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Impact-Deformation Relation of Surface Treated Wood Material

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Abstract

Wood and wood based material is used in various areas. Wood material is exposed to many external effects as it is used for furniture. Impact and drops have negative influence on these materials. Surface treatment is effective on wood material's durability. This may change due to layers of paint and the property of the paint used on the material. In this study, it's aimed to determine the differences by investigating the deformations occurring on wooden materials with various surface treatments due to impact and fall. MDF, intensively used in the furniture industry, was used. The impact-deformation relationship of the surfaces applied with wooden material, processed with surface treatment, together with cellulosic and polyurethane paint on various number of layer were examined. For surface hardness; impact tester was used for determining the effect of sudden impacts. Pendulum hardness tester was used to determine the layer hardness of the surfaces. Statistical assessment was performed for determining and revealing the impacts. At result of the study, for coating hardness, polyurethane paint provided better results in applications made with three layers, while cellulosic paint provided better results in applications with four layers, and cellulosic paint provided better results with five layers. Five-layer cellulosic application and three-layer polyurethane application provided similar results. Parameters effecting durability due to impact on different surface treatments and improvement of utilization quality have been determined which would be a base for a more effective application.

***Keywords*:** A. Wood material, B. Surface treatment, C. Impact, D. Deformation, E. Coating

Introduction

Wood is a material with an increasing importance in its use. It is one of the materials that the manufacturers have always used for centuries. Its characteristics and superiorities including the manufacturing stage play an important role in preferring the wood material. The economic life of the wood material should be prolonged and it should be used more effectively as it a valuable material. Protective surface treatments and impregnation applications are among the important procedures applied for prolonging the economic life of the wood material according to the place it is used for. Impregnation is the application related to the protection created by impregnating the chemical preservatives applied to the wooden material, used under atmospheric conditions, by the material. Protective surface treatments have a positive impact on the appearance of the product and also protect the material against external factors.

There are several studies related to different specifications of wood, and such studies still continue. In addition to light resistance and aging, the study carried out by Baysal (2011) examines the surface hardness performance in polyurethane varnish and alkyd based synthetic varnish applied to Fagus Orientalis wood impregnated with CCB. It's been stated that there is an increase in surface hardness in the samples varnished after CCB, and that an increase in surface hardening is observed on beech material as the concentration of CCB was increased.

In the study of Atar et al. (2004), it's been determined that bleaching agents reduce the surface hardness, and the surface hardness of the wood material did not affect the finishing varnish layer hardness.

In his study, Sönmez (1989) stated that the type of tree was not influential in the hardness of varnish layers, but the true impact depended on the type of varnish.

Çakıcıer et al. (2011) determined that surface hardness was very less in varnished samples after thermal treatment compared to the samples without varnish. They have stated that surface hardness value decreased with the increase in temperature and time. The same study also determined that the scraping resistance of the samples with thermal treatment was very lower than the ones without treatment.

In the study they examined the impact of boric acid solution on the hardness of water based varnish layer, Budakçı et al. (2009) suggested using beech material in the furniture and decoration components that were desired to have higher hardness value with the use of water based varnish, and 5% boric acid modification should be performed in the rate of 30% inside the water based varnish.

Oblak et al. (2006) stated that surface treatment statements should be analyzed in detail in order to completely reveal the physical, mechanical and chemical properties. As the surface treatment systems give different results with various application methods, it is important to determine the best method.

Similarly, Pavlic et al. (2004) stated that the systems should be tested and the best system should be selected according to the result of these tests in order to obtain a high quality surface treatment result. Resistance to impact is one of these test methods. It is used for determining the damages to be caused by the impacts during the use of impact test.

Impact tests evaluate the effects of accidental contact damage that may occur during use. They are usually carried out by the direct evaluation of the effect of a falling object, phere or dart of specified shape and hardness, onto the tested surface form different heights. During impact on coated surfaces, the deformation of the substrate can be relevant, significantly affecting the final results. It is of importance that the coating film is flexible enough to withstand, to a certain extent, the stretching at the fringes of the deformation without any cracking or cleavage.

Hardness can be defined as the ability of a coating film to resist indentation or penetration by a solid object. Hardness is also related to the dying state of the coating depending on solvents retention and, for chemical drying coatings, on the cross-linking effectiveness. The efficiency of the drying systems is then fundamental to achieve an adequate hardness. ISO 1522 is a damping method used to assess the hardness of a dry film of paint, varnish or related product by measuring how it reduces the oscillation amplitude of a pendulum (Bulian and Graystone 2009).

Persoz pendulum is used for this research as seen in Figure 1.



