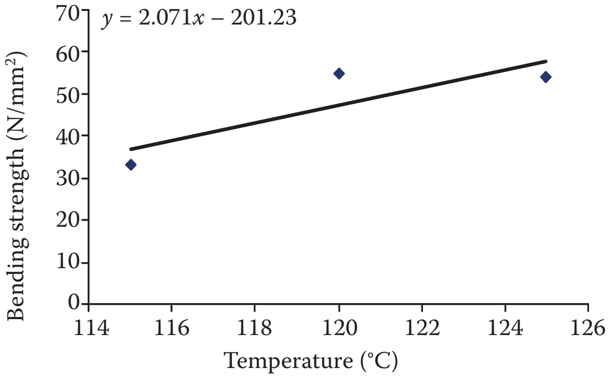

Fig. 7. Determination of the dependence of bending strength on temperature at pressure 1.1 N/mm^2

Thus, it follows that transverse specimens show virtually the same bending strength as longitudinal samples. This phenomenon can be explained in such a way that the lower (second) ply shows greater thickness during flexural stress (3.5 mm) than the first one (3.0 mm) taking over tensile strength. The specified strength amounting to 40 N/mm^2 in longitudinal samples was not fulfilled by sets No. 1 and 2. It follows that strength is fulfilled by all samples pressed at a temperature of only min. 120°C and min. pressure 1.1 N/mm^2. As for longitudinal samples the highest mean bending strength was shown by Set No. 9 (59.72 N/mm^2). The smallest mean value was shown by Set No. 2 (33.15 N/mm^2). As for transverse samples, the highest mean bending strength showed Set No. 9 (44.50 N/mm^2) and the smallest mean value was reached by Set No. 4 (32.87 N/mm^2).

The diagram depicts the heavy dependence of MOE on changes in a pressing temperature in the longitudinal type of samples (correlation coefficient 0.899).

The diagram depicts the heavy dependence of bending strength on changes in a pressing temperature in the longitudinal type of samples (correlation coefficient 0.845).

The diagram depicts the heavy dependence of MOE on changes in pressing power under the standard temperature of pressing in the longitudinal type of samples (correlation coefficient 0.851).

The diagram depicts the heavy dependence of bending strength on changes in pressing power at a standard temperature in the longitudinal type of samples (correlation coefficient 0.889).

Results of the measurement of MOE in bending are similar as in bending strength. They show an increasing trend with increasing temperature and pressure. Modulus of elasticity in bending ranged from 11,393.6 N/mm^2 to 18,024 N/mm^2 in longitudinal samples and from 5,794.1 to 6,897.5 N.mm^2 in transverse samples. The greatest MOE in bending in longitudinal samples occurred in Sample No. 9 (18,024 N/mm^2) and the smallest one in Sample No. 2 (11,393.6 N/mm^2). The greatest MOE in bending in transverse samples occurred in Sample No. 6 (6,897.5 N/mm^2) and the smallest one in Sample No. 1 (5,794.1 N/mm^2).

It follows that changes in a pressing temperature and specific pressure affect substantially values of MOE and bending strength. Longitudinal samples show bending strength 33.2 N/mm^2 at the same

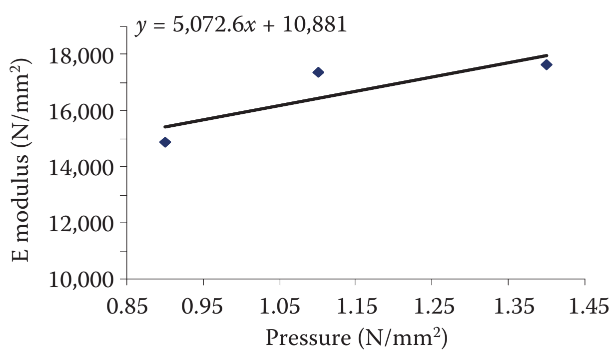

Fig. 8. Determination of the dependence of MOE on pressure at a standard temperature of 120°C

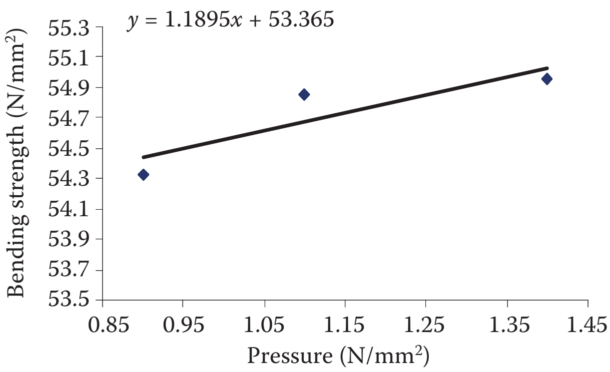

Fig. 9. Determination of the dependence of bending strength on pressure at a standard temperature of 120°C

