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Shape stability of chosen thin wood based panels after heating

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Abstract: *Shape stability of chosen thin wood based panels after heating*. Lignocellulose board materials are commonly used for furniture construction. Typically, these are particle boards, fibreboard or plywood with thicknesses from 10 to 20 mm, however, some furniture elements are made of thin boards with a thickness of 3-4 mm (back walls, bottoms of drawers and others). Modern furniture uses built-in components that are a source of heat, such as lamps, power supplies, ovens. Local high temperature may negatively affect the shape stability of thin lignocellulose plates. The aim of the research described in this article was to determine the impact of short-term exposure to high temperature on the dimensional stability of selected thin plate furniture materials. Four different HDF boards with nominal thicknesses of 3 mm and four different plywood boards with nominal thicknesses of 2 to 4 mm were tested. The test samples were subjected to a short-term exposure to temperatures of up to 250°C. As a result of the tests, it was found that HDF boards are characterized by a much higher shape stability at elevated temperature than boards made of plywood.

Keywords: HDF, plywood, furniture, shape stability

INTRODUCTION

In the furniture industry, various types of boards made of wood based materials are commonly used. An important design feature of lignocellulosic panel materials is their shape stability. Lignocellulose materials are characterized by low thermal transmittance as well as limited temperature resistance. It is assumed that the wood can stand a temperature of 170°C for a long time, while at a temperature exceeding 275°C its decomposition is accelerated (Borysiuk et al. 2019). Contemporary furnitures are often "embedded" with heat-emitting electrical and electronic devices (eg ovens, power supplies, light sources), which may expose wood based materials to the influence of increased temperature. This temperature, apart from the reduction of mechanical strength (Bekhta et al. 2003), also affects the dimensional stability of lignocellulose panels (Blomqvist 2015; Rindler et al. 2017).

The authors suggested that thin panels may be particularly sensitive to the risk of deformation. The purpose of the research described in the paper was to determine the impact of short-term exposure to high temperature on the dimensional stability of selected thin plate furniture materials.

MATERIALS AND METHODS

For presented research two different wood based material types have been chosen: HDF and plywood. In each group, four subtypes (table 1) depending on their producer and/or internal structure have been subjected to examination. The specimens of dimensions 150 × 100 mm were kept in normal conditions (temp. 20˚C, air humidity 65%) to a constant mass and at the time of experiment the moisture content was equal 5,5 ±0,7%. No special surface finishing, decay protection nor fire retardant treatment was applied.

Table 1. Examined wood based materials characterization.

Material	Denotation	Thickness (mm)	Density (kg/m^3)
HDF 1 (company 1)	HDF 1	3,05 ±0,03	839 ±5
HDF 2 (company 2)	HDF 2	3,05 ±0,04	903 ±45
HDF 3(company 3)	HDF 3	2,92 ±0,02	869 ±29
HDF 4 (company 4)	HDF 4	2,88 ±0,01	892 ±5
Plywood 1 (3-layer hardwood)	PLW 1	1,92 ±0,01	645 ±10
Plywood 2 (5-layer hardwood)	PLW 2	2,15 ±0,04	761 ±6
Plywood 3 (5-layer hardwood)	PLW 3	2,61 ±0,04	770 ±13
Plywood 4 (7-layer hardwood)	PLW 4	4,22 ±0,01	753 ±4

The samples have been then exposed to an elevated temperature in the oven according to the program shown in the figure 1.

