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THE EFFECT OF CLIMATIC CONDITIONS ON SOME MECHANICAL PROPERTIES OF WOOD-PLASTIC COMPOSITES

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Key words

Wood Flour-PP (Polypropylene), Composite Panels, Clımatic Condıtions, Mechanical Properties, Bending Strength.

Abstract

It has become a necessity to conduct a study on the behaviors of widely used wood-plastic composite sheets in various application areas. This study was conducted to determine the effect of low temperatures on some technological properties of wood-plastic composites. For this purpose, Wood-Plastic Composite Sheets obtained from thermoplastic materials polypropylene and scots pine wood flour and MDF wastes were kept in climatic environment (-20 °C for 10 days) and the hardness, bending strength and modulus of elasticity were investigated.

As a result, while the hardness values of the composites made from Scots pine wood has decreased after the climatic environment, the exact opposite values have been observed in MDF. The highest value in bending strength was observed in the composite produced from scots pine left in the climatic conditions. The highest values in the modulus of elasticity were determined in the composite sheets produced from MDF-used-fibres left in the climatic environment. According to this, the climatic environment has increased the bending strength and modulus of elasticity composite materials.

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1. INTRODUCTION

Rapid population growth, industrialization and economic originated developments have made searches for an alternative raw material instead of rapidly depleting forest resources necessary. Composite materials, which are created with forest products, offer significant alternatives for renewable, recyclable and sustainable resources. Composite materials can improve the properties when the materials forming the mixture alone are insufficient. The aesthetic value of wood, its low weight and its sustainability as well as the water resistance of the plastic material and the good adhesion of its thermoplastic structure have led to the significant development of the wood-plastic composite (WPC) industry (Ford, 1999; Süinanç, 2007; Rowell, 2009).

Composites formed by adding wood flour and MDF (Medium Density Fiberboard) wastes into the recycled plastics can also enable a decline in costs (Bilici, 2012). WPC offers a range of products such as deck, fence, flooring material, garden furniture, door and window profile for the areas where the weather resistance performance is sought for the furniture, construction and automotive industries as WPC potential application areas.

At what rate the wood used contributes to the composite, with which method it forms a compound, its moisture, its specific gravity, its anatomical structure, the temperature it is exposed and duration of exposure may affect the mechanical properties of the composite (Ilic, 1995; English and Falk, 1995; Groom et al., 1995; Bledzki et al., 2005, Aydemir, 2007; Kocaefe et al., 2008; Kaymakci and Akyildiz, 2011; Poletto et al., 2011; Wechsler et al., 2019).

With this study, it was aimed to determine the hardness and bending properties of wood-plastic composite materials changing in minus degrees.

2. METHODS AND MATERIALS

WPC which was obtained with mdf powder and thermoplastic Polypropylene and scotch pine flour was used as a test material (Figure 1.). Materials were randomly selected from the companies in Ankara Sincan Organized Industry, and mechanical and physical tests were conducted.


Figure 1. Wood-Plastic Composites

For the experiments, composites prepared from scotch pine and mdf wood flour were arranged as shown in Table 1 to keep per 10 samples under normal and climatic conditions.

Table 1: Experimental plan

Composite Type (Factor A)	Conditions (Factor B)	Experiment	Dimensions (mm)	Number
MDF wastes + Polypropylene Composite (MP)	Control	Elasticity (ISO 3133, ISO 3349)	360x20x20	10
		Hardness (ISO 3350)	50x50	10
	Climatic Conditions (C)	Elasticity	360x20x20	10
		Hardness	50x50	10
Wood flour + Polypropylene Composite (WP)	Control	Elasticity	360x20x20	10
		Hardness	50x50	10
	Climatic Conditions (C)	Elasticity	360x20x20	10
		Hardness	50x50	10

After test materials, apart from control materials, were kept in the ID-300 climatic test chamber, which is shown in Figure 2., for 10 days at -20 degrees, some mechanical and physical tests were carried out.

Figure 2. Climatic Test Chamber

3. RESULTS AND DISCUSSION

BENDING STRENGTH

The effect of the dual interaction of composite type and climatic conditions on the average bending strength values is given in Table 2.

