

NOVEL DECORATIVE PARTICLEBOARDS BY MEANS OF POST-IMPRINTED SURFACE PATTERNS

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Abstract

KLÍMEK PETR, WIMMER RUPERT, KRÁL PAVEL. 2015. Novel Decorative Particleboards by Means of Post-imprinted Surface Patterns. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 63(1): 45–48.

While high surface smoothness of particleboards is usually desired, boards with expressed surface topology can be seen as a more recent development. This research is about the development of 3D-imprinted surface patterns applied to both sides of single-layer particleboards. The imprintment was done as a post-treatment, meaning it was carried out as a final processing step during particleboard production. Commercial particleboard samples were imprinted using a hexagonal steel pattern under high pressure. Results show that because of the imprinting bending strength and stiffness were both reduced by 2/3 to 3/4 of the compared control values. Even with such severe reductions the imprintment process is seen as successful. A minimum of internal mechanical integrity remained making the new type of particleboard suitable for a number of design-related applications. With proper coating applications could be wall cladding, ceiling cladding, or decorative products. With the shown imprintment a new type of 3D-surface particleboard is introduced.

Keywords: particleboard, imprinting, pattern, 3D surface, modification, three dimensional, surface

INTRODUCTION

Major motivations that have led to the development of wood-based panels include their large possible dimensions, their much reduced anisotropy over solid wood, and the high resource efficiency. In addition, low production costs, the constancy of property profiles within and across panels and the high surface quality are all highly valued facts (Thoemen, 2010). While high surface smoothness is a usually desired feature, boards with expressed surface topology can be seen as a more recent development. Such three-dimensional (3D) surfaces are fabricated mainly for decorative purposes as already shown for interior architecture by Lussi & Ryden (1983). Barker & McLaughlin (1980) patented technology that was leading to 3D-patterned surfaces by a liquid top coat composition that has dried and cured. 3D-surface shapes have been also recently favored on skis, snowboards or skateboards (Genetier *et al.*, 1998).

The current work is about the development of 3D-imprinted surface patterns applied to both sides

of single-layer particleboards. The imprintment should be done as a post-treatment, meaning it is carried out as a final processing step during particleboard production. Although the panels are fully consolidated and the adhesives cured it is hypothesized that such decorative 3D surfaces can be produced, with the mechanical integrity of the particleboard still being acceptable.

MATERIAL AND METHODS

Test samples were obtained from commercial single-layer particleboards type P2 – European standard EN312 (abbreviated “DTD”), supplied by local producer of particleboards. Boards with three different thicknesses (12, 15 and 18mm) were obtained and tested. Dimensions of the samples followed EN 310. Length of samples was defined by 20-times the board thickness plus 50mm. Fifty samples were cut from each board, 25 for imprintment and 25 as a references. In total, 75 samples were imprinted (25 times three panels at thicknesses of 12; 15 and 18 mm).



1: Particleboard with imprinted pattern plates on both sides of the panel

Samples were imprinted in a 60t-hydraulic press using a hexagonal pattern (Fig. 1), the latter machined from a 3 mm thick stainless-steel plate. The pattern was imprinted on both sides of the boards. To prevent superposition the pattern on one side was shifted by one half hexagon diameter in longitudinal direction relative to the other side pattern. After preliminary testing, where the pressure was varied between 0.7 and 1.2 N·mm⁻², an optimum of 0.8 N·mm⁻² was found, which was then applied to all samples. Boards were pre-heated at 150 °C to achieve thermal softening of the surfaces. This thermal pre-treatment was limited to 15 minutes, before the imprinting under high-pressure was done for 10 minutes at temperature 150 °C.

The bending properties (Modulus of rupture MOR, Modulus of elasticity MOE) were measured according to EN 310. All tests were done on a ZWICK®Z050 universal testing machine, with the data processed with the testXpert V11.02® software. Loading speed was set to 15 mm·min⁻¹. For each sample data were recorded and evaluated statistically.

For the statistical analysis, arithmetic means (\bar{x}), minima (min) and maxima (max), standard deviation (σ), coefficient of variation (v), Student's t-test as well as Analysis of variance (ANOVA) were computed. Prior to the t-test calculation data were assessed for normal distribution, using the Shapiro-Wilk-Test. The ANOVA was employed to test whether or not the variances of the different groups are equal. For all statistical evaluations the software STATISTICA v10 was used.