Table 2. Gluing strength of plywoods

Arithmetic mean	Gluing strength in shear (N/mm²)					
	2nd ply	4th ply	2nd ply	4th ply	2nd ply	4th ply
	Set 1		**Set 2**		**Set 3**	
$\bar{x}$	0.99	1.22	1.01	1.23	1.13	1.03
	Set 4		**Set 5**		**Set 6**	
$\bar{x}$	1.12	1.09	1.14	1.29	1.29	1.20
	Set 7		**Set 8**		**Set 9**	
$\bar{x}$	1.06	1.08	1.23	1.12	1.05	1.42

standard specific pressure (1.1 N/mm²) and pressing temperature 115°C. At a pressing temperature of 120°C bending strength is 54.85 N/mm² showing an increase in strength by 65.46% and at a pressing temperature of 125°C bending strength is 53.87 N/mm² which represents an increase by 62.47% as against temperature 115°C.

Transverse samples show bending strength 37.28 N/mm² at the same standard specific pressure (1.1 N/mm²) and pressing temperature 115°C. At a pressing temperature of 120°C bending strength is 40.1 N/mm² which represents an increase by 4.43%. At a pressing temperature of 125°C bending strength is 43.7 N/mm² which means an increase by 13.78% as against values at a pressing temperature of 115°C.

In longitudinal samples pressed using a force of 0.9 N/mm² bending strength 38.65 N/mm² was reached at the lowest temperature. At the same pressing temperature and a specific pressure of 1.1 N/mm² bending strength amounted to 54.33 N/mm² and at a pressing force of 1.4 N/mm² bending strength amounted to 49.26 N/mm² which represents an increase by 27.45% as against a pressing force of 0.9 N/mm².

In transverse samples, bending strength amounted to 32.87 N/mm² at a standard temperature of 120°C. In using a pressing force of 1.1 N/mm² bending strength increased to 40.07 N/mm² which represents an increase by 18.31% and at a pressing force of 1.4 N/mm² bending strength amounted to 42.08 N/mm², i.e. an increase by 24.24% as against a pressing force of 0.9 N/mm².

Similar values and relations to changing temperatures and pressures were also obtained at the analysis of MOE. It follows that the highest increase in mechanical properties occurs between pressing temperatures 115 and 120°C and specific pressures 0.9 and 1.1 N/mm². With respect to a fact that at the lowest pressing temperature of 115°C and the lowest pressing force of 0.9 N/mm² bending strength values of longitudinal samples occurred below the minimum strength limit in bending 40 N/mm² we have to claim that pressing plywood sheets using these temperatures is not admissible. An increase in bending strength and MOE at a temperature of 125°C and pressure 1.4 N/mm² is slight or none. It follows that pressing becomes uneconomic with respect to the disproportionate increase in costs at the minimum improvement of mechanical properties (Král 2004).

Thus, it is possible to conclude that changes in pressing forces and temperatures can be carried out only on the basis of requirements for mechanical properties (bending strength, MOE).

Gluing strength of plywood sheets

Results of the analysis of gluing strength by a shear test in the set of plywood sheets Nos. 1 to 9 are given in Table 2 and correlation analyses in Figs. 10 and 11. Shear strength was measured in five-ply sheets for the second and the fourth ply.

Fig. 10 depicts the medium and higher dependence of shear strength on changes in a pressing force at a temperature of 120°C – correlation coefficient 0.691.

Fig. 11 depicts the medium dependence of shear strength on changes in a pressing temperature at a pressing specific force of 1.4 N/mm². Under conditions of using the pressure correlation coefficient amounted to 0.515. With a decreasing pressing

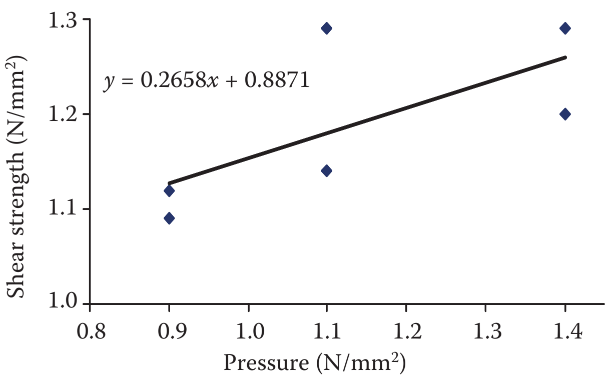

Fig. 10. Determination of the dependence of shear strength on pressure at a standard temperature of 120°C