Figure 1. Pendulum Hardness Tester (TQC,2015)

The expectations from the wood surfaces vary according to the aim of their user. Resistance of the surface against wearing with different effects or maintaining its current structure against the impacts are among the important properties looked for, including the hardness value of the surface treatment material in several areas of use.

In this study, it's aimed to reveal the effect of different layer thicknesses, applied with different surface treatment materials on wooden panel, on the surface treatment performance.

Materials and Methods

In the study, MDF material is selected as the wooden panel due to its extensive usage in the furniture industry. Commercially manufactured MDF panels were supplied by a local manufacturer. Average density levels of MDF samples were 0.68 g/cm^3. Samples were cut into 1000 mm by 200 mm size having a thickness of 18 mm. Surface treatment was applied with cellulosic and polyurethane paint in different layer thicknesses. Samples were coated employing a spray gun using a pressure of 0.80 MPa. Sequential application of primer and top coat of the finishes were applied to the surface of each panels with an angle of 90 degrees. The layer thicknesses were set as three-layer, four-layer and five-layer. UV undercoat was used on the materials. The materials selected and their specifications are shown (Table 1).

Paint type		Density (g/cm^3)	Solid content (%)	Viscosity (DIN6. sn)
Cellulosic base	Primer coating	1.30	58	60
	Top coat	0.98	44	130
Polyurethane base	Primer coating	1.42	77	115
	Top coat	1.18	50	290

Table 1. *Specifications of the finishing materials used for the experiments.*

Surface treatment material and application method were determined as the main variables of the study. In this context, the relations of impact-deformation arising at different thicknesses were studied. Impact tester ISO4211-4 was used for impacts. Pendulum hardness tester was used for determining the layer thickness of the surfaces. The surface treatment application plan carried out is shown (Table 2). Minitab 17 software program and multiple variance analysis "ANOVA" test have been used for the statistical assessments of the results. The data was considered at the level of α=0,05 for determining the effect and significance levels of the factors examined.

Panel Type	Finish Type	No. of Sample	Reprication	Finishing Process
MDF	Cellulosic Paint	3	5	Application 1 (primer+primer+top coat)
		3	5	Application 2 (primer+primer+top coat+top coat)
		3	5	Application 3 (primer+primer+top coat+top coat+top coat)
	Polyurethane Paint	3	5	Application 1 (primer+primer+top coat)
		3	5	Application 2 (primer+primer+top coat+top coat)
		3	5	Application 3 (primer+primer+top coat+top coat+top coat)

Table 2. *Surface treatment application plan*

Results

Surface treatment applications carried out with different layer thicknesses and paint types are assessed with ANOVA analysis. The results are shown in Analyze of Variance Table (Table 3). The results are assessed statistically with 95% confidence level. As a result of the ANOVA analysis, it's been found out that the paint type is significant in terms of the appearing surface treatment hardness, the layer thickness is not significant alone, but paint type-layer thickness interaction is significant.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Paint Type	1	2538,7	2538,7	7,11	0,009
Application Type	2	929,1	464,5	1,30	0,278
Paint Type*Application Type	2	8591,3	4295,6	12,04	0,000

Error	84	29980,5	356,9		
Total	89	42039,6			

Table 3: *Analyze of Variance: Coating Hardness versus Paint Type; Application Type*

The main effects obtained according to the results appearing from the surface treatment applications carried out on the MDF panel are shown (Figure 2). Considered in terms of the paint types, the pendulum hardness values of the cellulosic paint are better than the polyurethane paint.

