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Ресурсоефективність використання сировини у деревообробній промисловості Східної Європи: виклики і можливості для сталого розвитку

Представлено результати досліджень, які проведенні для лісового сектора. Дослідження базується на порівнянні лісових секторів трьох країн Східного партнерства (Україна, Молдова і Грузія) і лісового сектору Польщі. У процесі дослідження було визначено і проаналізовано основні економічні показники лісових секторів та лісових ресурсів для згаданих вище країн, проаналізовано внесок цих лісових секторів у ВВП країни. В результаті були визначені наступні проблеми сталого розвитку для деревообробної промисловості у Східній Європі: економічна міць лісового сектора в Східній Європі зміщена в бік лісового господарства; лісові сектори в країнах Східної Європи відрізняються дуже низькою продуктивністю; дуже малакількість підприємств в лісових секторах країн Східного Партнерства в порівнянні з країнами ЄС через складність ведення бізнесу; лісові сектори країн Східного партнерства виробляють набагато менше продуктів з обороту; частка лісового сектора в країнах Східного партнерства не перевищує рівень 2% від національного ВВП і є тенденція до постійного зменшення цієї частки.

Ключові слова: лісовий сектор; оборот; кількість підприємств; кількість працівників; країни СЄП; лісових ресурсів; основні проблеми та можливості; сталий розвиток.

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PREDICTION OF THE DURABILITY OF THERMOPLASTIC ADHESIVE PINE WOOD JOINTS

Abstract. Presented here are the results of predicting the durability of thermoplastic adhesive joints of pine wood by means of mathematical models. An analysis was made of the obtained results, on the basis of which it is established that with increasing the ambient temperature, the durability of thermoplastic polyvinyl acetate adhesive pine wood joints with the degree of load D4 decreases, and when the ambient humidity increases, the durability, by contrast, is slightly increasing.

Keywords: durability, adhesive joint, mathematical model, prediction, strength, humidity, temperature.

Topicality. Among the basic requirements that are imposed upon adhesive wood joints is ensuring adequate strength and durability. These requirements are interrelated and determine the quality and reliability of the product; this depends on the physical and mechanical properties of adhesives and materials to be glued, bonding process parameters, operating conditions, physical loading, etc. [1, 2]. Strength is an important characteristic of adhesive wood joints during operational service, but it does not offer a means of obtaining quantitative indicators of service time of glued products. It is durability that is the quantitative indicator of service time of any glued product. It is determined by the time of operation, duration or period of service life [3].

On the basis of experimental and theoretical studies, using simulation and mathematical modelling, we obtained a mathematical model to predict the durability of thermoplastic adhesive joints of oak wood [4, 5, 6, 7], which takes the following form:

$$\tau^{(i)} = \frac{1}{C^{(i)}} \cdot \ln\left(\frac{B^{(i)} \cdot \Delta W^{(i)}}{\sigma_{гран.} + A^{(i)} \cdot \Delta T^{(i)}} \right) \quad (1)$$

where $\Delta T^{(i)}$ is weighted average ambient temperature, ^{o}C; $\Delta W^{(i)}$ is weighted average ambient humidity, %; $\sigma_{гран.}$ is ultimate strength of the joint; the parameters $A^{(i)}$, $B^{(i)}$, $C^{(i)}$ are dependent upon variations in the ambient humidity and temperature; l is the coefficient for wood species that takes into account theological , physical and chemical properties of oak wood. The coefficients for other wood species which would take into consideration their physical and mechanical characteristics had to be calculated. The calculation of the coefficients for some wood species was given by the author in his previous works [8]. Taking into account the coefficient for pine wood species, the mathematical model of durability prediction will take the form:

$$\tau^{(i)} = \frac{0{,}635}{C^{(i)}} \cdot \ln\left(\frac{B^{(i)} \cdot \Delta W^{(i)}}{\sigma_{гран.} + A^{(i)} \cdot \Delta T^{(i)}} \right) \quad (2)$$

The results of the studies. The proposed mathematical model allows predicting the durability of both cross-linked and uncross-linked thermoplastic polyvinyl acetate adhesive joints of pine wood. That is, by specifying the degree of load for an adhesive joint, the ambient humidity and temperature, it is possible to predict the durability for thermoplastic adhesive pine wood joints by non-destructive method. During prediction of the durability of adhesive joints, the ambient humidity and temperature were consistent with their weighted average values for a 3-year period of long-term experimental studies [9]. For example, Figs.1 and 2 show a graphical interpretation of the results of predicting the durability of thermoplastic polyvinyl acetate adhesive joints of pine wood obtained by means of mathematical modelling. As can be seen from these dependences (see Fig.1), at weighted average ambient temperature of 4.19 ^{0} C and weighted average humidity of 65.46% the durability is 687 days. In the case of increasing humidity to 93.91% at this temperature, the durability is increased to 787 days, i.e. by 100 days, or 12%. A similar pattern is observed for weighted average temperatures of 7.89 ^{o}C and 12.23 ^{o}C for which the durability is also increasing by an average of 100 days.

