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Araştırma Makalesi Research Article

THE DETERMINATION OF THE SURFACE ADHESION RESISTANCE AND PENDULUM HARDNESS ON THE PARQUETS APPLIED UV VARNISH AS SINGLE AND DOUBLE LAYERS

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Abstract

In this study, it aimed to determine the pendulum hardness and adhesion resistance test results on the parquets which are produced from sapeli, limba, chestnut and iroko applied ultraviolet (UV) varnish sistem according to different varnish layers. As a result of this; the pendulum hardness and surface adhesion values were determined on the materials derived from the different layers. Consequently, it was found that the double layer UV system varnish had a higher pendulum hardness value than the single layer application. As a matter of fact, as the number of UV system varnish layer increased, the pendulum hardness values increased in the same ratio. Taking into account the results of the surface adhesion resistance experiments, it can be said that the wood texture has an important role on the UV system varnish application.

TEK VE ÇİFT KAT UV VERNİK UYGULANMIŞ PARKELERDE SALINIMSAL SERTLİK VE YÜZEY YAPIŞMA DİRENCİNİN BELİRLENMESİ

Anahtar Kelimeler
Parke,
Sertlik,
Yüzeye Yapışma Direnci,
UV Vernik Sistem

Öz

Bu çalışmada, sapelli, limba, iroko ve kestane odunlarından üretilen farklı vernik katmanlarına göre ultraviyole (UV) vernik sistemi uygulanmış parkeler üzerinde; salınımsal sertlik ve yüzeye yapışma (adhezyon) direnç testlerinin belirlenmesi amaçlanmıştır. Bu amaçla, elde edilen farklı katmanlardaki malzemeler üzerinde yüzeye yapışma direnci ve salınımsal sertlik değerleri belirlenmiştir. Bu bulgulara göre; çift kat UV dolgu verniği, tek kat UV dolgu verniğine göre yüksek salınımsal sertlik değerleri verdiği tespit edilmiş, UV sistemde vernik katman sayısı arttıkça salınımsal sertlik değerinin de arttığı tespit edilmiştir. Yüzeye yapışma direnci sonuçlarına göre; ahşap malzemenin sahip olduğu tekstür yapısının UV sistem vernik uygulamasında önemli bir role sahip olduğu görülmüştür.

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1. Introduction

UV curable technology is one of the fastest growing markets in the paint and coating industry (Landry et al., 2015, URL 3). UV curing has always been a preferred technology for wood flooring products (Ross 2007).

Various UV chemicals are used in parquet production. One of these chemicals is polyacrylic-based resin. It can be applied for top surface and natural coating.

Acrylic filler varnish is used to provide protection and decorative appearance in furniture and decoration

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works (URL 4).

Various chemicals have a hardness value after UV application. Varnished wood surfaces are exposed to various factors according to the properties of the place they are used (Kaygin and Akgun 2008).

Hardness for paint and varnish layer is important for physical and mechanical effects. The pendulum tester can be used to measure the hardness of paints and varnishes (Kaygin, 1997).

Kaygin ve Akgun (2008), reported that the release hardness value of the polyacrylic based Nanolacke UV varnish is higher than that of synthetic, cellulosic, polyurethane and polyester varnishes.

Color, scratch resistance, abrasion Resistance and hardness (könig) tests were determined on two different types of coatings (UV high solids acrylate and UV water based polyurethane acrylate dried by UV-LED and UV microwave mercury lamps) for sugar maple samples. According to research results, water-based coatings cured by UV-LED lamps had a coating an abrasion resistance and hardness lower than coating cured by UV-Mercury lamps. (Landry et al., 2015).

Ayata et al., (2017a) for beech and Gurleyen et al., (2017a) for Scots pine determined adhesion strength, pendulum hardness, surface roughness, colour and glossiness values on UV-system applied samples in two different types according to manufacturer recommendations by using UV sanding sealer and nanolacke UV matt varnish.

