

Effects of Press Pressure and Temperature on The Moisture Content, Vertical Density Profile and Janka Hardness of Pine Wood Panels

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ABSTRACT

The objective of this study was to investigate the effects of temperature and press pressure on the moisture content (MC), vertical density profile (VDP) and janka hardness of solid-wood panels. The experimental solid-wood panels used in the study were manufactured from *Pinus sylvestris* wood. The panels with dimensions of 250 mm by 500 mm by 18 mm were compressed at a temperature of 120°C and 150°C, pressure of 50 and 70 bar for 60 min in a hot press. As two panel for each factor and two levels, totally 8 panels were manufactured. Samples obtained from the panels were tested for janka hardness and VDP.

Thermal compressing of solid-wood panels with different pressing parameters improved final moisture content, density and janka hardness of the samples when compared to untreated samples. This study indicated that VDP could affect solid wood panel properties such as in manipulating some production parameters of wood-composite panels. In this way, end uses of solid-wood panels from pine wood could be expanded.

1. INTRODUCTION

Using compression and temperature of wood purposes to increase its physical and mechanical properties. Thermally compressed wood is known as staypak (Seborg et al. 1945; Stamm, 1964), while compressed wood with phenol formaldehyde (PF) resin pretreatment is called compreg (Stamm and Harris 1953; Stamm, 1964). Furrher studies were done by Tarkow and Seborg (1968) studying surface densification of wood. After 1980s compressed wood products for low density, and cheaper wood species were produced, especially for utilization some fast growing in Asia (Norimoto 1993; Wang et al. 2000; Norimoto 1994).

Compression in wood is generally considered to be analogous to hot pressing wood composites panels, except that it takes longer to obtain solid wood compression set without the bonding effect of resins. Wang and Cooper (2004) studied the effects of grain orientation and surface plasticizing methods on the VDPs of compressed balsam fir and spruce. In addition, Wand and Cooper (2005) investigated the effects of hot press closing rate, wood initial moisture content, and

sample size on the VDPs of compressed fir wood. Wood species and mixture ratios have some effects on the VDP and performance properties of MDF panels (Candan et al. 2007).

Density distribution through the thickness of wood composite panels such as fiberboard and oriented strandboard typically shows higher surface density and lower core density. Density gradient is affected by the combined influences of pressure, moisture content, temperature, resin curing, and other factors during pressing and affects physical and mechanical properties of the wood composites (Wang and Winistorfer 2000; Strickler 1959; Kamke and Casey 1988). Because of differences in material properties and hot pressing parameters compared to wood composite panels production, densified solid wood boards could show a different density profile. Candan (2007) studied on the effects of the process parameters on the VDP and technological properties of medium density fiberboard (MDF) and reported that press pressure affects vertical

density profile and technological properties of MDF panels.

Pressing wood under high temperature may result in faster drying, improved dimensional stability and

increased density, hardness and surface quality. In this study we evaluated the effects of pressing of pine wood boards under high temperatures on final moisture content, VDP and janka hardness.

2. MATERIALS AND METHODS

Commercial Scotch pine (*Pinus sylvestris* L.) boards with dimensions of 250 mm by 500 mm by 18 mm were compressed at a temperature of 120°C and 150°C, press pressure of 5 and 7 MPa for 60 min in a hot press (Figure 1). A 500 mm by 500 mm laboratory hot press was used to compress the boards (Figure 2). A total of five board groups with four treatment groups and a control group were investigated. Larger specimens (18 by 250 by 500 mm) were cut into 50 by 50 mm for tests.

All samples with grain angles of around 0 degree (tangential) were chosen to evaluate VDPs and Janka hardness for this study. As two solid wood panels in one treatment group, a total of ten boards was produced. VDP was measured with an X – ray density profiler (GreCon Measurement Systems, Germany) (Figure 3). A universal test machine was used for determining janka hardness. Pressing parameters for the boards is shown in Table 1.

Table 1. Pressing parameters for experimental groups

Group	Pressure (Bar)	Temperature (°C)	Time (hr)
A	50	120	1
B	50	150	1
C	70	120	1
D	70	150	1
Control	-	-	-

3. RESULTS AND DISCUSSION

3.1. Final Moisture Content of Boards

In the first experiment, the boards were dried by heating under pressure in the hot press from 60% to 13% moisture content (MC) since drying defects such as cracks, deformations and darkness were observed in the boards, predrying was applied on the boards for the last experiment. The boards predried to 20% MC were compressed in hot press and reached to 8% MC. The

boards subjected to predrying process were finally free of any defects and deformations.

3.2. VDP of Control Boards

The untreated control boards had an average PD of 510 kg/m³ and CD of 420 kg/m³. Mean density (MD) of control group was 460 kg/m³. The VDP is shown in Figure 4.

3.3. VDP of Compressed Boards

The samples pressed at a minimum press pressure (50 bar) and temperature (120°C) had lower peak density (PD) and core density (CD) when compared to untreated

boards. These samples had an average PD of 560 kg/m³ and CD of 435 kg/m³. Mean density (MD) of A group was 470 kg/m³. The VDP is shown in Figure 5.