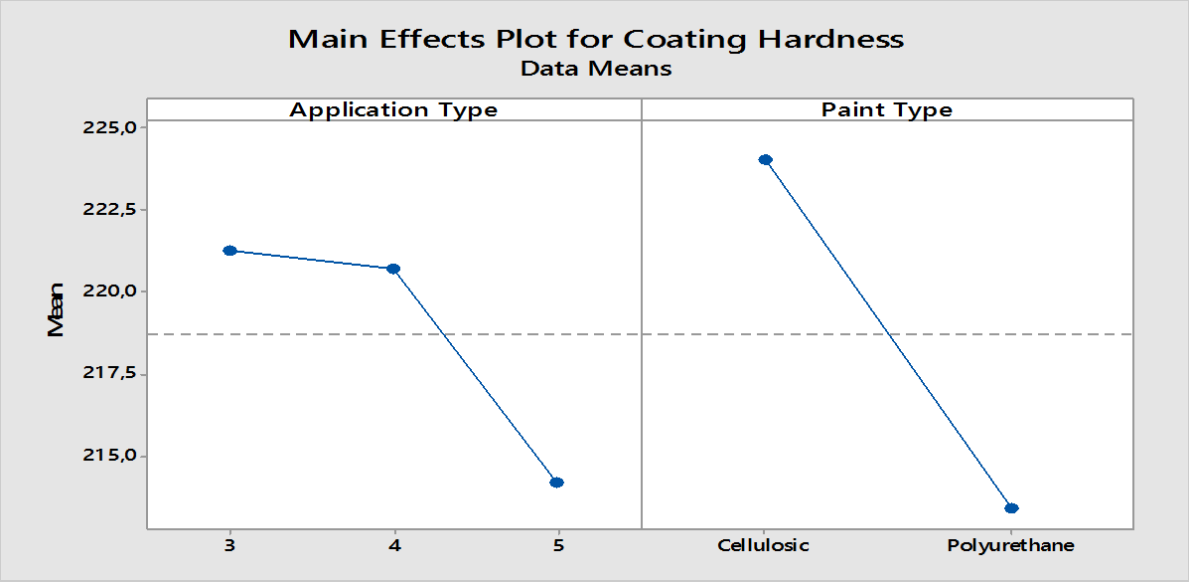

Figure 2: Main Effects for Coating Hardness

The results obtained when we assess the surface treatment parameters with interaction are as shown (Figure 3). Polyurethane paint provided better results compared to cellulosic paint in applications made with three layers. Cellulosic paint provided better results compared to polyurethane paint in applications made with four layers. For the applications made with five layers, cellulosic paint provided better results compared to polyurethane paint.

When the applications are compared with each other, five-layer cellulosic application and three-layer polyurethane application provided similar results.

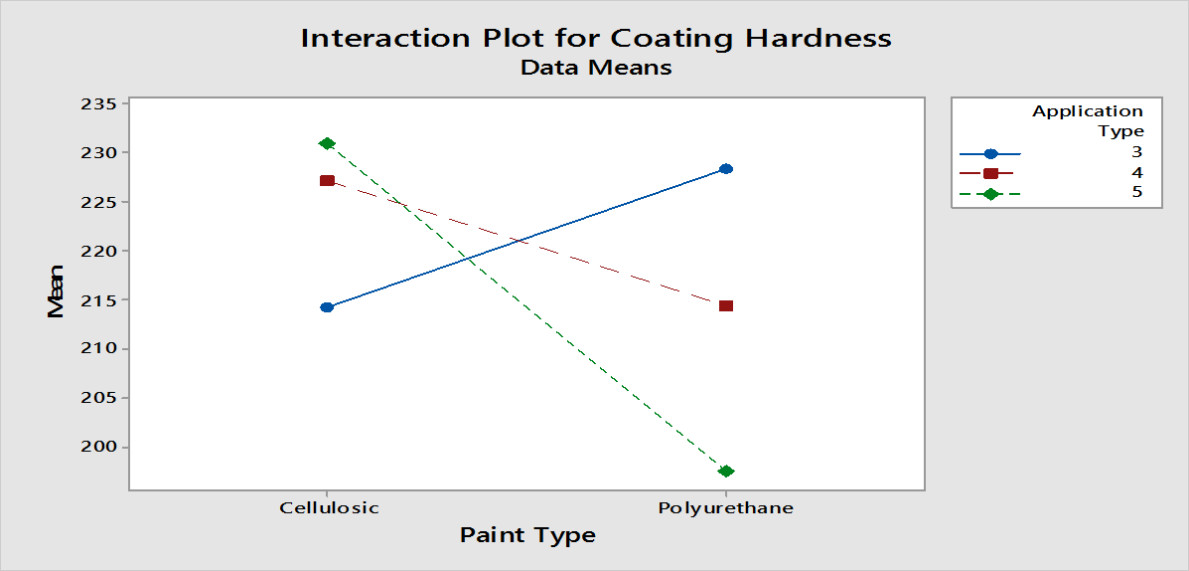

Figure 3: Interaction for Coating Hardness

Conclusions

It might be expected that the surface hardness values increase in general when the layer thickness is increased in surface treatment applications. According to the results of the study, however, there are significant differences when the interactions between the paint and number of layers are taken into account. Therefore, one can say that there is a need for determining different application thicknesses for different paint types for the properties expected from the surface treatment. Results of the studies performed by Oblak et al. (2006) suggest the need for right application methods at the right place for high quality surface treatment application. Waste values and cost arising in the surface treatment applications is another topic for discussion. Working with less layers would shorten the time of applications, as well as reduce the cost. Thus, the surface treatment parameters such as paint type, layer thickness etc. should be determined optimally for ensuring the targeted surface treatment performance.

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