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Surface Treatment, Layer Thickness and Surface Performance Relations of Wood Materials

Tuncer Dilik [1]–K.Hüseyin Koç[2]–Ender HAZIR[3]–E.Seda ERDİNLER[4]*

[1] Associate Professor Dr., Istanbul University, Faculty of Forestry, Department of Forest Industry Engineerig, 34473 Istanbul – Turkey
* *Corresponding author*
tuncerd@istanbul.edu.tr
[2] Professor Dr., Istanbul University, Faculty of Forestry, Department of Forest Industry Engineerig, 34473 Istanbul – Turkey
hkoc@istanbul.edu.tr
[3] Research Assistant, Istanbul University, Faculty of Forestry, Department of Forest Industry Engineerig, 34473 Istanbul – Turkey
ender.hazir@istanbul.edu.tr
[4] Assistant Professor, Istanbul University, Faculty of Forestry, Department of Forest Industry Engineerig, 34473 Istanbul – Turkey
seda@istanbul.edu.tr

Abstract

Wooden material has an important place in manufacturing sector when evaluated in the means of its utilization fields and the added value it creates. Wooden materials are used more efficiently with respect to the technological development. Preventive surface treatment makes up the biggest share of the added value wooden material creates. Surface treatment applied on wooden material plays an influencing role on the discrimination of the consumer. Surface treatment appears as an important cost to the producers. Surface treatment applications of wood and wooden materials in the industry are made with qualitative methods. As the thickness of the paint layer can't be controlled numerically it inhibits the expected benefits of surface treatment. For this reason layer thickness, an important cost and aesthetic factor, should be determined quantitatively and evaluated in the means of surface properties. Thus, one of the important parameters to set a more efficient and controllable system in surface treatment applications would be taken under control. In this study, it is aimed to determine layer thickness in preventive surface treatment and evaluate the relationship between layer thickness and surface properties. It will be much easier to head to the appropriate surface treatment applications and save in surface treatment supplies and wages. International standards are used to determine the samples and sample sizes. Research is applied according to ASTM D 4541, TS 6884, TS EN ISO 4624 standards.

***Keywords*:** A. Surface finishing, B. Coating thickness, C. Surface performance, D. Painting, E. Wooden.

Introduction

Surface treatments, as one of the final stages of production in wooden furniture and decoration applications, constitute the majority of production cost. In addition to this, it is effective in the performance of the products and the preferences of the customers. A good surface treatment increases the usage properties of the product, as well as facilitates its sales [1-5]. In surface treatments, factors such as surface roughness, adhesion resistance are influential in the surface performance. The use of MDF and particleboards gradually increases in furniture and decoration applications due to covering surface treatments. Although there are various national and international standards of surface treatments and their characteristics, it's seen that the required importance is not considered in application and the controls remain at subjective evaluation level [4]. Therefore, in the majority of the applications, the surface treatments may cause an increase in the production costs and prevent achieving the desired surface performance values [3, 5]. Various methods are being developed for a more effective and rational use in applying and evaluating the surface layer treatments with the recently developing technology. For this purpose, it's seen that surface modeling works, which allow objective evaluation of surface treatments, are also being carried out for wood materials [6-11].

In the literature, the general adhesion mechanisms between the wood material surfaces and protective layers have been examined with various studies and it's been stated that these materials are chemical, mechanical, electrostatic and acid-base adhesion. Furthermore, it's seen that adhesion resistance is determined by using different methods and the most commonly used methods are pull-off test and cross-cut test [4, 6, 8].

In this study, it is aimed to determine the thicknesses of the layers created with protective surface treatments to be applied on wood and wood-based materials and to explain the correlation between layer thicknesses and surface performance based on adhesion resistance. Thus, it's been considered that better applications can be carried out by taking the number of layers, layer thickness and surface performance expectation into account in industrial surface treatment applications. Therefore, the study is examined on two separate types of paint and two separate types of wood material with different layer thicknesses and different number of layers. The study is particularly limited with the wood materials and paint types commonly used in the industry. Thus, it's aimed to offer solutions for the problems related to layer structure as encountered in surface treatments and to ensure a more effective surface treatment application.