Table 2. Average values of bending strength (N/mm^2)

Factor A+B	X
MP	732.2
MP-C	743.9
WP	1152
WP-C	1531

* LSD:45.20, C: Climatic Condition

According to the bending resistance test, the highest value was obtained in WP-C (1531 N / mm^2) and the lowest was in MP (732.2 N / mm^2). Climatic conditions have increased the bending resistance values. In a similar study, the high-speed cooling did not affect significantly the mechanical properties of wood, while slow and gradual cooling reduced all values (Szmutku, et al., 2013). The highest bending strength values in terms of composite materials were detected in scots pine and the lowest was in mdf. The graph belong to this is given in Figure 3.

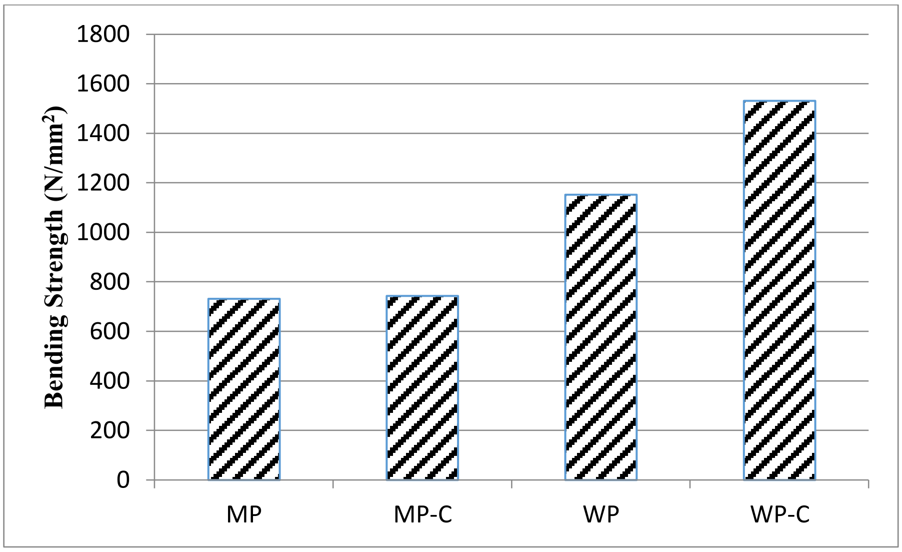

Figure 3. Bending Strength Performance Change

MODULUS OF ELASTICITY

Multiple variance analysis of the effects of composite type and climatic conditions on modulus of elasticity in bending is given in Table 3.

Table 3. Multiple Variance Analysis Results of Modulus of Elasticity in Bending

Variance Source	Degree of Freedom	Sum of Squares	Mean of Squares	F Value	α≤0.05 (Sig)
Factor A	1	92728606.998	92728606.998	757.4820	0.0002*
Factor B	1	6925801.583	6925801.583	56.5755	0.0000*
AB	1	1433609.970	1433609.970	11.7109	0.0000*
Error	20	2448338.156	122416.908		
Total	23	261.740			

A: Composite Type, B: Climatic Conditions, * significant

According to the results of multiple variance analysis, all interactions were found significant (α≤0.05). Table 4 shows the DUNCAN test results conducted to determine the difference is between which groups.

Table 4. Average Values for Modulus of Elasticity in Bending (N/mm^2)

Factor A+B	X
MP	12630
MP-C	13210
WP	8205
WP-C	9769

* LSD:421.3, C: Climatic Condition

According to the test carried out to determine the modulus of elasticity, the highest value was obtained in MP-C (13210 N / mm^2) and the lowest was in WP (8205 N / mm^2). The highest modulus of elasticity as composite type was obtained in composites obtained from mdf flour. The graph of these results is given in Figure 4.

