

PERCENTAGE OF WEIGHT INCREASE IN EUROPEAN SPRUCE WOOD (PICEA ABIES.MILL), IMPREGNATED WITH POLYURETHANE AND ACRYLIC COATINGS

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ABSTRACT:

Impregnating and coating of wood with film forming materials are methods for the surface treatment of wood. Through the method of double vacuum (engl. Double vacuum process) polymeric film forming materials are incorporated into cellular and intracellular cavities of the surface layers of the wood. The resulting percentage of increase in mass (engl. Weight Percent Gain - WPG) is significantly larger than on classical coated wood.

The progress rate of increase in mass of the test pieces, the impregnation with polyurethane coating is 11.4% and the impregnation with acrylic coating 10.6%. Differences in impregnated wood with polyurethane and acrylic coating are not statistically significant.

1. INTRODUCTION

Capillary absorption is a method of impregnating, with the influence of process vacuum and normal pressure, which brings an impregnating material in wood that does not have to occur a capillary saturation. In literature, capillary absorption and impregnating is identified with the following terms: „ Resin impregnation ", „ Impregnation modification", „ Hardened wood ", „ Wood-Polymer Composite ", „ Wood stabilization".

Modification of the wood represents a reversal of the natural features to improve properties and durability. The main objectives are: dimensional stability, improved mechanical properties, resistance to biological degradation. The modification of the wood uses procedures that affect the basic elements: cellulose, lignin and hemicellulose. The modification can occur by three groups of change (Homan, 2004): bulking of the cell wall, lumen filling and chemical bonding - chemical modification. Coating wood is the oldest procedure for surface treatment of wood which has primarily protective purpose. This processing despite all the good features has negative characteristics as weakening the adhesion of the material and wood, permeability to water and others.

2. AIM OF THE RESEARCH

The aim of the research is to see the performance of capillary absorption as a method of impregnation and to identify differences between the modification of the surface layer with capillary absorption of with two types film forming materials. Today the market for raw materials offers a wide variety of film forming materials. Based on the study of available research literature, the first goal is to define

two types of film forming materials that will be comparable with each other in implementing this research.

The interest of this research is to determine the amount of material that can be capillary soak into the wood and compare it with the material applied to the surface of the wood forming a continuous cover - film.

3. MATERIALS AND METHODS

3.1. Preparation of wooden test specimens

Test pieces are made out of spruce wood (*Picea Abies*.Mill), material from a local sawmill from Macedonia. The wood is selected without visible errors, with average growth in the radial direction to the eight annual rings of 10mm. Test pieces were conditioned to equilibrium moisture of wood $W = 13 \pm 2\%$ by weight allowable tolerance of $\pm 1,5\%$, according to ISO 554:1976.

Treated in the two groups of test pieces for each type of film forming material - coating with $n = 31$ to 34 numbers. Each coating is impregnated and coated:

- A group of samples with dimensions 150x70x20mm, impregnated with polyurethane (IPU) and impregnated with acrylic group (IAK) and
- A group of samples with dimensions 150x70x20mm, coated with polyurethane (FPU) and coated with acrylic (FAK).

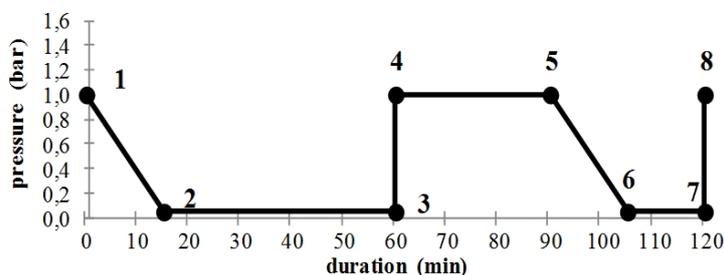
The determination of moisture content and wood density is made according to the usual methods prescribed by ISO 3130 and ISO 3131 standards.

3.2. Coating properties

Examined coatings are based polyurethane and acrylic resins, standard products from a range of renowned European manufacturer (ICA LP152P and ICA LAC367). Preparation of coatings was performed according to prescribed instructions from the manufacturer, and it is further diluting. The viscosity is determined according to the standard ISO 2431, the solid content according to ISO 1515.