Materials and Methods

Materials: MDF board and Particleboard as wooden based materials and Cellulosic and Polyurethane paints as surface treatment materials are selected for the study.

Method: Test applications take the national and international standards into account. Test design and sample pattern are as shown in Table 1. During the study, the paint process, which is examined as surface treatment, is applied as minimum 3 layers and maximum 5 layers. Applications on 5 samples prepared for each application level are carried out with spray gun as 1, 2 and 3 finish paint on the primer layer. In this context, the layer thicknesses obtained have been measured with PosiTector Probe 200 and the adhesion resistance is measured with PosiTest AT-A Automatic Adhesion Tester [12-14].

Table 1: Test design and sample pattern used in the study (*)

Material type	Paint type	Appli-cation	No. of samp.	Treat. 1	Treat. 2	Treat. 3	Treat. 4	Treat. 5
MDF (Medium Density Fiberboard) (MDF board in calibrated 18x200x1000 mm size)	Cellulosic Paint	Applic-1	5	Primer	Primer	Finish		
		Applic-2	5	Primer	Primer	Finish	Finish	
		Applic-3	5	Primer	Primer	Finish	Finish	Finish
	Polyurethane Paint	Applic-1	5	Primer	Primer	Finish		
		Applic-2	5	Primer	Primer	Finish	Finish	
		Applic-3	5	Primer	Primer	Finish	Finish	Finish
PARTICLE BOARD (Particle board in calibrated 18x200x1000 mm size)	Cellulosic Paint	Applic-1	5	Primer	Primer	Finish		
		Applic-2	5	Primer	Primer	Finish	Finish	
		Applic-3	5	Primer	Primer	Finish	Finish	Finish
	Polyurethane Paint	Applic-1	5	Primer	Primer	Finish		
		Applic-2	5	Primer	Primer	Finish	Finish	
		Applic-3	5	Primer	Primer	Finish	Finish	Finish

(*) All applications are carried out on the surface treatment line of an industrial company according to the instructions of the producer companies with the same batch of paint.

Results

The arithmetic average values related to the layer thicknesses obtained and adhesion resistance measured in the study are provided in Table 2. From the examination of the values available in the table, it's been determined that higher values are achieved in MDF material compared to particleboard, provided that adhesion resistance directly effective on the surface performance is valid for both paint types.

However, the impact of layer thickness, obtained according to the number of layers applied according to the paint type and application levels, on the adhesion resistance could not be determined exactly. While the highest adhesion resistance in MDF is obtained as 3,62 MPa with 179 micron layer thickness and 3 layers of cellulosic paint application, the lowest adhesion resistance is obtained as 2,37 MPa with 239 micron layer thickness and 4 layers of polyurethane paint application. For the applications on particleboard, the highest adhesion resistance is obtained as 1,54 MPa with 322 micron layer thickness and 4 layers of cellulosic paint application, while the lowest adhesion resistance is obtained as 0,83 MPa with 249 micron layer thickness and 3 layers of cellulosic paint application.

Table 2: Results related to adhesion resistance and layer thicknesses obtained in the study.

Wood material type	Paint type	Application	Layer thickness (micron)	Standard Deviation (σ)	Adhesion resistance (MPa)	Standard Deviation (σ)
MDF (Medium Density Fiberboard) (MDF	Cellulosic Paint	Application 1	179	5,57	3,62	0,46
		Application 2	181	11,68	2,86	
		Application	236	5,51	2,78	

board in calibrated 18x200x1000 mm size)		3				
	Polyurethane Paint	Application 1	167	2,08	2,95	0,60
		Application 2	239	13,32	2,37	
		Application 3	345	8,33	3,58	
PARTICLE BOARD (PB) (Particle board in calibrated 18x200x1000 mm size)	Cellulosic Paint	Application 1	249	13,89	0,83	0,38
		Application 2	322	19,08	1,54	
		Application 3	334	6,81	0,96	
	Polyurethane Paint	Application 1	199	10,54	0,85	0,16
		Application 2	295	3,06	1,16	
		Application 3	363	9,02	0,97	

The graphics showing the correlation levels of material and paint type, layer thickness and adhesion resistance according to the values in the table are as follows (Figure 1).

