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EFFECTS OF THE RATIO OF MIXING THE UF ADHESIVE AND THE UF ADHESIVE WITH INCREASED REACTIVITY ON MECHANICAL PROPERTIES AND THE CONTENT OF FORMALDEHYDE

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Abstract

HRÁZSKÝ, J., KRÁL, P.: *Effects of the ratio of mixing the UF adhesive and the UF adhesive with increased reactivity on mechanical properties and the content of formaldehyde.* Acta univ. agric. et silvic. Mendel. Brun., 2009, LVII, No. 1, pp. 41–50

The paper includes results of research work dealing with the study of the effect of mixing the traditional urea-formaldehyde adhesive Kronores CB 1100 D and the urea-formaldehyde adhesive Kronores CB 1200 D characterised by increased reactivity for selected physical and mechanical properties of particleboards, the content of free formaldehyde and productivity of the production line of particleboards. Within the research, other potential factors affecting properties of particleboards were also studied. Present adhesive prescriptions (1) and five experimental prescriptions were evaluated. In conclusion, optimum prescriptions were determined fulfilling the CSN EN 312 standard requirements for physical and mechanical properties of particleboards of P 2 class and a pressing factor was defined substantially affecting the rate of a production line or production productivity.

particleboards, UF adhesives, physical and mechanical properties, adhesive prescriptions, bending strength, modulus of elasticity, tensile strength perpendicular to the board plane

At present, we can observe the growing worldwide trend of the consumption, sale and production of agglomerated materials. These materials compensate for the lack of quality solid wood on the market, eliminate (to a certain extent) the anisotropic character of wood, decrease wood swelling and make possible the production of large board-type materials.

Particleboards are one of the representatives of agglomerated materials. According to the CSN EN 309 standard, these boards are defined as materials manufactured by hot pressing of the mixture of woody or other lignocellulose particles with an adhesive. As compared with solid wood these boards show homogenous structure and do not contain natural defects.

From the viewpoint of physical and mechanical properties particleboards are also of orthotropic character. Compared to wood, which has three basic planes differing by physical and mechanical properties, particleboards show ideally only two basic planes, viz. a plane parallel with the board plane and a plane perpendicular to the board plane. In the board plane, this material is virtually isotropic, which is given by the mall orientation of chips. For the production of particleboards it is possible to use not only standard wood and wood of lower quality, which is no longer suitably for sawmill purposes, but also materials from recycled woody products. Advantages consist in decreased costs of the input raw material.

For the manufacture of particleboards (PB), urea-formaldehyde adhesives (UF) are world-wide used in about 90%, phenolformaldehyde adhesives (PF) in 8% and only a small amount of particleboards is manufactured using melamineformaldehyde and isocyanate adhesives. In the Czech Republic, the position of UF adhesives is even more marked. In the production of particleboards, UF adhesives are particularly preferred due to low costs being cheapest in the field of synthetic adhesives. They are characterized by short setting time and thus also small pressing factor at the production of PB, they set at relatively low pressing temperatures and do not colour wood. In principle, it refers to polycondensation products of urea and formaldehyde, which are able to react together (by means of warm or a catalyst) resulting in macromolecular substances.

One of the most important aspects of the production of UF resins is the "molar ratio of urea and formaldehyde". This ratio together with the character of a prepolymer produced in the first step of the adhesive production shows its main task in the control of the creation of intermediate products originating in the course of setting and finally in properties of the cured adhesive.

Adhesives with low molar ratios U:F = 1:1.2–1.6 show longer service life (longer time of gelatination) and the lower content of formaldehyde but lower water resistance, smaller stiffness and strength. They also set slower than adhesives with high molar ratios U:F = 1:1.8 –2.0. To limit the amount of free formaldehyde adhesives with the molar ratio U:F = 1:0.98 – 1.15 are used at present. Released formaldehyde from the adhesive (after its setting in a final product) is of decisive importance in relation to the environment. Present adhesives show the very low content of free formaldehyde but, on the other hand, they contain considerable amounts of low-molecular methylol compounds, which remain partly unreacted during setting or even their division can occur on the surface of a woody substance. Just these unreacted low-molecular compounds are the substantial source of releasing the formaldehyde from particleboards. In order as little as possible amount of unstably bonded formaldehyde to remain in the bonding material it is necessary to carry out the reaction in such a way the methylol groups to be converted to a great extent to methylene-diurea or to polymethylene urea.