3.3. Method for impregnating

Capillary absorption of coatings in the wood is performed according to procedure with double vacuum, „Double vacuum process“(Videlov., H. 1980, Richardson, B. 2003). Wooden test pieces are fully immersed in the coating solution. The last act in a vacuum procedure is the removing of the impregnating solution from the autoclave, which is done in order to prevent the formation of a film on the surface of the wood. The ratio of the pressure and time of action are shown in the graph 1.



Graph 1. Regime of treatment of specimens

After treating the polymerization occurs in test pieces. The process of polymerization is followed until reaching constant weight under conditions prescribed by the standard ISO 554:1976.

3.4. Procedure for coating the specimens

Before use, the coating is dosed and determines their properties for the mixture. It is left to homogenize during 30 to 40min. For the application of the film forming materials a brush technique with a width of 30 to 40mm from natural fiber is used which provides an evenly applying of the coating to the surface. The coating is done by a first application transversely and then in the direction of the wood fiber what forms the leveled layer. Coating is applied in two layers, with longitudinal intermediate sanding with sand paper No.150. Occurring is in room conditions and the time between the loads is 24 hours.

3.5. Increasing mass

The increase in mass or,, Weight Percent Gain "- WPG, (Hill 2006), a percentage increase of the mass of the sample after treatment, compared to the initial:

$$\text{WPG (\%)} = \frac{Mm - Mu}{Mu}$$

Mm - mass of the treated sample (g); Mu - mass of the sample before treatment (g)

4. RESULTS AND DISCUSSION

4.1. Properties of coatings

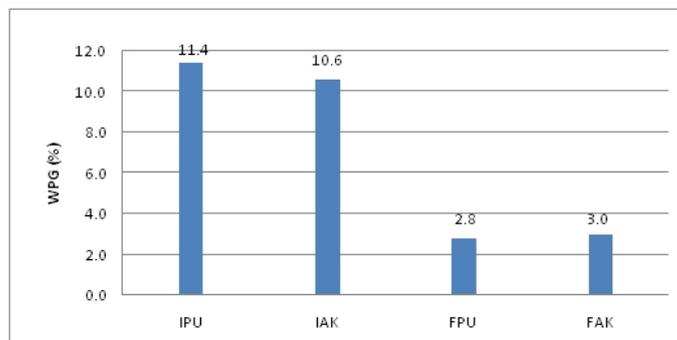
The average viscosity of the polyurethane coating is $v_{du} = 15$ "F4/20 ° C, the acrylic coating is $v_{ak} = 27$ " F4/20 ° C. During the procedure viscosity is unchanged. The mean value of the solid content of polyurethane coating is $NV_{du} = 49.3$ (%), and the acrylic coating $NV_{ak} = 54$ (%). Although acrylic coating has a slightly greater quantity of solid content, the difference of 4.7% is statistically insignificant.

4.2. Properties of wood

Mean percentage of wood moisture was $W = 11.57 \pm 0.21\%$. The mean value of wood density of spruce was $\rho_{12} = 0,44 \pm 0.03\text{g/cm}^3$. Wood density is in the range ($\rho = 0,33$ to $0,68$ g/cm^3) of reference data (Pejoski, b., 1966), an interval for spruce wood density from the Macedonian region.

4.3. Increasing mass

The comparisons aims to evaluate the differences in the percentage increase in mass of wood impregnated with polyurethane and wood impregnated with acrylic coating and the increase of mass of wood coated with polyurethane and wood coated with acrylic coating. The results of the measurements are presented in Chart 2.



IPU - wood impregnated with polyurethane coating, IAK - wood impregnated with acrylic coating, FPU - wood coated with polyurethane coating, FAK - wood coated with acrylic coating

Chart 2. Graphical representation of the weight increase - WPG of test specimens

The mean value of the increase in mass of wood, impregnated with polyurethane film forming material WPG_{ipu} , is greater than the mean of wood impregnated with acrylic film forming material WPG_{iak} . The absolute difference in mean values for the increase in mass of the wood is 0.8%, or percentage, wood impregnated with polyurethane film forming material is 7.5% higher than average wood impregnated with acrylic film forming material. Difference is not statistically significant.

