ONLINE ISSN 2069-7430
ISSN-L 1841-4737

PRO LIGNO
www.proligno.ro

Vol. 9 N° 4 2013
pp. 164-168

EFFECTS OF VARNISH VISCOSITY AND FILM THICKNESS ON ADHESION STRENGTH OF COATED WOOD

Turgay OZDEMIR
Assoc. Prof. Dr. – Karadeniz Teknik University- Faculty of Forestry
Address: Kanuni Kampusu. 61080 Trabzon. Turkey
E-mail: turgay@ktu.edu.tr

Özlem BOZDOĞAN
Graduate Students – Karadeniz Teknik University- Faculty of Forestry
Address: Kanuni Kampusu. 61080 Trabzon. Turkey
E-mail: ozlembozdogan@hotmail.com

Fatih MENGELOGLU
Assoc. Prof. Dr. – Kahramanmaras Sutcu Imam University- Faculty of Forestry
Address: KSU Avsar Yerleskesi. 46100 Kahramanmaras. Turkey
E-mail: fmengelo@ksu.edu.tr

Abstract:

Final quality of finishing depends on various elements including application method of coating, characteristics of substrate such as porosity, chemical structure, and interaction between coating and the substrate. The objective of this study was to determine the effect of varnish viscosity and film thickness on the adhesion strength of alder (Alnus glutinosa), and Scots pine (Pinus sylvestris). Samples were spray coated using cellulose based varnishes. Scots pine samples showed higher adhesion strength compared to alder samples. It appeared that varnish viscosity of 15s provided higher adhesion strength than 25s ones. It was statistically shown that the variation of the varnish viscosity affected the adhesion significantly while the effect of the film thickness was negligible.

Key words: *varnish viscosity; film thickness; adhesion strength; scots pine and alder.*

INTRODUCTION

Solid wood species are extensively used in furniture and cabinet manufacture in which the finish plays an important role in the overall quality and service life (Anonymous 1987). Although wood-based composites are widely used in furniture and cabinet manufacturing when high-quality products are required, solid wood is still essential raw material in most applications for construction and joinery products. One of the most important advantages of wood is its easy machinability and paintability compared to metal and plastic products. However, its non-uniform characteristic within and between species plays a significant role on its efficient and effective machining and painting.

Surface coating of wood is one of the most important parameters influencing properties of wood products in laminated applications. Final quality of coating depends on various elements including application of coating methods, characteristics of substrate such as porosity, chemical structure, and interaction between coating and the substrate (Good 1976, Richter *et al*. 1984, Kollmann and Cote 1964).

Many studies are available in the existing literature on the surface characteristics and adhesion between wood and coatings (e.g. Jaic and Zivanoviz 1995, Jaic *et al*. 1996, Meijer and Militz 2000, Allen 1978, Özdemir and Mengeloğlu 2008).

Depending on the type of finish, adhesion strength between the substrate and the coating agent is also important factor as function of humidity level as well as surface roughness of the panels. Penetration of coating through substrate related to adhesion strength have been studied by various authors (Zavarin 1984, Wiliams 1990). An activated panel surface can cause adhesion problems because of the interference with penetration of adhesive. Adhesion strength between coating and the surface is related to development of stresses in the coating which can also be reduced as a result of stored energy (Good 1976). The axial pull-off test is most widely used technique to evaluate adhesion strength of the coats. The main advantage of this technique includes its practicality and simple application for different surfaces.

The aim of this study is to determine effect of varnish type and film thickness on the adhesion strength of coated wood.

EXPERIMENTAL

Materials

A total of 80 flat grained defect free samples in the dimension of 30cm by 10cm by 1cm from two species, namely Scots pine (*Pinus sylvestris L.*), and Alder (*Alnus glutinosa subsp. barbata*) were used for the experiments. These species were selected of commercial usage and abundant in the Northeast of Turkey.

All samples were sanded using 100 - and 150 - grit sandpaper prior to conditioning them in a climate chamber to moisture content of 12%.

A commercially available cellulosic varnish was used in this study. Approximately 120g/m^2 of varnish were sprayed onto samples surface.

Methods

Varnish viscosity

Forty flat grained defect-free samples in dimension of 30cm by 10cm by 1cm from scots pine and alder wood species were used for viscosity measurement. Two different viscosity time, 15s and 25s, were selected according to the DIN cup/4mm/20°C. Three layers of coating were applied as two bases and one topcoat layer. The component details of the coatings considered were given in Table 1. After coating, dry coating thickness was determined by using a dry film thickness apparatus (ASTM D 4138) (Erichsen P.I.G 455). Dry film thickness of the composites was measured as 90µ, and 110µ, for viscosity of 15s, and viscosity of 25s, respectively.