The particle mat moisture shows a fundamental effect on the amount of released formaldehyde from particleboards in addition to the amount and type of ureaformaldehyde adhesive. In the contact with hot pressing plates the reversible process of a condensation reaction occurs, bonds split and methylolurea and free formaldehyde originate. This phenomenon is the more marked the moister the particle mat MAYER (1979). Also the pressing temperature and pressing time markedly affect releasing of formaldehyde from finished particleboards. Due to increasing the temperature and pressing time increased release of formaldehyde occurs during the manufacture of particleboards.

A temperature in the central layer markedly affects the content of released formaldehyde. The amount of released formaldehyde increases with the increasing temperature in the central layer of a particleboard. With the decreasing thickness of a particleboard significant decline in the amount of released formaldehyde occurs. Decreasing the PB thickness by 1 mm the amount of releasable formaldehyde decreases by 5.8%. Releasing the formaldehyde is a slow process, which continues for a long time after the manufacture of PB, ie even during the use of the boards depending also on temperature, relative moisture, intensity of ventilation and the amount of PB material in the room. With the increasing pressing temperature and pressing time the amount of released formaldehyde from a finished particleboard diminishes. Increasing the pressing time by 16% the amount of free formaldehyde decreases by 24%. However, increasing the pressing time decreases the productivity of labour and, therefore, this method of decreasing the escapoe of formaldehyde is not too suitable PERLÁC (1992).

In general terms, releasing the formaldehyde from particleboards is primarily affected by unreacted formaldehyde in the adhesive, incomplete setting the adhesive and also by formaldehyde from the hydrolytic dissociation of a UF adhesive not only in the course of PB pressing but also from a finished product. Also in the board cross profile, the degree of setting the adhesive is not uniform. From surface layers to the central layer, the degree of setting the adhesive decreases and, therefore, it is possible to suppose that the UF adhesive hydrolysis occurs particularly in the central layer where also the highest moisture is concentrated during the pressing process ŠTEFKA (1986). The environment acidity is an important condition for setting the adhesive. In the PB, acidity is given by the amount of a hardening agent added to the adhesive but also by the acidity of used boards. Slowed-down setting results in the increased amount of released formaldehyde from PB and, naturally, it can result in the impairment of physical and mechanical properties of PB. Various woody species show markedly different pH values. Nevertheless, pH values can fluctuate even within one woody species. The admixture of a hardening agent causes only the negligible fall of the amount of free formaldehyde. The central layer of PB can be considered to be the main source of this harmful substance.

To determine the amount of free formaldehyde two methods are most often used, viz. a *perforator method* (according to the CSN EN 120 standard) and *Roffael method* (according to the CSN EN 717–3 standard). The perforator value means the content of formaldehyde in the tested material expressed in mg per 100 g oven-dry matter (o.d.) sample (particleboards). The basis of the perforator method consists in the extraction of formaldehyde by warm toluene in a special testing apparatus, its subsequent absorbing in a water bath and iodometric determination. The method of represents the method of emission determination expressed by the same weight unit as in the perforator method. The basis of Roffael method (WKI) consists in two samples of PB placed above distilled water in a closed bottle for various time at a temperature of 40 °C. The escaping formaldehyde is absorbed in water being subsequently determined using iodometry or spectrophotometry (the CSN EN 717 standard, part 3). Found out values were converted according to a relation, which was determined by VVÚD Praha (Research and Development Institute of Wood in Prague) within the supervision of the PB production to values for the perforator method according to the CSN EN 120 standard. The Roffael method ("bottle method") can be used for tests of raw particleboards but not for classification tests. There are also other methods to determine the escape of free formaldehyde, eg a *chamber method*, used for the determination of the amount of formaldehyde in 1 m^3 air. This method differs above all by the size of chambers, by the coefficient of filling, exchange of air etc. To determine released formaldehyde from non-sheathed plywood as well as sheathed panels (particle and fibre boards, plywood) it is possible to use "*gas analysis*" according to the CSN EN 717 standard, part 2 (HRÁZSKÝ, KRÁL; 2004).

In applying the ever-increasing view of negative impacts affecting the environment it is inevitable to limit or at best eliminate the content of free formaldehyde. The European standard EN 13986 divides particleboards into two emission classes according to the content of free formaldehyde, viz. E 1 where the content of free formaldehyde is ≤ 8 mg/100 g o.d., and E 2 where the content of is > 8 mg/100 g o.d..

In the future, this standard should be extended by class E 1special, where the content of free formaldehyde is lower than 5 mg/100 g o.d. particleboard. It is evident that the content of formaldehyde together with mechanical properties is the most important parameter of particleboards. This content can be particularly affected by the type and properties of the adhesive used and less by the technology of production (HRÁZSKÝ, KRÁL; 2007).