That is, with increasing humidity from 65% to 92%, the durability increases, on average, by 13% regardless of the operating temperature.

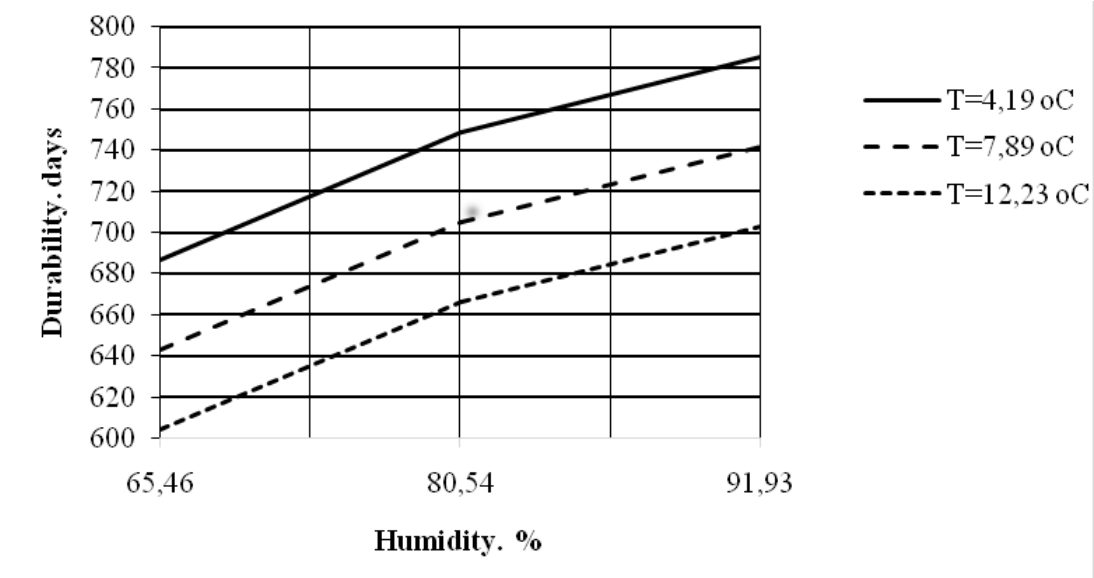

Fig.1. Prediction of the durability of adhesive pine wood joints bonded with cross-linked adhesive with the degree of load D4 depending on humidity changes

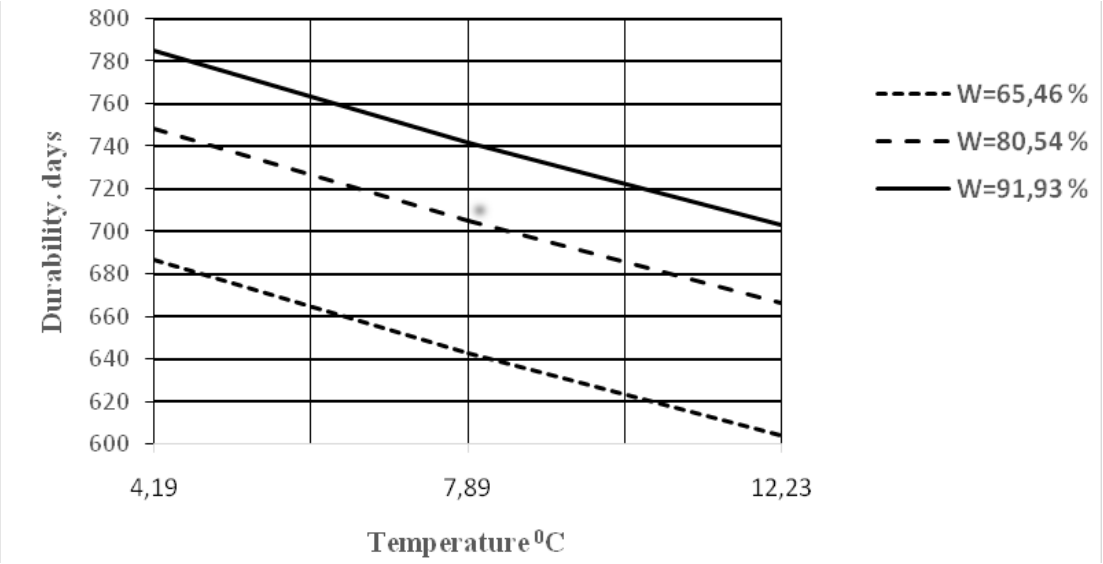

Fig. 2. Prediction of the durability of adhesive pine wood joints bonded with cross-linked adhesive with the degree of load D4 depending on temperature changes