In another study, surface adhesion resistance and pendulum hardness resistance values were found on UV system varnish applied (water-based paints and without paint) samples form of oak wood (Ayata et al., 2016).

The aim of this study is to evaluate the pendulum hardness and surface adhesion resistance properties of sapeli, limba, chestnut and iroko woods according to single and double layer UV varnish application. It is seen in the literature that this study is not done. The information obtained is thought to be important for the parquet industry.

2. Materials and Methods

2.1. Materials

2.1.1. Supply of wood species

In this study, sapeli (*Entandrphragma cylindrocum*), limba (*Terminalia superba*), iroko (*Chlorophora excelsa*) and chestnut (*Castanea sativa* Mill.) wood species were used. These wood species used in this study since they are the most preferred wood species in the parquet industry. Wood samples were taken from Hasep Wood Veneer Industry and Trade Inc. in Duzce City, Turkey. The size of specimens was 110 x 12 x 2 cm.

2.2. Methods

2.2.1. UV System Varnish Application

Single and double layer UV system varnish application processes were applied in the KPS Factory in Düzce City, Turkey.

The specimens were kept to 12% moisture contents in a special room at 20°C ± 2°C, a relative humidity of 65% (± 5%) (ISO 554 1976).

Today, this factory produces products to the parquet industry with two types (single and double layer) production method.

The process of applying single and double layer UV varnish parquet is given in Table 1. The technical data of chemicals are given in Table 2.

Table 1. Single and double layer UV varnish parquet application

	Process	**Single**
A	Sanding (3 cylinders) Calibrating Machines	80-120-220 Grit Sandpaper
B	A43-0646-UV Sanding Sealer	50 g/m²
C	UV lamp drying (mercury)	2 x 80 W
D	A43-0646-UV Sanding Sealer	-
E	UV lamp drying	-
F	Sanding 2 cylinders (grit sandpaper)	280-320
G	N93-0910 Nanolacke UV Matt Varnish	7.5 g/m²
H	UV lamp drying	2 x 80 W
I	N93-0910 Nanolacke UV Matt Varnish	7.5 g/m²
J	UV lamp drying	400 W
	Process	**Double**
A	Sanding (3 cylinders) Calibrating Machines	80-120-220 Grit Sandpaper
B	A43-0646-UV Sanding Sealer	35 g/m²
C	UV lamp drying (mercury)	2 x 80 W
D	A43-0646-UV Sanding Sealer	35 g/m²
E	UV lamp drying	400 W
F	Sanding 2 cylinders (grit sandpaper)	280-320
G	N93-0910 Nanolacke UV Matt Varnish	7.5 g/m²
H	UV lamp drying	2 x 80 W
I	N93-0910 Nanolacke UV Matt Varnish	7.5 g/m²
J	UV lamp drying	400 W

Table 2. Technical information about varnishes used in single and double layer UV varnish parquet application

	A43-0646 - UV Sanding Sealer (URL 1)	N93-0910 Nanolacke UV Matt Varnish(URL 2)
Description	Epoxy acrylic resin, ultraviolet ray curing sealers	Polyacrylic-based resin, nano-containing minerals, nano-composites UV curing varnish
Color	Transparent	
Solids (wt.%)	95 to 97	95 to 100
Density	1:15 to 1:20 (20°C, g/cm³)	1:09 to 1:15 (20°C, g/cm³)
Application	Solid hardwood, chipboard, MDF. Formulated for surface application	

2.2.2. Determination of Pendulum Hardness

Pendulum hardness (König) values were measured using an Model 299/300 Erichsen pendulum hardness tester (Hemer, Germany) according to ASTM D 4366-95 (1984).

Twenty replications were conducted (20 measure x 2 different layer x 4 wood type = 160) (Figure 1). The size of specimens was cut as 10 x 12 x 2 cm.