Generally, it is possible to note that our aim is to manufacture particleboards with the minimum content of formaldehyde, with satisfactory mechanical and physical properties using the lowest-possible pressing factor. The development of adhesives and their properties is the subject of continuous research and thus, it is necessary to use feedback at the production, which can help to assess the suitability of an adhesive depending on resulting properties of a particleboard.

The paper objective was to find out the most optimum ratio of two ureaformaldehyde adhesives used for a central layer at the production of particleboards 18 mm thick, namely under operational conditions of an important producer of particleboards in the CR. At the determination of this ratio, physical and mechanical properties of particleboards were taken into consideration the boards to fulfil requirements of the CSN EN 312 standard for P 2 class as well as for the emission class E 1 according to the EN 13986 standard, viz. the content of free formaldehyde should be minimal. The CSN EN 13986 standard determines that the content of free formaldehyde must be lower or equal 8 mg/100 g o.d. using the perforator method. The CSN EN 120 standard describes this method and its procedure.

Another factor, which was monitored from the aspect of production capacity, was pressing factor affecting the production capacity. In conclusion of the paper, the most optimum ratio was defined of two types of ureaformaldehyde adhesives from the aspect of production quality and capacity.

MATERIAL AND METHODS

Ureaformaldehyde adhesives manufactured by the Dukol Ostrava, s. r. o. company were used for the production of particleboards. It refers to adhesives Kronores CB 1100 D (Dukol EP) and Kronores CB 1200 D (Dukol EP–R). Kronores CB 1100 D is a common adhesive used for surface layers of particleboards. In a mixture with Kronores CB 1200 D the adhesive was used for central layers of three-layer particleboards. The second adhesive mentioned shows increased reactivity. It is suitable for the production of particleboards in continual presses, which operate with low pressing factors. The higher content of formaldehyde is its disadvantage. Adhesive prescriptions of particular pressing variants of particleboards are given in Tab. I. The variants are termed 1–6. The present prescription is termed 1.

Ureaformaldehyde adhesives are prepared by the condensation of urea and formaldehyde. At the preparation of an adhesive mixture the adhesive is diluted by water to about 50% concentration and its pH is neutral. The start of a setting reaction occurs after the hardening agent application, which decreases the pH value. Ammonium nitrate NH_4NO_3 was used as a hardener.

A hydrophobization agent is an important admixture to the adhesive mixture. This agent should guarantee decreased swelling of finished boards due to moisture. Paraffin emulsion at 1.0% per DM particleboard was used as the hydrophobization agent. To include particleboards of a thickness of 18 mm into class P 2 according to the CSN EN 312 standard the boards have to fulfil following requirements:

- Bending strength MOR ≥ 13 N/mm^2.
- Modulus of elasticity in bending MOE ≥ 1600 N/mm^2.
- Tensile strength perpendiculary to the board $\sigma_{t\perp}$ ≥ 0.35 N/mm^2.

Test specimens were cut out from boards of particular variants according to the CSN EN 326-1 standard. Their dimensions were determined according to the CSN EN 325 standard.

- Bending strength (MOR) and modulus of elasticity in bending (MOE) were determined according to the CSN EN 310 standard.
- Tensile strength perpendiculary to the board was determined according to the CSN EN 319 standard.
- The test specimen density was determined according to the CSN EN 323 standard.
- The moisture of test specimens was determined according to the CSN EN 322 standard.
- The content of free formaldehyde (HCHO) was determined according to the CSN EN 120 standard.

According to particular adhesive prescriptions 1–6 mentioned in Tab.I, particleboards were pressed on a continual press. Of each of the production two particleboards were always sampled. Each of the boards was divided into three belts (Fig. 1). Of each of the belts twelve specimens were sampled for bending tests (six from the longitudinal and six from the cross direction towards the production flow direction), eight for tensile strength perpendiculary to the board tests and three specimen sets to determine the content of free formaldehyde. Statistical quantities were not calculated separately for each of the boards but always for both two boards taken from production according to particular adhesive prescriptions 1–6. It means, that six belts were taken from each of the adhesive prescriptions to cut out test specimens for bending strength tests, modulus of elasticity and tensile strength perpendiculary to the board tests. There are also six test sets for each of the adhesive prescriptions 1–6 to determine free formaldehyde.

The statistical evaluation of results was carried according to the CSN EN 326 standard. Following statistical values were calculated:

- Mean $\overline{x_{ij}}$ of each of the test belt of a particular board for the every group of test specimens.
- Variance $S^2_{w,j}$ within each belt for the every group of test specimens.
- Total mean $\overline{\overline{x}}$ of all measured values or of the group of sampling values.
- Variability of belt means $S^2_{\bar{x}}$.
- Mean variability of measured values within the belts S^2_w.

RESULTS AND DISCUSSION

Tab. I gives particular variants of adhesive prescriptions used at pressing particleboards 18 mm thick.

