THE EFFECT OF PRESS TEMPERATURE ON SOME MECHANICAL PROPERTIES OF WOOD BASED COMPOSITE PANELS

Mustafa Kucuktuvek
Antalya Bilim Üniversitesi, School of Fine Arts and Architecture, Antalya, Turkey

ABSTRACT

This research investigated the effect of press temperature on some mechanical properties of wood based composite panels. For this purpose, three layers wood based composite panels were produced from a mixture of scots pine (*Pinus sylvestris* L.) and black pine wood (*Pinus nigra* V.) particles at certain ratios utilizing urea formaldehyde (UF) adhesive. All panels were tested for mechanical properties; modulus of rupture, modulus of elasticity, internal bond strength. The results have shown that press temperature were affected on the mechanical properties of the manufactured wood based composite panels. When the press temperature was increased the mechanical properties were also increased. However high press temperature may destroy the natural color of composite panel and increase manufacture cost. The manufactured composite panels may use as industrial design engineering material such as furniture, sliding doors, pool tables, floor underlayment, cupboards, home constructions, wall linings, cabinets and stair treads.

Key words: interior architecture, industrial materials, composite panel, press temperature.

1. INTRODUCTION

Wood based composite panels are very popular engineering product manufactured from wood particles, synthetic resins or other proper adhesives and hardener. Most of wood based composite panels have three layers. The outer layer has small wood particles and more adhesive ratio than core layer and core layer has bigger wood particle dimension and less adhesive ratio. Most of composite panel manufacturer are using about 34% wood particles for outer layer and 66% for core layer (Keskin et al. 2015).

Composite panels are widely used in the manufacture of interior decoration, furniture, sliding doors, pool tables, toys, floor underlayment, cupboards, home constructions, wall linings, cabinets, stair treads, shelving, joinery and many other civil and industrial engineering applications (Amazio et al. 2011). The demand for wood based composite panels such as particleboard and plywood has recently increased throughout the world. Particleboard is 57% of total consumption of wood based composite panels consumed and it is continuously growing at 2–5% annually (Ashori et al. 2009).

Some research has been done on the determination of some factors on the quality properties of wood based composite panels (Baharoglu et al. 2013). Among these factors studied are moisture content of wood (Baharoglu et al. 2012), particle geometry (Juliana et al. 2012), adhesive ratio (Ghalehno et al. 2011), loading cycles (Del Menezzi et al. 2011), hardener type (Atar et al. 2014), density profile and hot press diagram (Bardak et al. 2011), formaldehyde/urea mole ratio (Sari et al. 2010), using poppy husk (Keskin et al. 2015), using needle litter (Nemli and Aydin), press type (Nemli and Demirel 2007), press time (Kalaycioglu and Nemli 2006), using bark extractives (Nemli et al. 2006), residue type and tannin content (Neml et al. 2004) and lamination technique (Nemli and Colaoglu 2005).

This study aimed the effect of press temperature on some mechanical properties of wood based composite panels in laboratory condition.

2. EXPERIMENTAL METHODS

2.1. Wood particles

Scots pine (Pinus sylvestris L.) and black pine wood (Pinus nigra V.) particles are classified and obtained from ORMA Stock Corporation particleboard factory in Turkey as dried up to 3% moisture gradient. The thickness of wood particles, which are used in the core layer, are 0.25–0.40 mm, their widths are 2–6 mm and their lengths 10–25 mm. Diameter of wood particles which are used in outer layer, are 0.5–1.5 mm, and also their lengths are 1.5–3 mm.

2.2. Adhesive

In this study urea formaldehyde (UF) adhesive were used, and it has a density of 1.237 ± 0.020 g/cm^3, a viscosity of 140 to 200 cps at 20 ± 2 °C and an approximate pH value of 7.5 to 8.7, with a gel time of 15 to 25s at 100 °C. The maximum free formaldehyde ratio of UF is 0.8%, the adhesive were produced by a local plant.

2.3. Preparation test speciments

Three layers wood based composite panels were produced from a mixture of scots pine (*Pinus sylvestris* L.) and black pine wood (*Pinus nigra* V.) particles at certain ratios utilizing urea formaldehyde (UF) adhesive. Wood particles were dried in oven at 100±3 ^{o}C to get the target moisture content 3%. Moreover, 8% of UF resin was used for the core layer, and 10% for the outer layer which respectively depends on oven dry weight of the core and outer layers. The target density of the panels was 0.66 g/cm^3. The composite panel matrix was designed to make up to 34% wood particles at the outer layer, and 66% at the core layer. In order to harden the adhesive, 2% ammonium chloride (NH_4Cl) was also added to resin. Composite panels were manufactured by using standardized steps which simulated industrial production at the laboratory of Gazi University Technology Faculty. So as to obtain homogenized mixture, the hardener and the adhesive were weighted and mixed. Afterwards, the particles were weighed and sprayed with the prepared UF adhesive in a drum mixer for 5 minutes Fig 1. The composite panels were pressed under 2.5 N/mm^2 pressure, at 140, 160, 180 ^{o}C, for 6 minutes.

