Mobilya ve Ahşap Malzeme Araştırmaları Dergisi
Furniture and Wooden Material Research Journal
Research Article 2018 - 1 (1), 46-50

Determination of surface roughness parameters of heat-treated and untreated Scotch pine, oak and beech woods

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Abstract

Heat treatment is an industrial application that changes the physical, mechanical and chemical properties of wood. In addition, the smell, color and surface roughness of the heat treated wood also varies. The objective of this study is to investigate surface roughness properties (R_a, R_z and R_q) of heat treatment and untreated some wood types. In this study, wood specimens prepared from Scotch pine (*Pinus sylvestris* L.), oak (*Quercus petreae* L.) and beech (*Fagus orientalis* L.) wood species were heat-treated according to ThermoWood® method at 212°C for 1 hour and 2 hours in Bolu - Gerede, Turkey. Caliber sanding machine with 180 grinding were applied untreated and heat-treated specimens after heat treatment. Surface roughness parameters (R_a, R_z and R_q) according to ISO 4287 (1997) standard were determined for all samples. According to obtained data, it was observed that the R_a, R_z and R_q parameters decreased when the heat treatment time increased. It was determined that the surface roughness of all wood materials was changed by the applied heat treatment process.

Keywords: Surface roughness, heat treatment, Scotch pine, oak, beech

Isıl işlem uygulanmış ve uygulanmamış sarıçam, kayın ve meşe odunlarında yüzey pürüzlülüğünün belirlenmesi

Öz

Isıl işlem, odunun fiziksel, mekanik ve kimyasal özelliklerini değiştiren bir endüstriyel uygulamadır. Ayrıca, ısıl işlem görmüş odunun kokusu, rengi ve yüzey pürüzlülüğü de değişmektedir. Bu çalışmanın amacı, ısıl işlem uygulanmış ve uygulanmamış bazı odun türlerinde yüzey pürüzlülüğü (R_a, R_z ve R_q) özelliklerini incelemektedir. Bu çalışmada, sarıçam (*Pinus sylvestris* L.), meşe (*Quercus petreae* L.) ve kayın (*Fagus orientalis* L.) odun türlerinden hazırlanmış örnekler, Bolu - Gerede, Türkiye'de ThermoWood® metoduna göre 212°C'de 1 saat ve 2 saat süreyle ısıl işlem uygulanmıştır. Isıl işlemden sonra ısıl işlem uygulanmış ve uygulanmamış deney örneklerine 180 kumluk kalibre zımparalama işlemi uygulanmıştır. Yüzey pürüzlülüğü parametreleri (R_a, R_z ve R_q) ISO 4287 (1997) standardına göre bütün örnekler üzerinde belirlenmiştir. Elde edilen sonuçlara göre; ısıl işlem süresinin artması ile R_a, R_z ve R_q parametrelerinin azaldığı görülmüştür. Tüm ahşap malzemelerin yüzey pürüzlülüğü uygulanmış ısıl işlem uygulaması tarafından değiştiği belirlenmiştir.

Anahtar kelimeler: Yüzey pürüzlülüğü, ısıl işlem, sarıçam, meşe, kayın

Article History: summit: 14.06.2018 revised: 25.06.2018, accepted: 25.06.2018, published: 28.06.2018
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Citation: Ayata, Ü., Gürleyen T., Gürleyen L., Cakıcıer N., (2018), Determination of Surface Roughness Parameters of Heat-treated and Untreated Scotch pine, Oak and Beech Woods, Furniture and Wooden Material Research Journal, 1(1), 45-50