I: *Variants of adhesive prescriptions*

Prescriptions	Kronores CB 1200 D (kg)	Kronores CB 1100 D (kg)	Proportion Kronores CB 1200 D (%)	Proportion Kronores CB 1100 D (%)	Pressing factor s/mm
existing – 1	4.5	2.1	68.18	31.82	4.1
2	4.1	2.5	62.12	37.88	4.2
3	4.6	3.0	54.55	45.45	4.3
4	3.1	3.5	46.97	53.03	4.4
5	2.6	4.0	39.39	60.61	4.4
6	6.6	0.0	100.00	0.00	4.1

In Tabs. I and II, prescriptions 1 show the present condition of production. Boards do not fulfil requirements for mechanical and physical properties according to the CSN EN 312 standard for class P 2. The value of tensile strength perpendiculary to the board is $\sigma_{t\perp}$ je 0.327 N.mm^{-2} and should be at least 0.35 N.mm^{-2}. This requirement is fulfilled only at 93%. Values of bending strength do not reach minimal requirements as well. Bending strength MOR‖ is 11.758 N.mm^{-2}, but it should reach at least 13 N.mm^{-2}. The standard requirement is fulfilled only at 90%. Bending strength MOR$_{\perp}$ is 11.405 N.mm^{-2} and should be at least 13 N.mm^{-2}. The standard requirement is fulfilled only at 88%. On the contrary, moduli of elasticity MOE fulfil the requirement. A minimum required value is 1600 N.mm^{-2} and both moduli exceed the requirement minimally by 47%. The value of free formaldehyde is 6.02 mg/100 g o.d. particleboard and thus the requirement is fulfilled to classify the boards into class E1 according to the CSN EN 120 standard. Pressing factor is 4.1 s/mm.

Conclusion: These prescriptions do not fulfil all required criteria.

In the second line (bold face) of Tab. II, values are given of particleboard properties produced using prescriptions 2. The boards do not fulfil requirements for mechanical and physical properties according to the CSN EN 312 standard for class P 2. Values of bending strength do not reach minimum requirements. Bending strength MOR‖ is 12.363 N.mm^{-2}, but should reach at least 13 N.mm^{-2}. Thus, the standard requirement is fulfilled only at 95%. Bending strength MOR$_{\perp}$ is 11.465 N.mm^{-2}, but should be at least 13 N.mm^{-2}. The standard requirement is fulfilled only at 88%. On the other hand, modulus of elasticity MOE fulfil the standard requirement. Minimum required value is 1600 N.mm^{-2} and both models exceed the value by 45%. The value of tensile strength perpendiculary to the board $\sigma_{t\perp}$ is 0.356 N.mm^{-2} and thus, the standard requirement is fulfilled. The value of the content of free formaldehyde is 6.38 mg/100 g o.d. particleboard, which fulfils a requirement to include the board into class E1 according to the CSN EN 120 standard. Pressing factor is 4.2 s/mm.

Conclusion: These prescriptions do not fulfil all required criteria.

In the third bold face line of Tab. II, values of properties are given of particleboards produced using prescriptions No. 3. The boards fulfil requirements for mechanical and physical properties according to the CSN EN 312 standard for class P 2. Values of bending strength reach minimum requirements. Bending strength MOR‖ is 13.585 $N.mm^{-2}$ and should reach at least 13 $N.mm^{-2}$. The standard requirement is fulfilled at 104.5%. Bending strength $MOR_{\perp}$ is 13.040 $N.mm^{-2}$ and should be at least 13 $N.mm^{-2}$. Thus, the standard requirement us fulfilled at 100.3%. Also moduli of elasticity MOE fulfil the standard requirement. The minimum required value is 1600 $N.mm^{-2}$ and both moduli exceed the value. The value of tensile strength perpendiculary to the board $\sigma_{t\perp}$ is 0.368 $N.mm^{-2}$ and, thus, the standard requirement is fulfilled. The value of the content of free formaldehyde is 6.90 mg/100 g o.d. particleboard, which fulfils a requirement to include the board into class E1 given by the CSN EN 120 standard. Pressing factor is 4.3 s/mm.

Conclusion: These prescriptions fulfil all required criteria.