2.2.3.Determination of Surface Adhesion Resistance

Adhesion strength resistances were measured using 1 ton (10 kN) ALSA electromechanical universal testing machine according to ASTM D-4541 (1995).

Ten replications were conducted (10 measure x 2 different layer x 4 wood type = 80) (Figure 1). The size of samples was cut 10 x 12 x 2 cm.

Steel test cylinders (Ø 20 mm) and 404 plastic steel epoxy strong adhesives were used.

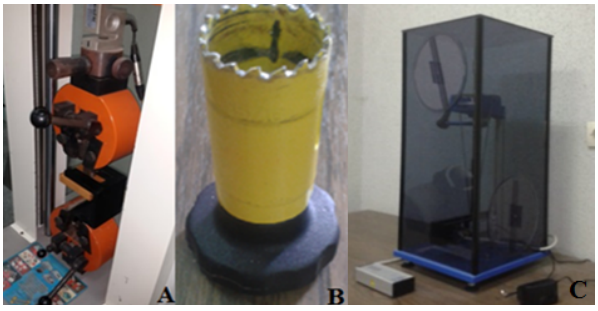

Figure 1. A) Electromechanical Universal tester, B) Cutter and C) Pendulum hardness tester

Experiment samples were kept to dry for 24 hours. The adhesion strength (X) was calculated with Eq. 1.

$$X = 4F / \pi.d^2 \quad (1)$$

Where;
F = the rupture force (Newton)
d = the diameter of the experiment cylinder (mm) (ASTM D-4541, 1995).

2.2.4. Statistical Analysis

SPSS 17 (Sun Microsystems, Inc., 4150 Network Circle, Santa Clara, California 95054, U.S.A.) package program was used for statistical analysis. Duncan test and univariate analysis of variance were determined.

3.Results

Variance analysis (ANOVA) was determined values of pendulum hardness and surface adhesion resistance; results are shown in Table 3 and Table 4 respectively.

According to Table 3, wood type, varnish layer number factors and interaction of these factors were significant in pendulum hardness values ($\alpha \leq 0.05$).

In the values of surface adhesion, wood type factor and interaction of these factors were significant, while the factor of number of layer was not significant ($\alpha \leq 0.05$) (Table 4).

Table 3. Results of variance analysis of wood type - layer number on effect of pendulum hardness values

Source	df	Sum of Squares	Mean Square	F	Sig.
Wood type (A)	3	4.696.619	1.565.540	45.700	0.000*
Number of layer (B)	1	7.222.656	7.222.656	210.838	0.000*
Interaction (AB)	3	739.919	246.640	7.200	0.000*
Error	152	5.207.050	34.257		
Total	159	17.866.244			
*: Significant according to $\alpha \leq 0.05$					

Table 4. Results of variance analysis of wood type - layer number on effect of surface adhesion values

Source	df	Sum of Squares	Mean Square	F	Sig.
Wood type (A)	3	56.753	18.918	88.682	0.000*
Number of layer (B)	1	0.752	0.752	3.525	0.065**
Interaction (AB)	3	2.807	0.936	4.386	0.007*
Error	72	15.359	0.213		
Total	79	75.671			
*: Significant according to $\alpha \leq 0.05$, **: Insignificant					

The results of multiple comparisons for pendulum hardness and surface adhesion values are presented in Table 5 and Table 6, respectively.

According to Table 5, wood type - number of layer interaction; highest values of maximum pendulum hardness were obtained in sapeli double layer specimens with UV varnish applied and the lowest values were obtained in limba single layer specimens with UV varnish applied.

Pendulum hardness values of double layer were obtained higher than single. Pendulum hardness values of iroko and chestnut woods were very close (Table 5).