While PD of solid wood board samples pressed at a minimum press pressure (50 bar) and maximum temperature (150°C) was 650 kg/m³, CD was 550 kg/m³

as shown in Figure 6. In addition, B group's MD was 580 kg/m³.

C solid wood board pressed at a maximum press pressure (70 bar) and minimum temperature (120°C)

had PD of 780 kg/m³, CD of 610 kg/m³ also the VDP is shown in Figure 7. The group's MD was 660 kg/m³.

D solid wood board pressed at a maximum press pressure (70 bar) and maximum temperature (150°C) had the highest PD and CD were 900 kg/m³, 800 kg/m³

respectively also the VDP is shown in Figure 8. The group's MD calculated 830 kg/m³.

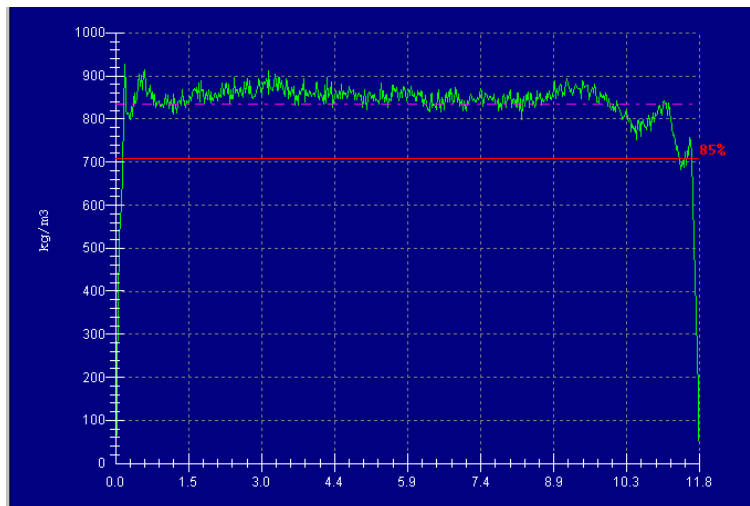


Figure 8: VDP of D board

3.4. Janka Hardness

Janka hardness was evaluated for control and all treatment groups as shown in Table 2.

Table 2: Janka hardness values of solid wood boards

Treatment	Janka Hardness (kg/f)
Control	193.29
50 bar + 120°C	230.11
50 bar + 150°C	269.96
70 bar + 120°C	274.93
70 bar + 150°C	382.30

The lowest janka hardness values (193.29 kg/f) were observed in untreated board group. First treatment group's janka hardness value (230.11 kg/f) was higher than that in the control group. As pressing temperature increased to 150°C, hardness values increased. When

pressure increased from 50 bar to 70 bar, the hardness value improved. The board group produced at the maximum press pressure and pressing temperature level had the highest hardness value (382.30 kg/f) with increasing about 100%.

4. CONCLUSIONS

- In conventional drying methods, total drying time is in general 24 hours for 20 mm thick pine lumber when the MC is decreased from 20% to 8%. However in the process we used, drying time decreased to 1 hour using high

pressure and temperature. In this process, the board thickness decreased to 11 mm by using the maximum pressure. Although the thickness reduction was approximately 45%, no drying defects occurred.

- It was concluded that the VDP in the solid wood panels was closely related with the press pressure and pressing temperature. Increasing pressure and temperature was resulted in increased PD and MD values which are defining factors VDP.
- This research indicated that as increased press pressure and temperature as increased janka hardness value in solid wood boards and when the pressing parameters used maximum levels hardness value was the highest. Because of densification on the surface layers of solid wood boards, janka hardness value was affected positively. The group D had the highest PD value showing the greatest hardness.
- Finally with some additional findings such as strength, surface roughness, color and shrinkage-swelling behavior of this type of wood material from preferably cheaper tree species, it can be defined the using areas of this wood product dried and hardened in hot press.
- Future study will focus the effect of pressing parameters on the surface roughness and water absorption behavior of solid wood boards.

LITERATURE CITED

Candan, Z. 2007: Effects of production parameters on vertical density profile (VDP) and technological properties of medium density fiberboard (MDF), M.S. thesis, Istanbul University, Istanbul, Turkey.

Candan, Z.; Akbulut, T.; Sisci, A.F.; and Zhang, X. 2007: Effect of species and mixtures on the formation of the vertical density profile and bending properties in medium density fiberboard (MDF) panels, Forest Products Society 61st Annual Meeting, Tennessee, USA.

Kamke, F.A.; Casey, L.J. 1988: Fundamentals of flakeboard manufacture: Internal – mat conditions, Forest Products Journal, 38(6): 38 – 44.

Norimoto, M. 1993: Large compressive deformation in wood, Mokuzai Gakkaishi, 39(8): 867 – 874.