In the fourth bold face line of Tab. II, values are given of particleboard properties produced using prescriptions No. 4. The boards do not fulfil requirements for mechanical and physical properties according to the CSN EN 312 standard. Values of bending strength do not reach minimum requirements. Bending strength MOR‖ is 12.093 $N.mm^{-2}$, but it should reach at least 13 $N.mm^{-2}$. The standard requirement is fulfilled only at 93%. Bending strength $MOR_{\perp}$ is 11.434 $N.mm^{-2}$. This strength should be also 13 $N.mm^{-2}$. The standard requirement is fulfilled only at 88%. On the other hand, moduli of elasticity MOE fulfil the standard requirement. A minimum required value is 1600 $N.mm^{-2}$ and both moduli exceed the value at least by 48%. The value of tensile strength perpendiculary to the board $\sigma_{t\perp}$ is 0.361 $N.mm^{-2}$ and thus the standard requirement is fulfilled. The value of the content of free formaldehyde is 6.93 mg/100 g o.d. particleboard, so a requirement to include the board into class E1 given by the CSN EN 120 standard is fulfilled. Pressing factor is 4.4 s/mm.

Conclusion: These prescriptions do not fulfil all required criteria.

In the fifth bold face line of Tab. II, values are given of particleboard properties produced using prescriptions No. 5. The boards do not fulfil requirements for mechanical and physical properties given by the CSN EN 312 standard. Values of bending strength do not reach minimum requirements. Bending strength MOR‖ is 12.065 $N.mm^{-2}$ and should reach at least 13 $N.mm^{-2}$. The standard requirement is fulfilled only at 93%. Bending strength $MOR_{\perp}$ is 11.577 $N.mm^{-2}$. This strength should be also 13 $N.mm^{-2}$. The standard requirement is fulfilled only at 89%. On the other hand, moduli of elasticity MOE fulfil the standard requirement. A minimum required value is 1600 $N.mm^{-2}$ and both moduli exceed the value at least by 46%. The value of tensile strength perpendiculary to the board $\sigma_{t\perp}$ is 0.345 $N.mm^{-2}$ and thus, the standard requirement is fulfilled. The value of the content of free formaldehyde is 6.22 mg/100 g o.d. particleboard, so a requirement to include the board into class E1 given by the CSN EN 120 standard is fulfilled. Pressing factor is 4.4 s/mm.

Conclusion: These prescriptions do not fulfil all required criteria.

In the sixth bold face line of Tab. II, values are given of particleboard properties produced using prescriptions 6. The boards do not fulfil requirements for mechanical and physical properties given by the CSN EN 312 standard. Values of bending strength do not reach minimum requirements. Bending strength MOR‖ is 12.060 $N.mm^{-2}$, but it should amount to at least 13 $N.mm^{-2}$. The standard requirement is fulfilled only at 93%. Bending strength $MOR_{\perp}$ is 11.499 $N.mm^{-2}$. This strength should be also 13 $N.mm^{-2}$. The standard requirement is fulfilled only at 88%. On the contrary, moduli of elasticity MOE fulfil the standard requirement. Minimum required value is 1600 $N.mm^{-2}$ and both moduli exceed the value minimally by 42%. The value of tensile strength perpendiculary to the board $\sigma_{t\perp}$ is 0.361 $N.mm^{-2}$, so the standard requirement is fulfilled. The value of the content of free formaldehyde is 7.45 mg/100 g o.d. particleboard, so the requirement given by the CSN EN 120 standard to include the board into class E1 is fulfilled. Pressing factor is 4.1 s/mm.

Conclusion: These prescriptions do not fulfil all required criteria.

Evaluation of adhesive prescriptions

- For the purpose of evaluation we used values of pressing factor, modulus of elasticity, bending strength, tensile strength perpendiculary to the board and the content of free formaldehyde.
- In the CSN EN 312 standard for class P 2, determined values of particular properties are considered as a basis, ie 100%. Values found are then converted to this basis.
- In formaldehyde and pressing factor, the lowest value represents 100%, other values are converted (as %) to the value.
- This percentage expression is summarized into one table (Tab. III). Further, a formula was determined for the calculation of the suitability of R to determine optimum prescriptions.

Relationships for assessing the most optimum prescriptions

$$R = M\,(MOR_{\parallel} + MOR_{OH\perp} + MOE_{\parallel} + MOE_{\perp} + \sigma_{t\perp}) - Lf - Fd\ (\%)$$

where: $M\,(MOR_{\parallel} + MOR_{\perp} + MOE_{\parallel} + MOE_{\perp} + \sigma_{t\perp}) - Lf - Fd$