Table 5. Duncan test results of pendulum hardness values of the wood type - layer number interaction

Wood type	Number of layer	N	Ave-rage	*HG*	Stan dard Dev.	Mini-mum	Maxi-mum
Iroko	Single	20	57.20	D	6.83	45.00	71.00
	Double	20	69.45	B	7.69	51.00	83.00
Chestnut	Single	20	57.55	D	5.22	51.00	71.00
	Double	20	69.70	B	4.55	62.00	78.00
Limba	Single	20	44.40	E	4.38	40.00	54.00
	Double	20	64.90	C	4.12	58.00	72.00
Sapeli	Single	20	65.45	C	5.32	56.00	74.00
	Double	20	74.30	A*	7.48	61.00	94.00

*: Highest value, N: Number of measurements, *HG*: Homogeneity group

Highest surface adhesion resistance was observed in sapeli samples with a single layer of UV varnish applied. Lowest average value was obtained limba in double-coated UV varnish (Table 6).

It can be said that wood species give different results due to different anatomical structures.

Table 6. Duncan test results of surface adhesion values of the wood type - layer number interaction

Wood type	Number of layer	N	Ave-rage	*HG*	Stan dard Dev.	Mini-mum	Maxi-mum
Iroko	Single	10	2.120	C	0.38	1.557	2.771
	Double	10	2.605	B	0.32	2.159	3.166
Chestnut	Single	10	1.438	D	0.23	1.118	1.793
	Double	10	2.079	C	0.30	1.691	2.605
Limba	Single	10	1.024	E	0.26	0.694	1.627
	Double	10	0.896	E	0.12	0.637	1.032
Sapeli	Single	10	3.374	A*	0.90	2.226	5.003
	Double	10	3.152	A	0.66	2.354	4.500

*: Highest value, N: Number of measurements, *HG*: Homogeneity group

Ayata et al., (2016) found out that for adhesion (1.24 MPa) and pendulum hardness (68.17) of UV varnish system unpainted applied (UV sealer clear S + UV antiscratch semi matt W) on the natural form of oak (*Quercus petreae*) wood.

When number of UV system varnish layers increased, hardness and adhesion resistance increased for scots pine (*Pinus sylvestris*) (Gurleyen et al., 2017a) and beech (*Fagus orientalis* Lipsky.) (Ayata et al., 2017a).

Ayata et al. (2017b) found that hardness value of single layers was lower than hardness of double layers for UV system parquet varnish layers applied to ash (*Fraxinus excelsior*) wood heat-treated at 212°C for 2 hours according to ThermoWood method.

Gurleyen et al. (2017b) determined hardness value of double layers was higher than hardness value of single layer for UV system parquet varnish layers applied rowanberry (*Sorbus* L.) wood.

In another study, pendulum hardness values of the polyacrylic based nanolacke UV varnish prepared according to industrial standards for beech and oak woods were 94.4 and 91.9 respectively (Kaygin and Akgun 2008).

Adhesion resistances of unaged of maple (*Acer pseudoplatanus* L.), northern red oak (*Quercus rubra*), American black walnut (*Juglans nigra*), beech (*Fagus orientalis* L.) and walnut (*Juglans regia*) woods were found 1.378 MPa, 1.023 MPa, 1.170 MPa, 1.413 MPa and 2.253 MPa, respectively by Ayata et al., (2018).

4. Discussion and Conclusion

In this study; surface adhesion resistance (MPa) and pendulum values of parquets obtained by single and double layer UV varnish system application were tried to be determined by using sapeli, limba, iroko and chestnut woods.

According to the obtained data of the research, single and double layer UV varnish system applied to wood materials have a significant effect on pendulum hardness values.

When pendulum hardness value was obtained significantly, surface adhesion resistance wasn't significant on number of layer factor.

Double coated UV varnish system varnish (35 gr/m^2 + 35 gr/m^2) was determined to have a higher pendulum hardness value as compared to its single application (50 gr/m^2).

As the number of coats increased, the value of pendulum hardness increased.

The highest surface adhesion resistance and pendulum hardness values were found on sapeli wood.

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Yazarlar tarafından herhangi bir çıkar çatışması beyan edilmemiştir.

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