Norimoto, M. 1994: Heat treatment and steam treatment of wood, Wood Industry, 49(12): 588 – 592.

Seborg, R.M.; Millett, M.A., and Stamm, A.J. 1945: Heat – stabilized compressed wood (Staypak), Mech. Eng. 67:25 – 31.

Stamm, A.J. 1964: Wood and cellulose science, Ronald Press, New York, USA.

Stamm, A.J.; Haris, E.E. 1953: Chemical processing of wood, Chemical Publishing Co., Inc, New York, USA.

Strickler, M.D. 1959: Effect of press cycle and moisture content on properties of Douglas fir flakeboard, Forest Products Journal, 9(7): 203 – 215.

Tarkow, H.; Seborg, R.M. 1968: Surface densification of wood, Forest Products Journal, 18(9):104 – 107.

Wang, J.; Cooper, P.A. 2004: Vertical density profiles in thermally compressed balsam fir wood, Forest Products Journal, 55(5): 65 – 68.

Wang, J.; Cooper, P.A. 2005: Effect of grain orientation and surface wetting on vertical density profiles of thermally compressed fir and spruce, Holz als Roh- und Werkstoff, 63: 397 – 402.

Wang, J. M.; G.J., Zhao; Lida, I. 2000: Effect of oxidation on heat fixation of compressed wood of China fir, Forestry Studies in China, 2(1): 73 – 79.

Wang, S.; Winistorfer, P.M. 2000: Fundamentals of vertical density profile formation in wood composites, Part 2, Methodology of vertical density formation under dynamic condition, Wood and Fiber Science, 32(3): 220 – 238.

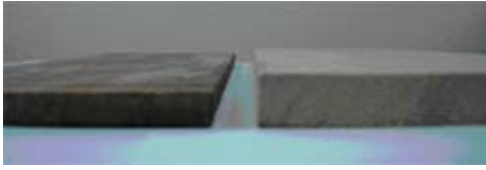


Figure 1: Treated (left) and untreated (right) boards



Figure 2: Hot pres



Figure 3: Vertical density profile meter

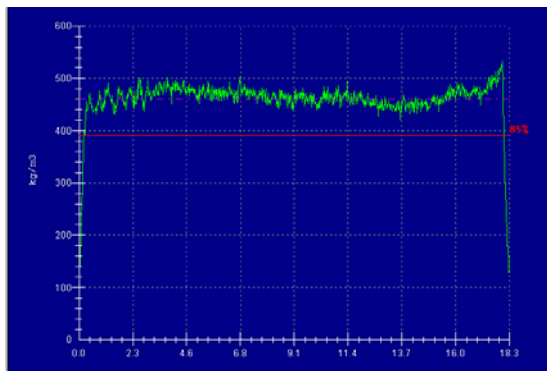


Figure 4: VDP of control board

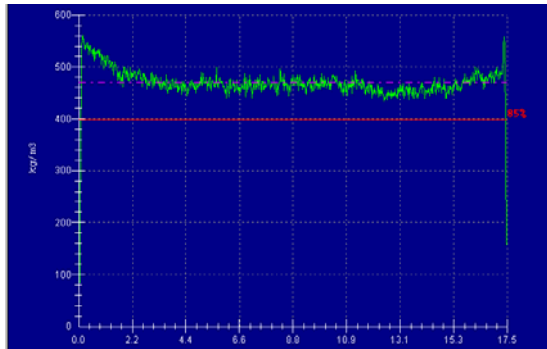


Figure 5: VDP of A board

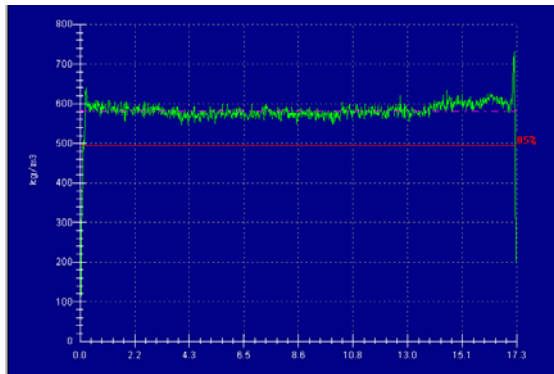


Figure 6: VDP of B board

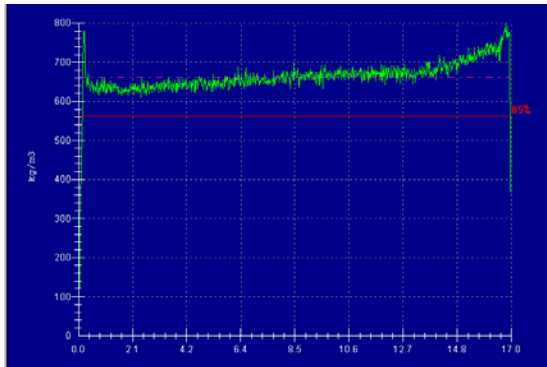


Figure 7: VDP of C board