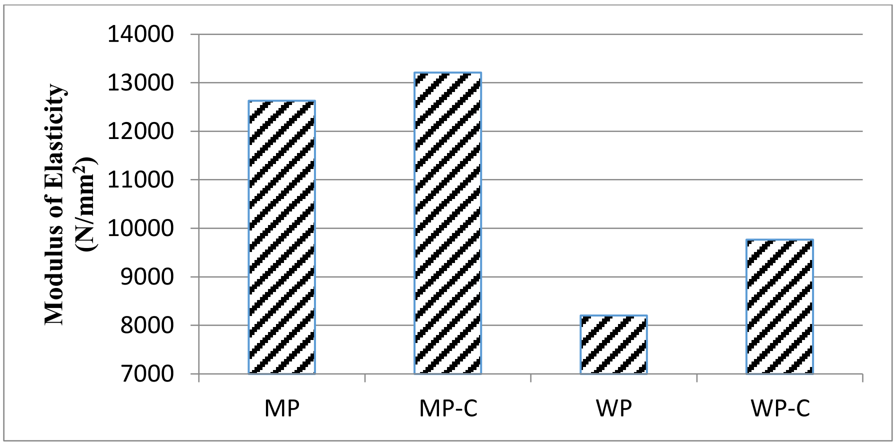

Figure 4. Modulus of Elasticity Performance Change

HARDNESS

Multiple variance analysis concerning the effects of composite type and climatic conditions on hardness strength values are given in Table 5.

Table 5. Multiple Variance Analysis results of Hardness Strength

Variance Source	Degree of Freedom	Sum of Squares	Mean of squares	F values	α≤0.05 (Sig)
Factor A	1	0.426	0.426	2.4583	0.1306
Factor B	1	0.067	0.067	0.3886	0.0000*
AB	1	1.271	1.271	7.4081	0.0131*
Error	20	3.431	0.172		
Total	23	5.195			

A: Composite Type, B: Climatic Conditions, * significant

According to the results of multiple variance analysis, all interactions were found significant (α≤0.05) except for the single effect of composite type. DUNCAN test results, which were conducted to determine between which groups the difference occurs, are given in Table 6.

Table 6. average Values for Hardness Strength (N/mm^2)

Factor A+B	X
MP	1.568
MP-C	2.134
WP	1.762
WP-C	1.407

* LSD:0.4953, C: Climatic Condition

According to the test results for hardness strength, the highest value was obtained in MP-C (2.134 N / mm2) and the lowest in WP-C (1.407 N / mm2) when looked to the composite and environment types. The graph belonging these results is given in Figure 5. MDF and scotch pine which constitute the filling materials of the composites have showed different properties in terms of hardness values at low temperatures (Aydemir, 2007; Kocaefe et al., 2008; Gürleyen et al., 2017). While low temperatures increased MP's hardness and it decreased in WP.

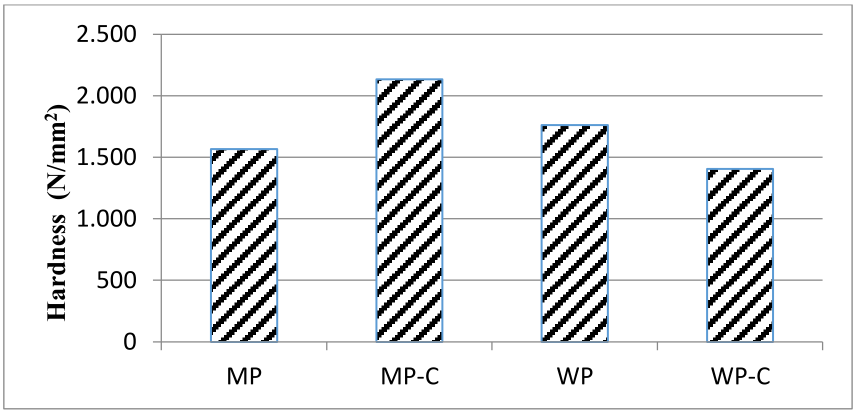

Figure 5. Hardness Strength Performance Change

4. CONCLUSION

The main objective of the present research was to determine the effects of the climatic conditions in minus degrees on some mechanical properties of composite materials obtained from various filling materials.

In general, low temperatures have increased the bending strength values by approximately 2-33% and the modulus of elasticity values by 4-19%. The highest value was obtained in WP-C in terms of bending resistance. While the hardness values of MP increased (36%), it decreased (20%) in WP concerning hardness values.

According to the obtained findings, composites used in the study showed different qualities in terms of mechanical properties at low temperatures. Therefore, it can be said that the filling materials utilized in the production of the composite material and the low temperatures at the usage area affect the mechanical properties of the composites.

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