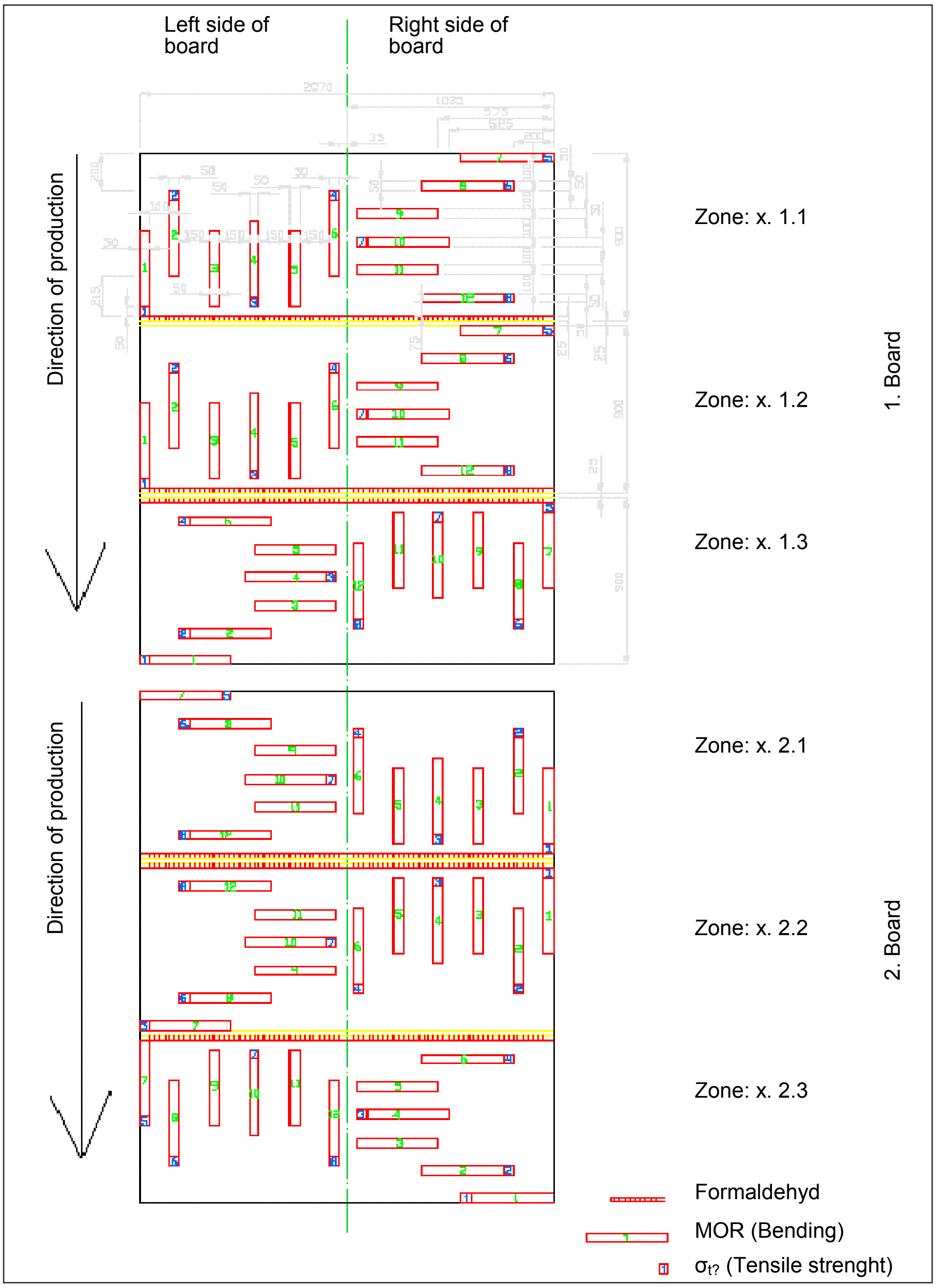
is the sum of the percentage expression of mechanical properties
MOR $_{\parallel}$ – bending strength in longitudinal direction
MOR $_{\perp}$ – bending strength in % in cross direction
MOE $_{\parallel}$ – modulus of elasticity in bending in % in longitudinal direction
MOE $_{\perp}$ – modulus of elasticity in bending in % in cross direction
$\sigma_{t\perp}$ – tensile strength perpendiculary to the board in %
Lf – pressing factor in %
Fd – the content of free formaldehyde in %

II: *Statistical evaluation of particleboard properties pressed using adhesive prescriptions 1–6*