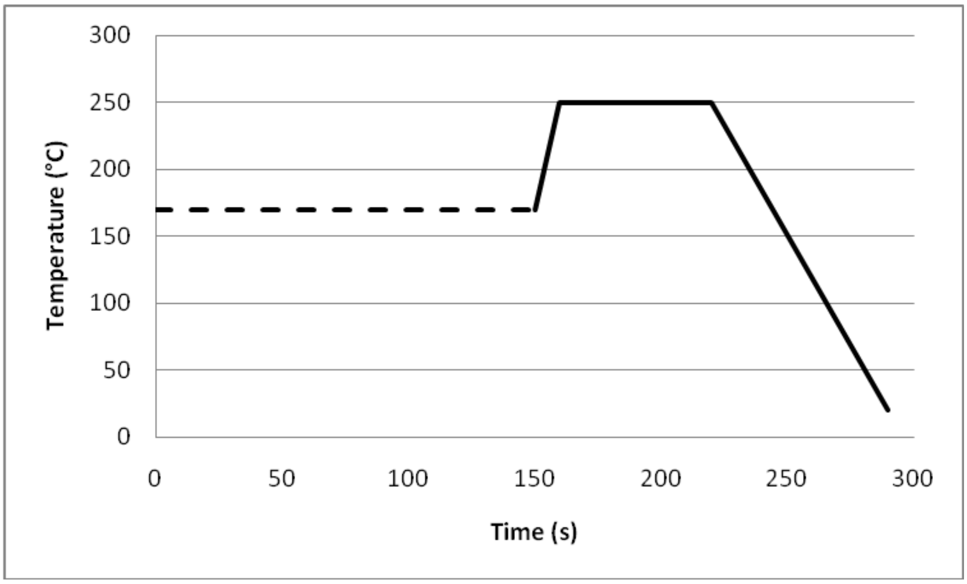

Figure 1. Temperature program for panels heating.

After heating all specimens have been again kept in normal conditions and next the geometries of their surfaces were measured in two perpendicular direction on the wide surface with a focus to surface curvature. The measurements were carried out on an stylus-type experimental stand The stand was designed on the basis of an induction displacement sensor Tesatronic® TT300 which measuring head moves along the examined surface with a constant feed speed. The head was equipped with a stylus of a 90˚ angle and a nose radius of 100 µm. Measurement data in the form of the point list (xi, yi) was recorded and then analyzed. The resulting data was subjected to the curve fitting in the form of an arc:

$$y = \sqrt{R^2 - (x-a)^2} + b$$

where a and b are meaningless coordinates of an arc center and R is its radius. The least squares has been optimized to perform the fitting. A curvature C of each panel was evaluated as:

$$C = R^{-1}$$

The coefficient of anisotropy was calculated simply by dividing the curvatures – higher and lower for two perpendicular dimensions of each specimen:

$$k_a = \frac{C_{max}}{C_{min}}$$

All results were averaged for each panel subtype.

RESULTS

The tested panels have shown very differentiated shape after heating They were all visibly bent. An example of surface profile and fitted arc function is shown in the figure 2.

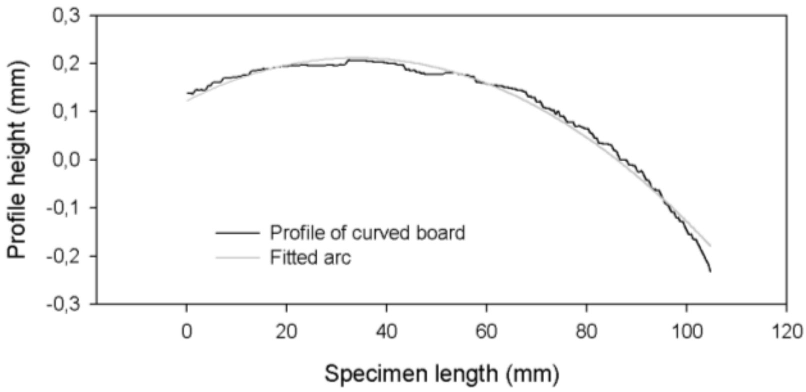

Figure 2. Example of the board surface profile and fitting arc used to curvature derivation.

Figure 3 shows sorted panels with respect to average maximal (no matter of grain or production direction) curvature. As visible HDF boards were generally more stable after heating than plywood samples. The curvature of the most bent panel was around 10 times higher than the less one. The less of all deformed specimen was plywood PLW 2 with maximal radius of arc was 2 422 m and, what is surprising, the most deformed was another specimen of the same panel with radius 1.1 m.