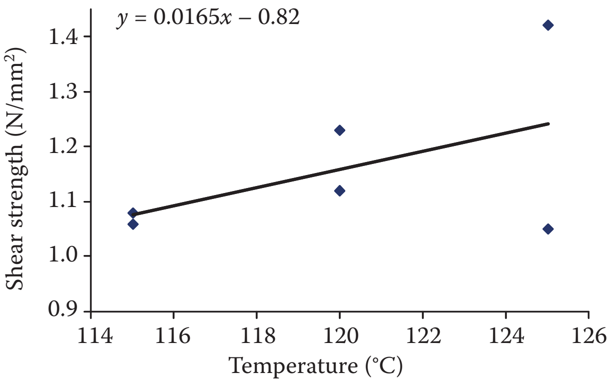

Fig. 11. Determination of the dependence of shear strength on temperature at pressure 1.4 N/mm^2

force correlation dependence of shear strength on a pressing temperature also decreases. In using a pressing force of 0.9 N/mm^2 correlation coefficient amounted to 0.245 and at a specific pressure of 0.9 N/mm^2 only 0.104.

CONCLUSION

Then paper presents results of an institutional research aimed at assessing the effect of different technological conditions in the course of pressing on physical and mechanical conditions of plywood sheets. Spruce plywood sheets of the following construction were studied: spruce 3.0 mm longitudinal; spruce 3.5 mm transverse; spruce 3.0 mm central; spruce 3.5 mm; spruce 3.0 mm. The plywood sheets were manufactured as five-ply and PF B118 phenol-formaldehyde adhesive was used for their production. The period of pressing was set to 14 minutes at a specific pressure of 0.9 N/mm^2; 1.1 N/mm^2 or 1.4 N/mm^2. Depending on various pressing temperatures 115, 120 and 125°C, density, bending strength, MOE in bending and gluing strength by a shear test were assessed. Determined values of plywood properties were statistically tested.

The mean moisture of plywood sheets ranged from 5.42 to 6.47%. The density of plywoods reached the lowest value of 476 kg/m^3 in Set No. 1 pressed by the lowest specific force 0.9 N/mm^2 at the lowest temperature of 110°C. The highest mean density was reached in Set No. 9, viz 547.4 kg/m^3 (pressing force 1.4 N/mm^2, pressing temperature 125°C). Density and pressing force show a strong correlation dependence (coefficient 0.982). In longitudinal types of samples, bending strength ranged from 33.15 to 59.72 N/mm^2 and in transverse types of samples from 32.87 to 44.50 N/mm^2.

On the basis of results obtained, transverse samples came up to the strength of longitudinal samples. This phenomenon can be explained in such a way that the lower second ply shows higher thickness (3.5 mm) in bending stress than the first ply (3.0 mm) and takes over tensile strength (Král 2004). Prescribed strength of longitudinal samples (40 N/mm^2) was not fulfilled in Sets 1 and 2. Thus, strength requirements were fulfilled in all samples pressed only at a temperature of min. 120°C and min. pressing force 1.1 N/mm^2.

Results of the measurement of MOE in bending were similar as in bending strength. With increasing temperature and pressure MOE showed an increasing trend. MOE in bending ranged from 11,393.6 to 18,024 N/mm^2 in longitudinal samples and from 5,794.1 to 6,897.5 N/mm^2 in transverse samples.

The greatest increase in mechanical properties occurred between pressing temperatures 115 to 120°C and between specific pressing forces 0.9 and 1.1 N/mm^2. An increase in bending strength and MOE at a temperature of 125°C and specific pressure 1.4 N/mm^2 was slight or none. Thus, pressing becomes uneconomic at setting higher parameters on the basis of the disproportionate increase in costs at the minimum improvement of mechanical properties.

All tested samples reached gluing strength ranging from 1 to 1.4 N/mm^2 thereby fulfilling general requirements for shear strength. With decreasing pressing force the correlation dependence of shear strength on pressing temperature also decreased.

Evaluation of shear strength in relation to changing parameters of pressing demonstrated that interrelations between pressing temperature and specific pressure were stronger than in other properties under investigation. The correlation analysis showed that changes in pressing parameters (temperature and pressure) showed medium to higher effects on the quality of gluing. Increasing the temperature and pressure is considerably uneconomic with respect to resulting utility properties because the required gluing strength was also achieved at the lowest values of pressing temperature and specific pressure (Král 2004).