	Density (kg/m³)	MOR ‖ (N/mm²)	MOE ‖ (N/mm²)	MOR ⊥ (N/mm²)	MOE ⊥ (N/mm²)	Tensile strength (N/mm²)	HCHO mg/100 g o.d. particleboard	Moisture (%)
Prescriptions 1								
$\overline{x_{ij}}$	620.067	11.758	2562.305	11.405	2356.145	0.327	6.02	5.69
$S^2_{\bar{x}}$	5.541	0.241	21432.36	0.160	38622.66	0.00007		
S^2_w	36.580	3.403	133177.45	1.799	61272.13	0.00262	0.017	0.041
Prescriptions 2								
$\overline{x_{ij}}$	625.620	12.363	2744.460	11.465	2328.390	0.356	6.38	6.44
$S^2_{\bar{x}}$	4.28	0.143	709.26	0.051	2523.80	0.00019		
S^2_w	163.88	4.864	165538.57	1.309	18569.08	0.00310	0.031	0.049
Prescriptions 3								
$\overline{x_{ij}}$	626.500	13.585	2751.510	13.040	2333.540	0.368	6.90	6.00
$S^2_{\bar{x}}$	9.77	0.105	592.59	0.015	104.82	0.00018		
S^2_w	125.49	4.713	177161.45	1.272	14859.10	0.00299	0.128	0.071
Prescriptions 4								
$\overline{x_{ij}}$	616.345	12.093	2745.180	11.434	2360.185	0.361	6.93	6.05
$S^2_{\bar{x}}$	18.68	0.176	1711.37	0.030	897.16	0.00039		
S^2_w	108.93	3.684	153589.79	1.078	18421.78	0.00323	0.013	0.062
Prescriptions 5								
$\overline{x_{ij}}$	611.576	12.065	2693.070	11.577	2339.435	0.345	6.22	6.34
$S^2_{\bar{x}}$	6.94	0.219	1289.90	0.158	4212.84	0.00008		
S^2_w	227.64	4.453	178526.51	1.585	16138.70	0.00259	0.024	0.055
Prescriptions 6								
$\overline{x_{ij}}$	614.605	12.060	2678.855	11.499	2266.097	0.361	7.45	6.46
$S^2_{\bar{x}}$	2.88	0.287	1931.81	0.073	4038.82	0.00029		
S^2_w	211.60	4.577	172064.07	0.969	14472.90	0.00357	0.084	0.067

III: *Percentage evaluation of particleboard properties according to particular adhesive prescriptions*

	MOR $_{\parallel}$	MOR $_{\perp}$	MOE $_{\parallel}$	MOE $_{\perp}$	$\sigma_{t\perp}$	Lf	Fd	R	Order
Prescriptions 1	90.45	87.73	160.12	147.25	93.43	100.00	100.00	378.98	5
Prescriptions 2	95.10	88.19	171.50	145.50	101.71	102.44	105.98	393.58	2
Prescriptions 3	104.50	100.31	171.94	145.62	105.14	104.88	114.62	408.01	1
Prescriptions 4	93.02	87.95	171.56	147.50	103.14	107.32	115.12	380.73	4
Prescriptions 5	92.81	89.05	168.31	146.19	98.57	107.32	103.32	384.29	3
Prescriptions 6	92.77	88.45	167.38	141.63	103.14	100.00	123.75	369.62	6



1: *A cutting plan for sampling test specimens*

CONCLUSION

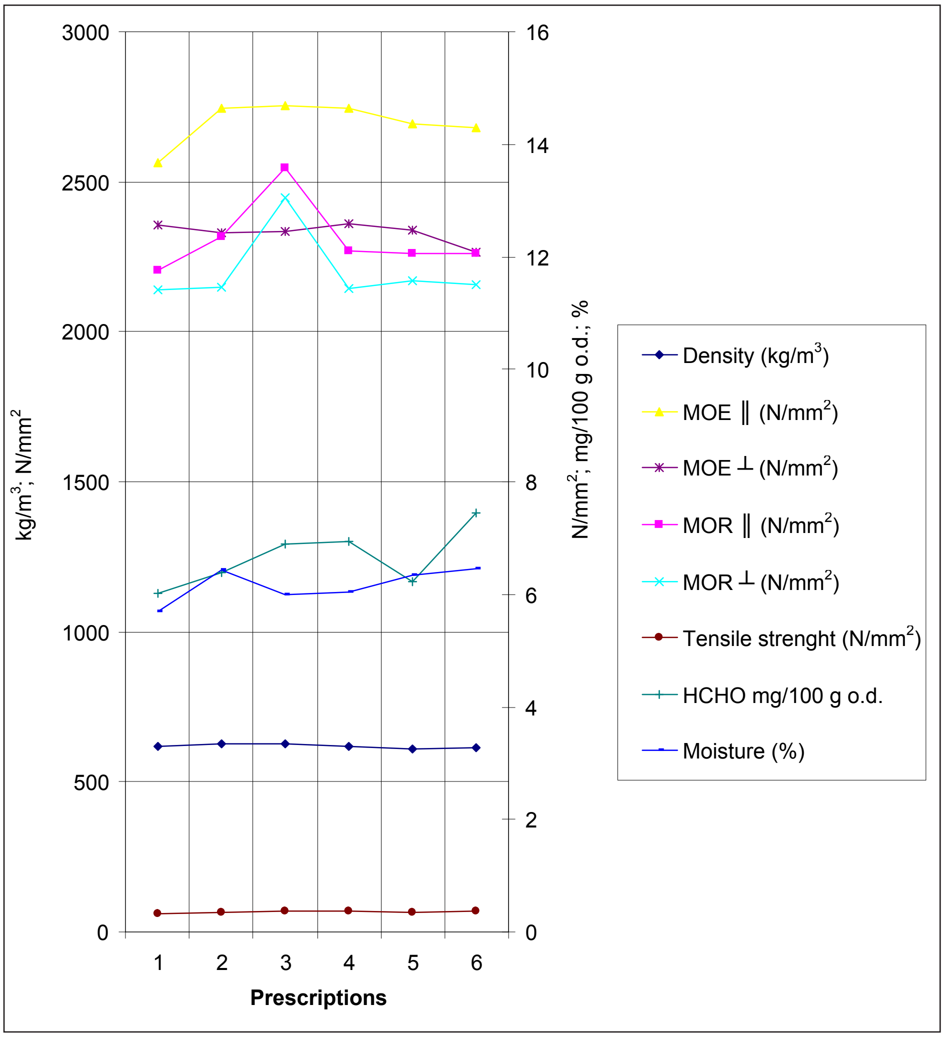
Research described in the paper resulted in the evaluation of adhesive prescriptions No. 3 as most optimum from the viewpoint of mechanical properties and the content of free formaldehyde in particleboards. The ratio of mixing adhesives in the prescriptions is as follows:

Kronores CB 1200 D : Kronores CB 1100 D = 54.45% (4.6 kg) : 45.45% (3.0 kg)

Boards manufactured using adhesive prescriptions 3 show following properties:

The most optimum adhesive prescriptions from the viewpoint of particular criteria are:

- ***Pressing factor:*** prescriptions 1 and 6 are most optimum, the pressing factor is 4.1 s/mm.
- ***Mechanical properties:*** prescriptions 3 are most optimum, particleboards show the highest mechanical properties (bending strength, modulus of elasticity in bending, tensile strength perpendiculary to board) and the satisfactory content of free formaldehyde from the viewpoint of emission class E 1.
- ***The content of free formaldehyde:*** present prescriptions 1 are most optimum, the content of free formaldehyde in particleboards amounts to 6.02 mg HCHO/100 g o.d. particleboard.



2: *The course of mean values of particular physical and mechanical properties of particleboards pressed according to adhesive prescriptions 1–6*

IV: *Properties of particleboards manufactured using adhesive prescriptions 3*

Prescriptions 3	Density (kg/m³)	MOR ‖ (N/mm²)	MOE ‖ (N/mm²)	MOR ⊥ (N/mm²)	MOE ⊥ (N/mm²)	Tensile strength perpendiculary (N/mm²)	HCHO mg/100 g o.d. particleboard	Moisture (%)
$\bar{x}_{ij}$	626.50	13.585	2751.51	13.040	2333.54	0.368	6.90	6.00
$S^2_{\bar{x}}$	9.77	0.105	592.59	0.015	104.82	0.00018		
S^2_w	125.49	4.713	177161.45	1.272	14859.10	0.00299	0.128	0.071

SOUHRN

Vliv poměru míchání UF lepidla a UF lepidla se zvýšenou reaktivitou na mechanické vlastnosti, obsah formaldehydu a produktivitu výroby třískových desek

Obsahem příspěvku jsou výsledky výzkumné práce zabývající se zkoumáním vlivu směšování klasického močovinoformaldehydového lepidla Kronores CB 1100 D a močovino-formaldehydového lepidla Kronores CB 1200 D vyznačující se zvýšenou reaktivitou na vybrané fyzikální a mechanické vlastnosti třískových desek, obsah volného formaldehydu a produktivitu výrobní linky třískových desek významného výrobce TD v ČR. Při výzkumu byly rovněž sledovány další možné faktory ovlivňující vlastnosti třískových desek. Vyhodnocena je současná lepidlová receptura (1) a pět receptur experimentálních. Závěrem práce je stanovení optimální receptury splňující požadavky ČSN EN 312 na fyzikální a mechanické vlastnosti třískových desek třídy P 2 a určení lisovacího faktoru, který zásadně ovlivňuje rychlost výrobní linky čili produktivitu výroby.

třískové desky, UF lepidla, lepidlová receptura, pevnost v ohybu, modul pružnosti, pevnost v tahu kolmo na rovinu desky, obsah volného formaldehydu, hustota, lisovací faktor

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