Polyurethane coating with properties $v_{pu} = 15$ "F4/20 ° C and $NV_{pu} = 49\%$, and impregnating the wood gives the percentage increase in mass $WPG_{ipu} = 11.4\%$. Acrylic coating has $v_{ak} = 27$ " F4/20 ° C and $NV_{ak} = 54\%$, and it gives the percentage increase in mass of the wood $WPG_{iak} = 10.6\%$. Coating with a lower viscosity in the case polyurethane gives greater percentage increase in mass. Polyurethane coating, due to the lower viscosity penetrates deeper inside the wood. After evaporation of the solvent, the wood remains with a higher percentage of solid content and has therefore a higher percentage of mass increase. The values of viscosity and solid content are within the recommendations (VidelovH., 1980), and the impregnating viscosity is lower than $v = 40$ "F4/20 ° C. the low viscosity arises due to the higher proportion of solvents in the coating composition and the smaller percentage of solid content. Solid content of coatings, according to the same author's recommendation, is less than 55%.

The mean value of the percentage increase in mass of wood coated with acrylic film forming material WPG_{iak} , is greater than the mean value of the wood coated with polyurethane film forming material WPG_{ipu} . The absolute difference in mean values for the increase in mass of the wood is 0.2%, or percentage, wood of FAK is 7.1% greater mean from FPU. The difference is not statistically significant.

The percentage of increase in mass of wood coated with acrylic coating is slightly higher than the wood applied polyurethane coating. The different increases in mass are directly depending on the percentage of solid content of coating. The composition of the coating which contains a higher percentage of solid content - non-volatile compounds on the surface of the wood will form a thicker film, and it will increase the mass of coated wood.

In this case, we can say that the difference of solid content, including acrylic and polyurethane coating is 5% what is not a real significant difference in the percentage increase in mass of the wood.

The median percentage increase in mass of impregnated wood with polyurethane coating - WPG_{ipu} is 8.6% greater than the mean of the percentage increase in mass of wood coated with polyurethane coating - WPG_{ipu} . Impregnated wood has an about 4 times greater increase in mass compared to

coated wood. Wood impregnated with acrylic coating has an about 3.5 times greater rate of increase in mass than coated wood.

According to (Richardson., B, 2003), the most important factor which affects the penetration, the formation of the film thickness and thus the increases in mass, is the viscosity. The addition of solvents reduces the viscosity of the coating and simultaneously adjust the percentage of the solid content (Jaic., M. 2001). The composition of the coating with a lower percentage of solid content - non-volatile compounds - contains higher percentage of solvent volatile substances (Graystone.J, Bulian.F, 2009).

The research results show that the percentage increase in mass of impregnated wood is greater than of coated wood treated with polyurethane and acrylic film forming material. The difference is significant and shows that high factor of significance obtained in these comparisons.

The percentage of the increase in mass of coated wood is smaller than the WPG of impregnated wood, because the film layer which is applied to the surface is much thinner than the surface layer of wood that is impregnated. External surface of the wood is much lower than the developed area of the surface layer of the wood. According to the literature of (Jaic., M. 2001), Cube of pine wood (*Pinus lambertiana*), with sides of 1cm and area of 6cm² and bulk mass $\rho = 0.36\text{g/cm}^3$, has an internal area of 170m². Thickness of the film formed on the outer surface, is greater than the surface of the internal building elements of the wood. Still greater is the quantity of material located in the wood in relation to the surface, and therefore impregnating gives greater percentage increase in weight compared to the coated wood.

5. CONCLUSIONS

Based on the research following major conclusions can be made:

1. Capillary absorption is a method of impregnation, combining action of vacuum and normal pressure that brings impregnating material in wood, which does not have to occur capillary saturation.
2. The percentage of increase in mass of wood impregnated with polyurethane and wood impregnated with acrylic coating is equal. The effect of these film forming materials are similar. The polyurethane coating is made WPG = 11,4% in test specimens 150x70x20mm while acrylic coating WPG = 10,6%.
3. The percentage of increase in mass of wood treated with impregnating is about 3.5 to 4 times higher than coated wood.

The results of the processing of wood, impregnation and capillary absorption suggest a possible practical application of this method as a surface treatment technology, specifically for the modification of wood surface. The method can also be applied for impregnations with special purposes.

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