Table 1

Mixture portion of coatings

Varnish variety	Varnish (portion)	Hardener(portion)	Thinner(portion)
Cellulosic primer coat	100	-	80
Cellulosic top coat	100	-	80

Film thickness

Forty flat grained defect-free samples in dimension of 30cm by 10cm by 1cm from scots pine and alder wood species were used for viscosity measurement. Two different dry film thickness were used. Three layers of coating were applied as two bases and one topcoat layer for first group of film thickness. Four layers of coating were applied as two bases and two topcoat layer for second group of film thickness. The component

details of the coatings considered were given in Table 1. After coating, dry coating thickness was determined by using a dry film thickness apparatus (ASTM D 4138) (Erichsen P.I.G 455). Dry film thickness of the composites was measured as 110µ, and 160µ, one top coat and two top coat, respectively.

Test

Adhesion strength of the coated samples was also determined employing the pull - off method. A total of twenty random adhesion strength measurements were taken from the surface of each panel group using the Erichness Adhesion tester - 525 MC. Head of the equipment with a radius of 20mm is glued to the surface and tension force is applied to the surface layer by pulling the coating from the face of the samples. Adhesion strength value of the coating is expressed in terms of the tension force in N/mm^2.

Statistical analysis

The SPSS statistical software program was used for statistical analysis. In this study, the general factorial design for two factor analyses was utilized to determine the effect of the wood species and the varnish type on the abrasion, hardness and gloss properties of wood panels.

RESULTS AND DISCUSSION

Effect of varnish viscosity

In this study, the effect of wood species (pine, and alder) and varnish viscosity (15s, and 25s) on the adhesion strength were investigated. Summary of the results was presented in Table 2.

Table 2

Adhesion strength of the wood panels

Wood species	Varnish Viscosity (second)	Adhesion strength (N/mm ^{2})
Scots pine	15	2.12 B[1],1[2] (0.18)[3]
	25	1.84 B, 2 (0,34)
Alder	15	1.76 A, 1 (0.11)
	25	1.64 A, 2 (0.30)

[1]The different capital letters show statically different groups for wood species
[2]The different capital letters show statically different groups for varnish viscosity
[3]The value in parenthesis is the standard deviation.

According to test results, ring orientation and wood species affected the adhesion strength. Statistical analysis was shown in Table 3 and 4.

Table 3

Analysis of t- test for adhesion strength of varnish viscosity

Viscosity time	x	s	t value	Significant level
15 s	1.97	0,30	3.34	0.002
25 s	1.69	0,22		

Table 4

Analysis of t- test for adhesion strength of wood species

Wood species	x	s	t value	Significant level
Scots pine	1.93	0.25	2.26	0.029
Alder	1.73	0.30		

Statistical analysis showed that there was a significant effect of varnish viscosity and wood species on the adhesion strength. Scotch pine had the highest adhesion value with 1.93N/mm^2, alder had the lowest adhesion value with 1.73N/mm^2. This is due to the wood properties such as density, permeability etc.

Regarding to statistical analysis, there was a significant effect of varnish viscosity on the adhesion strength. As can be seen Fig. 1, varnish viscosity of 15s has higher adhesion strength values compared to varnish viscosity of 25s. Liquids having low viscosity better penetrate and bond into wood structure than liquids having higher viscosity (Good 1976).

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 9 N° 4 2013
pp. 164-168

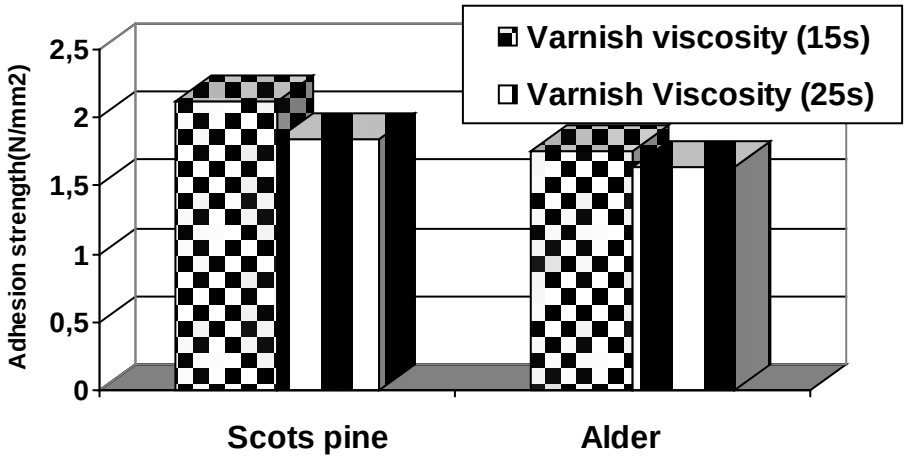

Fig. 1
Adhesion strength of wood panels.

Effect of film thickness

The effect of wood species (pine, and alder) and film thickness(one - top coat, and two - tops coat) on the adhesion strength were investigated. Summary of the results and statistical analyses were presented in Table 5-7, respectively.