1. Introduction

Each wood material has a different surface quality. When a wood material is heat treated, the surface properties are changed. These changes affect by the heat treatment temperature and duration. Today, various methods have been developed to determine the surface properties of wood materials. One of these methods is surface roughness. The surface roughness test consists of various parameters. Some of these parameters are R_a, R_z, R_y and R_q values. Several authors evaluated the surface roughness properties of heat-treated woods. For instance, Korkut and Budakci (2010) examined R_a, R_z, R_y and R_q values of rowan (*Sorbus aucuparia* L.) heat-treated wood. Unsal and Ayrilmis (2005) found R_a value for heat-treated *Eucalyptus camaldulensis* Dehn.). Korkut et al. (2008) obtained R_a, R_z, R_y and R_q values of heat-treated Turkish Hazel (*Corylus colurna* L.). Korkut and Guller (2008) determined R_a, R_z, R_y values for heat-treated red-bud maple (*Acer trautvetteri* Medw.) wood. Gunduz et al. (2008) determined R_a, R_z, R_y, R_q values of camiyani black pine heat-treated at 120°C, 150°C and 180°C for 2, 6 and 10 h. Aytin et al. (2015) recorded R_a value for heat-treated wild cherry (*Prunus avium*) at 190°C and 212°C for 1 h and 2 h. Korkut et al. (2013) reported that R_a, R_z and R_y values of the specimens decreased with heat treatment compared to untreated specimens for heat-treated wild cherry (*Prunus avium*) at 212°C for 1.5 h and 2.5 h. Palermo et al. (2014) obtained surface roughness for heat-treated *Eucalyptus grandis* wood at 190ºC for 390 minutes. Surface roughness decreased with increasing treatment times and temperature (Unsal and Ayrilmis 2005, Korkut et al. 2008, Korkut and Guller 2008, Korkut and Budakci 2010). In a study, it was said that heat treatment improves surface quality (Gunduz et al. 2008; Aytin et al. 2015). According to Gunduz et al. (2008), significant difference was obtained (R_a, R_z, R_y and R_q) for three temperatures and three durations of heat treatment. These values decreased with increasing treatment temperature and treatment times. Korkut et al. (2013) determined surface roughness (R_a, R_z and R_y) values of the specimens decreased with heat treatment compared to untreated specimens. Palermo et al. (2014) showed significant differences in surface roughness as a function of machining feed direction, sandpaper grit size, and heat treatment for heat-treated *Eucalyptus grandis* wood at 190ºC for 390 minutes.

In the literature, there is no information about the effect of heat treatment at 212°C for 1 h and 2 h according to ThermoWood method on surface roughness properties of scotch pine (*Pinus sylvestris* L.), oak (*Quercus petreae* L.) and beech (*Fagus orientalis* L.) wood. This study is thought to be positive for the furniture and timber industry.

2. Material and Method

2.1.Material

Scotch pine (*Pinus sylvestris* L.), oak (*Quercus petreae* L.) and beech (*Fagus orientalis* L.) plank (55 cm x 10 cm x 2 cm) were taken from organized industrial zones of Duzce Forest Products, in Duzce City, Turkey. Scotch pine (*Pinus sylvestris* L.) is used utility poles, flooring, boxes/crates, posts, paper (pulpwood), and construction lumber (URL 1). Oak (*Quercus petreae* L.) is used furniture, cabinetry, flooring, interior trim, barrels, boatbuilding, and veneer (URL 2), and beech (*Fagus orientalis* L.) wood is used flooring, brushes, furniture, blocks, woodenware, handles, veneer and carpenters (Bozkurt and Erdin, 1997). Later, these specimens were conditioned to 12% moisture contents in climatic chamber at (20±2°C, 65±3%), relative humidity according to ISO 554 (1976) standard.

2.2.Method

2.2.1. Thermal Process Application

Heat treatment variations were applied according to ThermoWood process books (Anonymous 2003). ThermoWood® process was conducted at 212°C for 1 hour and 2 hours in Novawood factory in Gerede-Bolu City, Turkey. After, heat-treated wood specimens were kept to 12% moisture contents in a climatic chamber at 20±2°C and relative humidity of 65±5% (ISO 554, 1976).

2.2.2. Caliber Sanding Application

Heat treated and untreated specimens were applied to the calibrated abrasive machine with 180 grinding, at a carpenter workshop in organized industrial zones of Duzce Forest Products, in Duzce region, Turkey. After, samples were cut 10 cm x 10 cm x 2 cm. Heat treated and untreated specimens were kept in a conditioned room with 65±3% relative humidity and 20±2°C temperature until constant weight was achieved (ISO 554, 1976).

2.2.3. Surface Roughness Measurement

Surface roughness parameters (R_a, R_z and R_q) of wood specimens were performed by using Surface Roughness Tester TIME 3200 according to ISO 4287 (1997) standard (Fig. 1).

Figure 1. Surface Roughness Tester TIME 3200

2.2.4. Statistical Analysis

The surface roughness parameters (R_a, R_z and R_q) were measured using twenty replicates of each sample and an average value was determined for untreated and heat-treated samples. The SPSS 17 Software program was used.