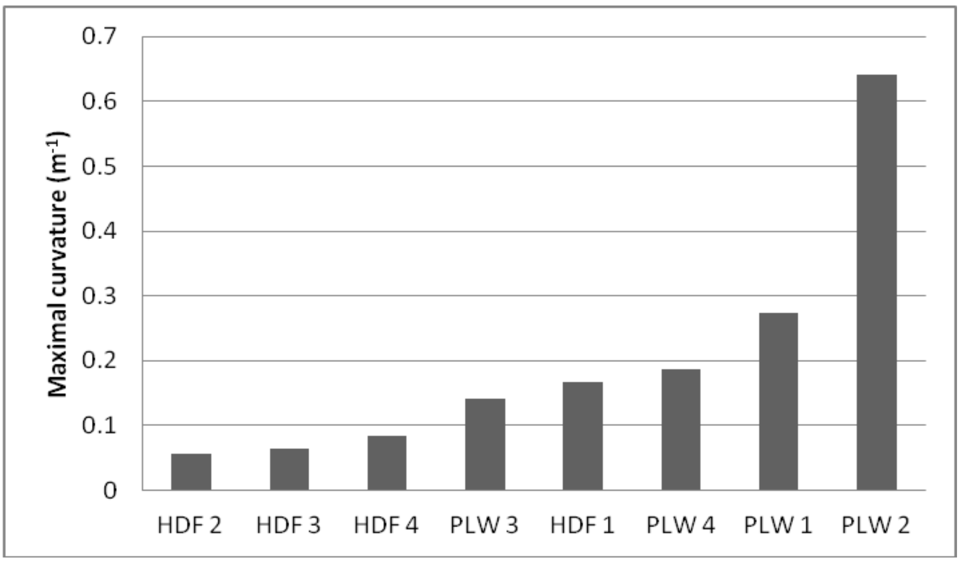

Figure 3. Maximal curvatures of panels after heating ascending sorted.

Figure 4 shows a comparison of longitudinal and perpendicular curvatures for each subtype of panels. The standard deviation bars in the figure 4, shows a comparison of longitudinal and perpendicular curvatures for each subtype of panels. It is visible that plywood in general has higher curvatures, higher differences between directions and higher standard deviations. The most recommended of tested panels are HDF 2 and HDF 3 as they never reach 0.1 m^{-1}.

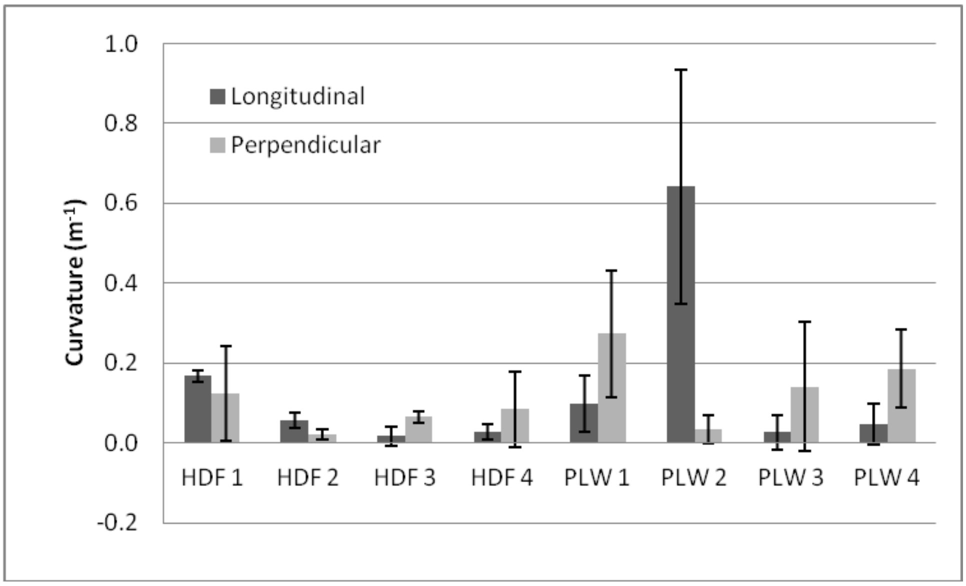

Figure 4. Maximal curvatures of panels after heating ascending sorted.

Figure 5 presents coefficients of anisotropy of panels. For PLW 2 it reaches almost 20 while for PLW 1 it not exeeds 3.