References

KRÁL P., HRÁZSKÝ J., 2004. Assessing the effect of a coating system on the rate of plywood moistening and changes in dimensions in relation to the change in relative air humidity. Journal of Forest Science, *50*: 86–100.

KRÁL P., 2004. Effect of coating system on the plywood moistening at different climates. In: 4th International Science Conference Chip and Chipless Woodworking Processes 2004. Tatry – Starý Smokovec, 14–16 October 2004: 345–350.

MATOVIČ A., 1993. Fyzikální a mechanické vlastnosti dřeva a materiálů na bázi dřeva. Brno, MZLU: 212.

POLÁČIK A., 1982. Technológia výroby konštrukčných veľkoplošných materiálov. Časť 1. Výroba dýh a preglejovaných dosák. Zvolen, VŠLD: 184.
ČSN EN 325, 1995. Desky ze dřeva. Stanovení rozměrů zkušebních těles. Český normalizační institut: 8.
ČSN EN 326-1, 1997. Desky ze dřeva. Odběr vzorků, nařezávání a kontrola. Část 1. Odběr vzorků, nařezávání zkušebních těles a vyjádření výsledků zkoušky. Český normalizační institut: 12.

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Vliv rozdílných lisovacích podmínek na vlastnosti smrkových překližek

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ABSTRAKT: Článek prezentuje výsledky institucionálního výzkumu zaměřeného na posouzení vlivu rozdílných technologických podmínek při lisování na fyzikální a mechanické vlastnosti překližovaných desek. Byly analyzovány smrkové překližované desky s nominální tloušťkou dýh 3,0 a 3,5 mm. Překližované desky byly vyrobeny jako pětivrstvé a k jejich výrobě byla použita fenolformaldehydová pryskyřice BAKELITE PF B118. V závislosti na rozdílné lisovací teplotě 115 °C, 120 °C, 125 °C a na různém specifickém tlaku byla posuzována hustota, pevnost v ohybu, modul pružnosti v ohybu a pevnost lepení smykovou zkouškou. Zjištěné hodnoty vlastností byly statisticky testovány.

Klíčová slova: překližka; hustota překližky; pevnost v ohybu; modul pružnosti v ohybu; lisovací teplota; statistická analýza

Vlastnosti konstrukčních dýhových materiálů jsou určovány především jejich strukturou – konstrukcí. Neustálý a promyšlený výzkum vzájemných souvislostí mezi strukturou a vlastnostmi je proto cílovým bodem zkoumání materiálů. Zdokonalování technologických a výrobních metod předpokládá především velmi detailní stupeň poznání souvislostí a jevů za spolupůsobení účinkových faktorů a možností působení na procesy tak, aby se uskutečňovaly za nejvhodnějších podmínek s optimálními výsledky.

Konstrukce vrstvených dýhových materiálů se vytváří lisováním složených souborů dýh jednostranně nebo oboustranně nanesených syntetickou pryskyřicí v horkých lisech za spolupůsobení teplotního pole o různé intenzitě. Proces stlačení v horkém lisu, který vede ke zhuštění a vytváření hustotního profilu, závisí na velikosti odporu jednotlivých vrstev vůči slisování. Rozhodující je struktura (konstrukce) materiálu, vycházející z profilu jejich tloušťky, která je rozměrem do značné míry určujícím materiálové charakteristiky.

Článek prezentuje výsledky institucionálního výzkumu zaměřeného na posouzení vlivu rozdílných technologických podmínek při lisování na fyzikální a mechanické vlastnosti překližovaných desek. Předmětem výzkumu byly smrkové překližované desky o konstrukci: SM 3,0 mm podélná; SM 3,5 mm příčná; SM 3,0 mm střed; SM 3,5 mm; SM 3,0 mm. Překližované desky byly vyrobeny jako pětivrstvé a k jejich výrobě byla použita fenolformaldehydová pryskyřice PF B118. Doba lisování byla stanovena na 14 minut při specifickém tlaku 0,9 N/mm^2; 1,1 N/mm^2 a 1,4 N/mm^2. V závislosti na rozdílné lisovací teplotě 115 °C, 120 °C a 125 °C byla posuzována hustota, pevnost v ohybu, modul pružnosti v ohybu a pevnost lepení smykovou zkouškou. Zjištěné hodnoty vlastností byly statisticky testovány.

Průměrná vlhkost překližek se pohybovala v rozmezí 5,42 % až 6,47 %.