Figure 1: Drum mixer

The glued particles were placed on the three layers, after cold press the glued particles were pressed by using a laboratory scale hydraulic hot press. Thickness of composite panels was controlled via stop bars. Four panels were made for each group. The dimension of the panels was 500x500x18 mm (Fig. 2).

Figure 2: Trimming composite panels

The production parameters of composite panels are displayed in Table 1. The panels conditioned at 65% relative humidity and 20^{o}C to reach the moisture content of about 12% before trimming to final dimension of 460x460x18mm.

Table 1: Production parameters of composite panels

Parameter	Value
Press temperature (^{o}C)	140 – 160 – 180
Pressing time (min)	6
Adhesive ratio outer (%)	10
Adhesive ratio core (%)	8
Peak pressure (N/mm^2)	2.5
Thickness (mm)	18
Dimensions (mm)	500 x 500
33% NH_4Cl content (%)	1 – 2 – 3
Outer layer (%)	34
Core layer (%)	66
Number of panels	12

2.4. Testing method

All panels were tested for mechanical properties; modulus of rupture, modulus of elasticity, internal bond strength.

All test samples were prepared from the drafts, according to European test standards. Ten samples were tested for each group. The modulus of rupture (MOR) and modulus of elasticity (MOE) values were determined according to European Norm (EN 310, 1993). The internal bond strength (IB) was evaluated according to European Norm (EN 319, 1993).

Table 2:

3. RESULTS AND DISCUSSION

According to European Norm (EN 310, 1993), the modulus of rupture (MOR) of the composite panels was tested. Duncan’s mean separation test indicated that the effects of variance sources on the MOR and the difference were meaningful between all composite panels. The result of homogeneous subsets for composite panels can be seen in Table 2. when the press temperature was 180 ^{o}C in the manufacture of the composite panel the highest MOR values were detected (13.87 N/mm^2). On the contrary, the lowest MOR values were obtained in the composite panels manufactured at 140 ^{o}C (13.21 N/mm^2).

Table 2: Mechanical properties of experimental panels

Press Temperature (°C)	*Modulus of Rupture (*MOR) (N/mm²)	*Modulus of Elasticity* (MOE) (N/mm²)	*Internal Bond Strength* (IB) (N/mm²)
140	13.21[a]	1792[a]	0.64[a]
160	13.62[b]	1923[b]	0.72[b]
180	13.87[c]	2022[c]	0.74[b]

[a, b, c] Homogeneous subsets ($p<0.05$)

As it is seen in the Fig. 3, MOR values of composite panels were increased depending on the increase of the press temperature. European Norm (EN 312, 1993) standards are necessary for the minimum MOR of 11 N/mm^2 for general purpose composite panels. The curves of figures 3, 4 and 5 are obtained and drawn using B-spline function in the graph software Oroginpro. B-spline is a combination of flexible bands that passes through the number of points that are called control points and creates smooth curves. These functions enable the creation and management of complex shapes and surfaces using a number of points. As Table 2 indicates, all panels which were made in this study, provided MOR values exceeding the EN 312 standards.

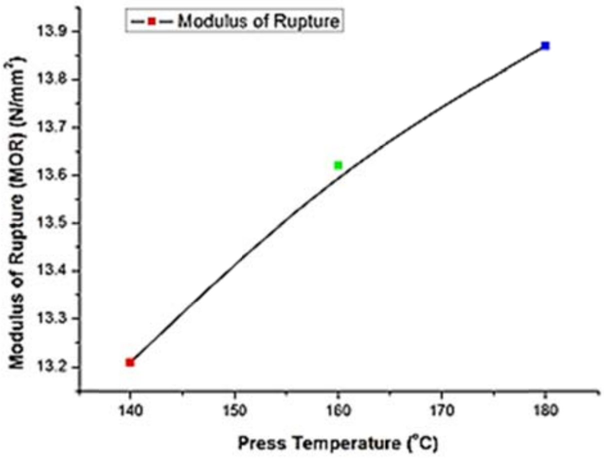

Figure 3: Modulus of Rupture

The similar MOR values were achieved in the composite panels (Guler *et al.* 2008) and the other study also showed the similar results (Kalaycioglu *et al.* 2006).