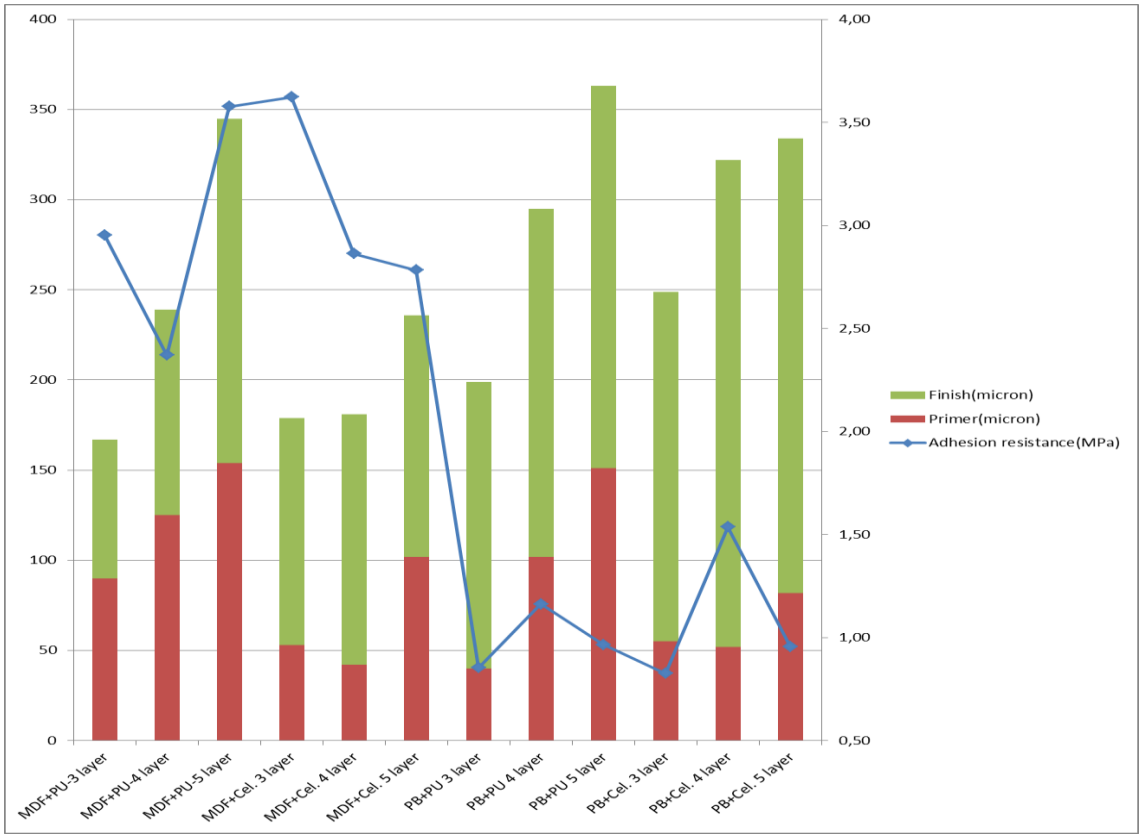

Figure 1: Relations between layer thickness and adhesion resistance with material and paint.

Conclusions

Accordingly, differences were found based on to the adhesion resistance values, material type, paint type and layer thicknesses. Examining the reasons for such difference, as it can be seen in the graphics, the layer thickness and surface performance correlation varies according to the wood material and paint types (Figure 1). During the tests, the breaking in paint layer is found out to appear between primer layer and wood material for all. Accordingly, it can be stated that finish layers on the primer paint layer is not directly effective on the adhesion resistance. This situation can be explained as the adhesion set between the primer layer and finish layer is higher than the adhesion developing between the primer layer and wood material.