Hustota překližek dosáhla nejnižší hodnoty 476 kg/m^3 u souboru desek č. 1 lisovaných nejnižším specifickým tlakem 0,9 N/mm^2 a při nejnižší teplotě 110 °C. Nejvyšší průměrné hustoty bylo dosaženo u souboru č. 9 ve výši 547,4 kg/m^3 (lisovací tlak 1,4 N/mm^2, lisovací teplota 125 °C). Hustota a lisovací tlak vykazuje silnou korelační závislost (koeficient 0,982).

Pevnost v ohybu se pohybovala u podélného typu vzorků od 33,15 N/mm^2 do 59,72 N/mm^2, od 32,87 N/mm^2 do 44,50 N/mm^2.

Ze zjištěných výsledků vyplývá, že příčné vzorky se svou pevností vyrovnávají pevnosti podélných vzorků. Tento jev je možné vysvětlit tím, že spodní druhá vrstva při namáhání ohybem má větší tloušťku (3,5 mm) než první (3,0 mm) a přebírá tahovou pevnost. Předepsanou pevnost u podélných vzorků 40 N/mm^2 nesplnily soubory č. 1 a 2. Z toho vyplývá, že pevnost splňují všechny vzorky lisované pouze při teplotě min. 120 °C a minimálním tlaku 1,1 N/mm^2.

Výsledky měření modulu pružnosti v ohybu byly obdobné jako u pevnosti v ohybu. Se zvyšováním teploty a tlaku měl také MOE rostoucí trend. Modul pružnosi v ohybu se u podélných vzorků pohyboval od 11 393,6 N/mm^2 do 18 024 N/mm^2 a u příčných vzorků od 5 794,1 N/mm^2 do 6 897,5 N/mm^2.

Podélné vzorky mají při stejném standardním specifickém tlaku (1,1 N/mm^2) pevnost v ohybu při lisovací teplotě 125 °C proti teplotě 115 °C hodnoty vyšší o 62,47 % a příčné vzorky mají při stejném specifickém tlaku a teplotách pevnost v ohybu o 13,78 % vyšší proti hodnotám při lisovací teplotě 115 °C.

Na podélných vzorcích lisovaných tlakem 1,4 N/mm^2 dosáhla pevnost v ohybu 49,26 N/mm^2, což představovalo nárůst 27,45 % proti lisování tlakem 0,9 N/mm^2 a u příčných vzorků o 24,24 % proti lisování tlakem 0,9 N/mm^2.

Obdobných hodnot a závislostí na měnící se teplotě a tlaku bylo dosaženo při analýze MOE. Z toho vyplývá, že k největšímu nárůstu mechanických vlastností docházelo mezi lisovacími teplotami 115 až 120 °C a specifickými tlaky 0,9–1,1 N/mm^2. Vzhledem k tomu, že se při nejnižší lisovací teplotě 115 °C a nejnižším lisovacím tlaku 0,9 N/mm^2 hodnoty pevnosti podélných vzorků dostaly pod minimální mez pevnosti v ohybu 40 N/mm^2 v podélném směru, musíme lisování překližek při těchto teplotách a tlacích brát jako nepřípustné. Nárůst pevnosti v ohybu a MOE při teplotách 125 °C a tlacích 1,4 N/mm^2 je mírný nebo žádný. Z toho vyplývá, že lisování při nastavení těchto parametrů se stává neekonomickým na základě neúměrného zvětšení nákladů při minimálním zlepšení mechanických vlastností.

Ze získaných poznatků lze přijmout závěr, že změny lisovacího tlaku a teploty se mohou provádět jen na základě požadavků na mechanické vlastnosti (pevnost v ohybu, MOE).

Všechny zkoušené vzorky dosáhly pevnosti lepení v rozmezí 1–1,4 MPa; tím splnily všeobecné požadavky na smykovou pevnost. Se snižováním lisovacího tlaku se snižovala i korelační závislost smykové pevnosti na lisovací teplotě.

Hodnocení smykové pevnosti lepení v závislosti na měnících se parametrech lisování souvisí ve vzájemném spolupůsobení jak lisovací teploty, tak i specifického tlaku. Z korelačních analýz vyplynulo, že změny lisovacích parametrů (teploty a tlaku) měly střední až vyšší podíl na kvalitě lepení. Jakékoliv zvýšení teploty a tlaku je značně neekonomické vzhledem k výslednému efektu, protože požadované pevnosti lepení bylo dosaženo i při nejnižších hodnotách lisovací teploty a specifického tlaku.

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