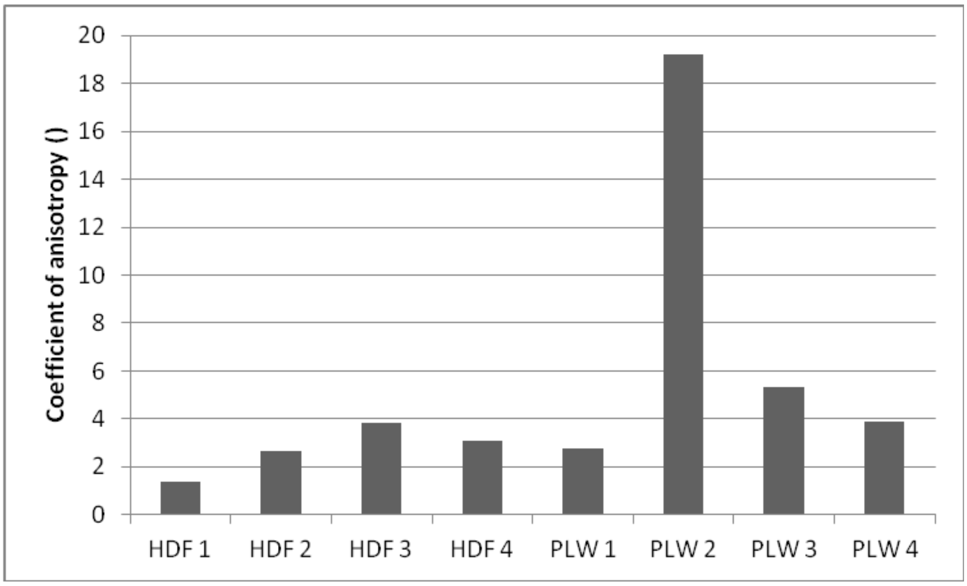

Figure 5. In-plane anisotropy of tested panels.

CONCLUSIONS

After analyzing the results of the experiment, the following conclusions and observations were formulated:

1. Tested HDF boards have greater dimensional stability than boards made of plywood (Fig. 2-4). This is due to their more homogeneous internal structure.
2. For 5-layer hardwood plywood (PLW 2) coefficients of anisotropy reaches almost 20 while for 3-layer hardwood plywood (PLW 1) it not exeeds 3 (fig. 5). Plywood panels because of their layered and less homogenic structure seem to be very anstable. Probably veneers of its layers have different quality: lathe checks, thiskness variations etc.

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AUTHOR'S PARTICIPATION

Maciej Sydor – giving an idea of the research, analysis of scientific literature, participation in the experiment, co-writing the manuscript, corresponding author. Bartosz Pałubicki - identification and elaboration of the scientific way of approaching the problem, planning the experiment, participation in the performance of the experiment, working out the research results and comparing them in a form allowing their interpretation, co-writing the manuscript.

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Streszczenie: *Stabilność kształtu wybranych cienkich płyt drewnopochodnych po podgrzaniu*. Do budowy mebli powszechnie wykorzystuje się lignocelulozowe tworzywa płytowe. Zwykle są to płyty wiórowe, pilśniowe, klejonka lub sklejka o grubościach od 10 do 20 mm, jednak niektóre elementy mebli wykonuje się z cienkich płyt o grubości 3-4 mm (ścianki tylne, dna szuflad i inne). We współczesnych meblach stosuje się wbudowane podzespoły będące źródłem ciepła, takie jak np. lampy, zasilacze czy piekarniki. Lokalna wysoka temperatura może negatywnie wpływać na stabilność kształtu cienkich płyt lignocelulozowych. Celem, opisywanych w niniejszym artykule badań, było określenie wpływu krótkotrwałego odziaływania wysokiej temperatury na stabilność wymiarową wybranych cienkich płytowych tworzyw meblarskich. Przebadano 4 różne płyty HDF o nominalnych grubościach 3 mm i cztery różne płyty sklejkowe o nominalnych grubościach od 2 do 4 mm. Próbki badawcze poddawano krótkotrwałemu odziaływaniu temperatury do 250°C. W wyniku przeprowadzonych badań stwierdzono, że płyty HDF charakteryzują się znacznie większą stabilnością kształtu w podwyższonej temperaturze od płyt wykonanych ze sklejki.

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