The modulus of elasticity (MOE) of the manufactured composite panels was analyzed According to European Norm (EN 310, 1993). Duncan’s mean separation test, for the effects of variance sources on the MOE, concluded that the difference was meaningful among all composite panels. The conclusions of homogeneous subsets for composite panels are shown in Table 2. The highest MOE values were observed (2022 N/mm^2), when 180 °C press temperature was applied. On the other hand, the lowest MOE values were obtained in the composite panels, when 140 °C press temperature was applied (1792 N/mm^2) Fig. 4.

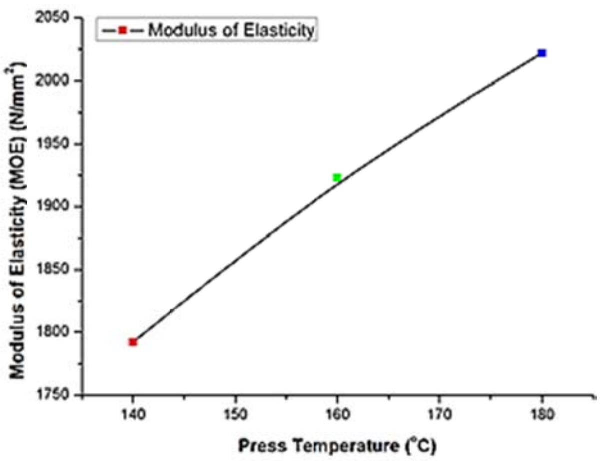

Figure 4: Modulus of Elasticity

The requirement of European Norm for modulus elasticity in general purpose composite panels is 1600 N/mm^2. All composite panels were fulfilled the minimum MOE that has been determined in the EN 312 for interior fitments including the furniture manufacture.

In a similar literature, the MOE values were observed in the composite panels that produced mixture of peanut hull (*Arachis hypoqaea* L.) and European Black pine (*Pi-*

nus nigra A.) wood chips (Gueler *et al.* 2008). Coating of the composite panel surfaces and use of phenolic resins can improve the mechanical properties of the panels (Buyuksari *et al.* 2010).

The internal bond strength (IB) of the panels was tested according to European Norm (EN 319). What Duncan's mean separation test shows as a result is that the difference for the effects of variance sources on the internal bond was not meaningful between 160 ^{o}C and 180 ^{o}C press temperature. Table 2 displays the result of homogeneous subsets for composite panels. The highest IB values were monitored, when 180 ^{o}C press temperature applied in the manufacture of the composite panel (0.74 N/mm^2), the lowest IB values were observed in the composite panels (Fig. 5) which applied 140 ^{o}C (0.64 N/mm^2).

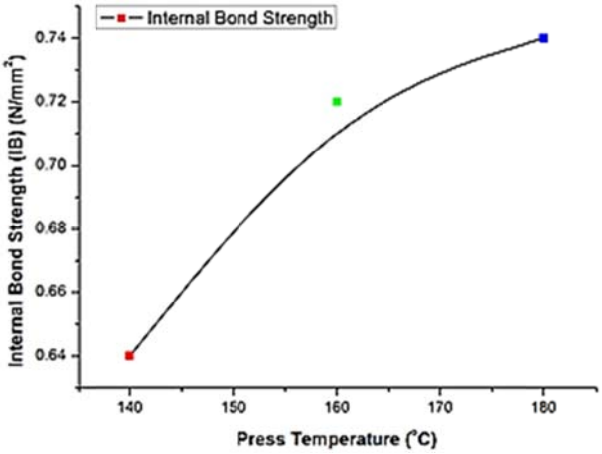

Figure 5: Internal Bond Strength

IB values of composite panels were increased with the increase of press temperature in the panel manufacture. Depending on that fact, the composite panels, which are manufactured by applying 140 ^{o}C, 160 ^{o}C and 180 ^{o}C press temperature fulfills the standard of IB, it has been determined in the European Norm (EN 312) for interior fitments, including the furniture manufacture. Similar internal bond strength result was stated in literature (Buyuksari *et al.* 2010).

4. CONCLUSIONS

The results have shown that press temperature were affected on the mechanical properties of the manufactured wood based composite panels. When the press temperature was increased the mechanical properties were also increased. However high press temperature may destroy the natural colour of composite panel and increase manufacture cost.

The manufactured composite panels by using scots pine (*Pinus sylvestris* L.) and black pine wood (*Pinus nigra* V.) particles utilizing urea formaldehyde (UF) adhesive may use as interior and exterior architecture material such as furniture, sliding doors, pool tables, floor underlayment, cupboards, home constructions, wall linings, cabinets and stair treads.

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UNIVERSITY OF FORESTRY

FACULTY OF FOREST INDUSTRY

INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN

2/2017

INNO vol. VI Sofia

ISSN 1314-6149
e-ISSN 2367-6663

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