3. Results and Discussions

Table 1 shows the changes in surface roughness R_a, R_z and R_q at varying treatment temperatures and durations. According to results, parameters R_a, R_z and R_q decreased for scotch pine, oak and beech wood heat treated when we focused comparison with the untreated example. R_a, R_z and R_q values for scotch pine and beech wood species and R_a and R_q for oak wood were decreased as the heat treatment time increased. The highest R_a, R_z and R_q values were obtained in the untreated oak wood samples and, R_a, R_z and R_q values were 6.86, 58.63 and 11.03, respectively. R_a, R_z and R_q values values of scotch pine wood type and, R_a and R_q values of oak wood type were similar to each other after the heat treatment time had increased from 1 hour to 2 hours. The lowest result for R_a, R_z and R_q values were obtained in beech wood type heat-treated at 212°C for 2 h. Similar results were also observed in another studies (Unsal and Ayrilmis 2005; Korkut et al. 2008; Korkut and Guller 2008; Gunduz et al. 2008; Korkut and Budakci 2010; Korkut et al. 2013; Aytin et al. 2015). These decreases can be explained by hemicellulose degradation in the cell wall and due to the high temperature applied (Rusche 1973; Feist and Sell 1987).

Table 1. Results of the statistical analysis for surface roughness parameters

Test	Wood Type	Duration	N	Mean	*HG*	Std. Deviation	Minimum	Maximum
R_a	**Scotch pine (*Pinus sylvestris* L.)**	**Control**	**20**	5.16	D	0.38	4.36	5.97
		212°C for 1 h	**20**	4.40	E	0.27	3.99	4.71
		212°C for 2 h	**20**	4.32	E	0.61	3.16	5.05
	Beech (*Fagus orientalis* L.)	**Control**	**20**	6.09	B	0.50	5.33	7.25
		212°C for 1 h	**20**	3.54	F	0.21	3.28	4.02
		212°C for 2 h	**20**	2.69	G	0.08	2.52	2.83
	Oak (*Quercus petreae* L.)	**Control**	**20**	6.86	A*	1.01	5.54	9.56
		212°C for 1 h	**20**	5.60	C	0.69	4.49	7.10
		212°C for 2 h	**20**	5.47	CD	1.06	3.89	7.81
R_z	**Scotch pine (*Pinus sylvestris* L.)**	**Control**	**20**	41.38	C	3.41	36.16	48.57
		212°C for 1 h	**20**	36.92	D	3.26	32.19	43.80
		212°C for 2 h	**20**	34.11	DE	5.21	23.08	40.01
	Beech (*Fagus orientalis* L.)	**Control**	**20**	46.85	B	4.59	42.15	61.24
		212°C for 1 h	**20**	31.17	E	3.35	23.49	37.19
		212°C for 2 h	**20**	21.77	F	1.38	18.89	24.61
	Oak (*Quercus petreae* L.)	**Control**	**20**	58.63	A*	6.07	47.83	69.93
		212°C for 1 h	**20**	50.14	B	7.52	41.14	65.41
		212°C for 2 h	**20**	55.54	A	13.60	37.57	84.78
R_q	**Scotch pine (*Pinus sylvestris* L.)**	**Control**	**20**	6.90	D	0.36	6.44	7.64
		212°C for 1 h	**20**	5.82	E	0.37	5.27	6.48
		212°C for 2 h	**20**	5.58	E	0.79	4.01	6.29
	Beech (*Fagus orientalis* L.)	**Control**	**20**	8.18	C	0.58	7.58	9.67
		212°C for 1 h	**20**	4.82	F	0.38	4.06	5.47
		212°C for 2 h	**20**	3.49	G	0.08	3.32	3.60
	Oak (*Quercus petreae* L.)	**Control**	**20**	11.03	A*	1.40	9.46	14.87
		212°C for 1 h	**20**	9.90	B	1.58	6.86	12.17
		212°C for 2 h	**20**	9.87	B	2.22	6.26	12.78
N: Number of measurements, *HG*: Homogeneity group, *: Highest value.								

4. Conclusions

According to obtained data, following results can be inferred;

- In this study, the changes in surface roughness parameters (R_a, R_z and R_q) of scotch pine, oak and beech wood heat treated (ThermoWood) and untreated species were determined.
- SPSS results were shown, R_a, R_z and R_q values decreased with the increase of heat treatment time in wood species.
- The R_a, R_z and R_q values of heat treated beech wood at 212°C for 2 h decreased too much in comparison with the untreated samples. Surface roughness for wood materials is important in the furniture industry. Heat-treated timbers can be used in outdoor furniture.

Acknowledgments

The author thank Hasep Wood Veneer Industry and Trade Inc. for wood materials, Novawood factory in Gerede - Bolu City, Turkey for heat treatment application. This work was submitted as an oral presentation in the 9th PRWAC (Pacific Regional Wood Anatomy Conference) & Annual Meeting IAWS (International Academy of Wood Science) 2017 in Bali, Indonesia.

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