RESULTS

Bending properties of the 12 mm-thick imprinted boards and the reference boards are listed in Tab. I. The data show that because of the imprinting both the MOE and the MOR were reduced by 2/3 to 3/4 of their compared control values. The 12 mm-thick boards showed a 70% reduction for MOR, while MOE was reduced by 80% (from 3700 to 700 N·mm⁻²). The 15 mm and the 18 mm-thick boards, respectively, responded similar with reductions for both MOR and MOE. Performed Scheffé Post-Hoc tests revealed no significant differences between DTD 12 and DTD 15, for both MOE and MOR. The DTD 18 board properties were significantly higher than those from DTD 12 and DTD 15, which suggests that thicker boards are more suitable for pattern imprinting. The reduced mechanical properties of the 12 mm-thick boards were mostly due to heavy structural distortions observed after pressing. Core layer distortions were hardly visible in the DTD 18 board type.

DISCUSSION

Results have shown that post-imprintment of particleboards significantly reduced the bending properties (MOR and MOE). The 12 mm-thick boards have shown a MOR reduction by 71%, and a MOE reduction by 80%. It became clear that post-imprintment has partially destructed the structural integrity of the panels. During the imprintment the cured and crystalline-like resin has a brittle nature, and the imprintment process has widely disintegrated the panel structure. Also, the glued wood particles get broken and separated, all together contributing to the loss of mechanical performance.

However, mechanical integrity is not completely lost. Even with the severe reduction in the bending

I: Descriptive statistics of the tested particleboard samples; without imprintment (control) and with imprintment (3D shaped); mean value \bar{x} , standard deviation σ , coefficient of variation (%) v

	DTD 12				DTD 15				DTD 18			
	Control ^a		3D shaped • ^b		Control ^a		3D shaped • ^b		Control ^a		3D shaped • ^b	
	MOR	MOE	MOR	MOE	MOR	MOE	MOR	MOE	MOR	MOE	MOR	MOE
\bar{x} (Nmm ⁻¹)	19.06	3736	5.62	726.5	19.5	3979	7.39	972.8	19.93	3950	7.47	980.4
Min (Nmm ⁻¹)	16.95	3535	3.69	502.6	16.16	3637	5.3	718.9	16.17	3473	5.3	718.9
Max (Nmm ⁻¹)	21.56	3941	7.58	2130	22.59	4354	9.16	1224	23.95	4349	9.16	1224
σ (Nmm ⁻¹)	1.25	124.3	1.36	310.6	1.41	172.4	1.22	148.5	2.11	234.8	1.17	150.3
v (%)	6.56	3.33	1.09	42.76	7.25	4.33	16.5	15.26	10.56	5.99	15.61	15.33

• $p < 0.05$ for ANOVA

^{a, b} values having same letter are not significantly different (Duncan test)



2: 3D surface-pattern particleboard (left); coated with Truewhite liquid gloss 101314 (Wickes®) paint (right)

performance, the imprintment process is seen as successful. The imprinting of a hexagonal pattern on particleboard surfaces has significantly altered the board structure; however, a minimum of internal mechanical integrity remained. In this sense, the stated hypothesis can be confirmed, saying that 3D surfaces can be produced with post-imprintment, with some mechanical integrity remaining at an acceptable level. The new type of

particleboard is not suited to be used in higher-strength applications. However, a number of design-related applications are seen that do not require higher strength. With proper coating applications could be wall cladding, ceiling cladding, or decorative products (Fig. 2). With the shown imprintment a new type of 3D-surface particleboard has been created, which may find new market niches.

CONCLUSION

1. Through post-imprintment of a steel hexagonal pattern onto particleboard surfaces a new type of product was created.
2. The imprintment has significantly reduced mechanical integrity, however, an acceptable level of strength and stiffness has remained.
3. A number of design-related applications are seen, such as wall cladding, ceiling cladding, or decorative products.
4. Further research is needed such as applying different imprintment patterns, improve the process through e.g. steam injection, in-situ imprinting of particle mats, other modification treatments to allow better imprinting.
5. The 3D surface modification through imprinting can be also expanded to the other wood-based panels, i.e. fibreboards and oriented-strength-board (OSB).

Acknowledgement

This research was supported by the European Social Fund and the state budget of the Czech Republic, project InWood “The Establishment of an International Research Team for the Development of New Wood-based Materials” reg. no. CZ.1.07/2.3.00/20.0269, and the Internal Grant Agency (IGA) by the Faculty of Forestry and Wood Technology, Mendel University Brno (IGA-14/2014).

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