Table 5

Adhesion strength of the wood panels

Wood species	film thickness	Adhesion strength(N/mm ^{2})
Scots pine	One-top coat, 110 µ	1.78 B[1],1[2] (0.37)[3]
	Two-tops coat, 160 µ	1,72 B, 1 (0.28)
Alder	One-top coat, 110 µ	1.63 A, 1 (0.35)
	Two-tops coat, 160 µ	1.68 A, 1 (0.38)

[1]The different capital letters show statically different groups for wood species
[2]The different capital letters show statically different groups for film thickness
[3]The value in parenthesis is the standard deviation.

Table 6

Analysis of t- test for adhesion strength of dry film thickness

Film Thickness	x	s	t value	Significant level
One - top coat	1.71	0.36	- 0.088	0.931
Two - tops coat	1.70	0.33		

Table 7

Analysis of t- test for adhesion strength of wood species

Wood species	x	s	t value	Significant level
Scots pine	1.75	0.32	1.88	0.036
Alder	1.65	0.36		

It was statistically that there were no differences between one top coat and two top coat. However, there was a significant effect of wood species on the adhesion strength.

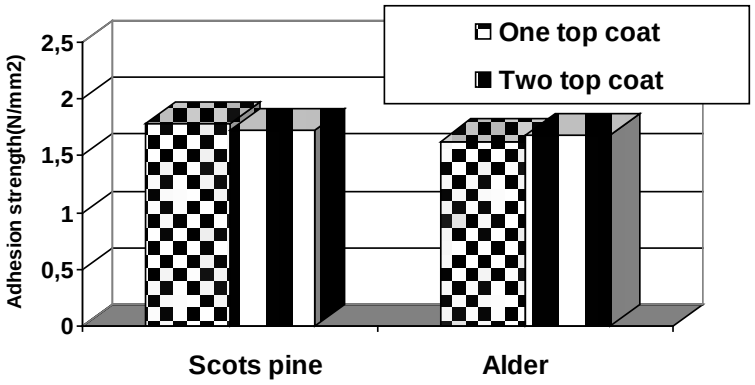

Fig. 2
Adhesion strength of wood panels.

As can be seen from Fig. 2, adhesion strength of scotch pine samples with one top coat was found to be higher value than those with two - tops coat. However, adhesion strength of alder samples with one top coat was lower value than those with two- tops coat, which resulted from the anatomical properties of the wood species. Statistically no significant variation affect between one - top coat and two - tops coat, which was also observed by Budakcı and Sönmez (2009).

CONCLUSIONS

In this experimental study, the effects of the varnish viscosity and the film thickness on the adhesion strength were studied. Two different values of the varnish viscosity were considered: 15s and 25s. In addition, two different geometrical orientation of the coatings were tested comparatively: one - top coat and two – tops coat. It was disclosed that a decrease in the varnish viscosity improved the adhesion strength while the usages of the one - top or two - tops coat didn't change the adhesion strength. In addition, Scots pine wood presented better performance when compared to the alder wood.

REFERENCES

Allen KW (1978) A review of contemporary views of theories of adhesion, J. Adhes., 21(3–4):261–277

ANON (1987) Furniture and Joinery for Devoloping Countries, UNIDO, Unido Publication No.: E. 88.III, Vienna

ASTM D 4138 (1971) Test Method for Measurements of Dry Film Thickness of Protective Coatings. ASTM:Philadelphia

ASTM D 4541 (1978) Test methods for Pull-off Strength of Coatings Using Portable Adhesion Testers, ASTM:Philadelphia

Budakci M, Sonmez A (2009) Bazı ahşap verniklerin farklı ağaç malzeme yüzeylerindeki yapışma direncinin belirlenmesi, Journal of Fac. Eng. Arch. Gazi. University, 25(1):111-118

Good RJ (1976) Definition of adhesion, J. Adhes. 8(1):1–9

Jaic M, Zivanovic R (1995) 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

Jaic M, Zivanovic R, Stevanovic-Janezic T, Dekanski A (1996) Comparison of surface properties of beech and oakwood as determined by ESCA Method, Holz Roh-und Werkstoff, 54:37–41

Kollmann FFP, Cote WA (1984) Principles of Wood Science and Technology, v.I, Springer, pp. 162

Meijer MDE, Militz H (2000) Wet adhesion of low - VOC coatings on wood a quantitative analysis, Prog. Org. Coat., 38:223–240 (Elsevier Science)

Richter K, Feist WC, Knaebe MT (1995) The effect of surface-roughness on the performance of finishes. 1. Roughness characterization and stain performance, For. Prod. J. 45(7–8):91–97

Ozdemir T, Mengeloglu F (2008) Some Properties of Composite Panels Made from Wood Flour and Recycled Polyethylene, International Journal of Molecular Sciences, 9(12):2559-2569, *al of the Physical Sciences* Vol. 6(8):2100-2106, 18 April

William RS, Plantinga PL, Feist WC (1990) Photodegratation of wood affects paint adhesion, Forest Prod J, 40:45–49

Zavarin E (1984) Activation of wood surface and non-conventional bonding, R. Rowell (Ed.), The chemistry of solid wood, ACS, Washington