These results generally reveal the importance of primer layer in order to ensure the desired surface performances in protective surface layer treatments, as well as the importance of working with one-layer application with the ideal layer thickness rather than working with multi-layer importance. A similar situation has tried to be explained with general adhesion mechanisms in various literature studies carried out for determining the adhesion resistance of varnish and paint types on the surfaces of different wood materials. [4, 5, 10, 16]

As a result, according to the findings of the study, it's been found out that the wood material type is important for the painting works of the furniture and decoration elements, which need to have high adhesion resistance, and it's also been considered that the primer layer is important rather than the layer thickness in the applications and a finish application with ideal layer thickness will be sufficient. However, more detailed studies will be beneficial for establishing a numerical and parametric correlation. As is known, the numerical value of the layer thicknesses is not known in the covering surface treatments with different numbers of layers applied on wood materials and the correlation between the number of layers and surface performance can be defined as a qualitative relation based on the number of layers. Therefore, the studies performed are insufficient for parametric evaluation of the relationship between the number of layers, layer thickness and surface.

References

[1] Kurtoglu, A., 2000. Wood Material Surface Treatments, General Information, Volume 1, Istanbul University, Faculty of Forestry, Department of Forest Industry Engineering, Istanbul, 2000.

[2] Şenok, A. S., 2000. Some Considerations Related to Pain Industry in Turkey, *ISO Journal*, p.32, March-2000.

[3] Sönmez, A., 2000. Surface Layer Treatments in Wood Works I., Preparation and Coloring, Gazi University, Faculty of Technical Education, Çizgi Matbaacılık, Ankara, 2000.

[4] Budakci, M. Sönmez, A., 2010. Determining the Adhesion Resistance of Some Wood Varnishes on Different Wood Material Surfaces, *J.Fac.Eng.Arch.Gazi Univ., Vol. 25, No:1, 111-118,* 2010.

[5] Çakicier, N., 2007. Changes Determined by Aging on Wood Material Surface Treatment Layers, *Doctoral Thesis*, Istanbul University Institute of Science, Istanbul, 2007.

[6] Özdemir, T. – Hiziroglu, S., 2007. Evaluation of Surface Quality and Adhesion Strength of Treated Solid Wood, *Journal of Materials Processing Technology*, 186, pp. 311-314, 2007.

[7] Hazir, E., 2012. A Modeling Work on Evaluating the Quality of Wooden Surface Quality, *Master Thesis*, Istanbul University Institute of Science, Istanbul, 2012.

[8] Ahola, P., 1991. Adhesion Between Paint and Wood Substrate, *Surface Coatings International,* 74, No.5, 173-176, 1991.

[9] Nejad, M.- Cooper, P., 2011. Exterior wood coatings.Part-2: Modeling correlation between coating properties and their weathering performance, *J.Coat technol.Res*, 8 (4) 459-467,DOI 10.1007/s11998-011-9331-4, 2011.

[10] Mittal, K.L., 1995. Commentary, Adhesion Measurement of Films and Coatings, VSP, p.1-13, Utrecht, The Netherlands.

[11] Jaic, M. – Zivanovic, R., 1997. The influence of the ratio of the polyurethane coating components on the quality of finished wood surface, *Holz als Roh- und Werkstoff*, 55, 319-322, 1997.

[12] Nelson, G. L., 1995. Adhesion , Paint and Coating Testing Manuel, *Chapter 44, ASTM Special Technical Publication*, Philadelphia, P.A., 513-523, 1995.

[13] ASTM D 4541, 1995. Standard test method for pull-off strength of coatings using portable adhesion testers, American Society for Testing and Materials, 1995.

[14] TS EN ISO 4624, 2006. Paints and varnishes – Pull-off test for adhesion.

[15] TS 6884, 2005. Wooden furniture surfaces – Determining the adhesion resistance of paint and varnish layers.

[16] Dilik, T.- Hiziroglu, S., 2012. Bonding strength of heat treated compressed Eastern red cedar wood, *Materials and Design*, Volume 42, pages: 317-320, 2012.

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