A similar pattern is observed for weighted average temperatures of 7.89 ^{o}C and 12.23 ^{o}C for which the durability is also increasing by an average of 100 days. That is, with increasing humidity from 65% to 92%, the durability increases, on average, by 13% regardless of the operating temperature.

The effect of temperature on the durability (see Fig.2) shows that for the weighted average temperature of +4.19 ^{o}C and humidity of 65.46%, the durability is 685 days, while at a temperature of 12.23 ^{o}C the durability is reduced to 605 days.

The decrease in durability, on average, by 80 days with temperature change from 4.19 to 12.23 ^{o}C, also occurs at humidity values of 80.54 and 91.93%, but with higher durability values (for example, to 781 days at a humidity of 91.93%). Thus, a rise in temperature, on average, by 1 ^{o}C shortens the life of product by 10 days, while an increase in humidity by 1% increases the service life by about 3 days.

Fig. 3 shows the predicted durability of adhesive pine wood joints glued with thermoplastic adhesives depending on variation in weighted average temperature at various ambient humidity levels.

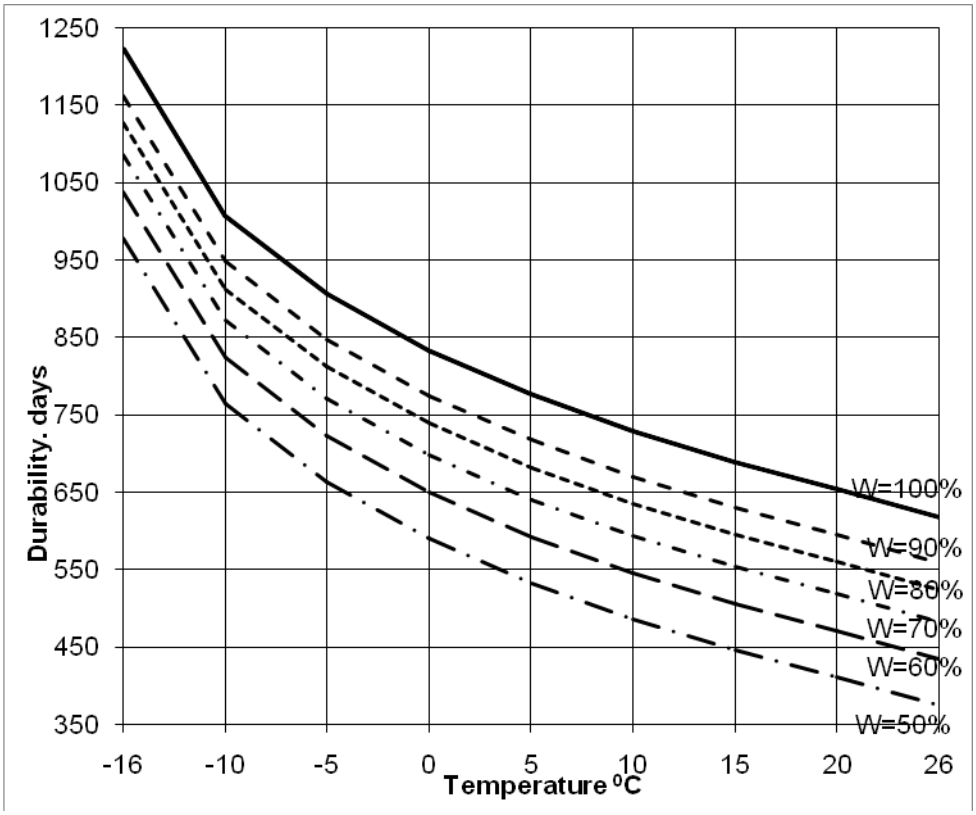

Fig.3. Prediction of the durability of adhesive pine wood joints glued with cross-linked adhesive at the degree of load D4 depending on weighted average temperature changes at various ambient humidity levels

Fig. 4 shows predicted durability of adhesive pine wood joints glued with cross-linked adhesives with load D4 depending on changes in weighted average humidity for various operating temperatures.

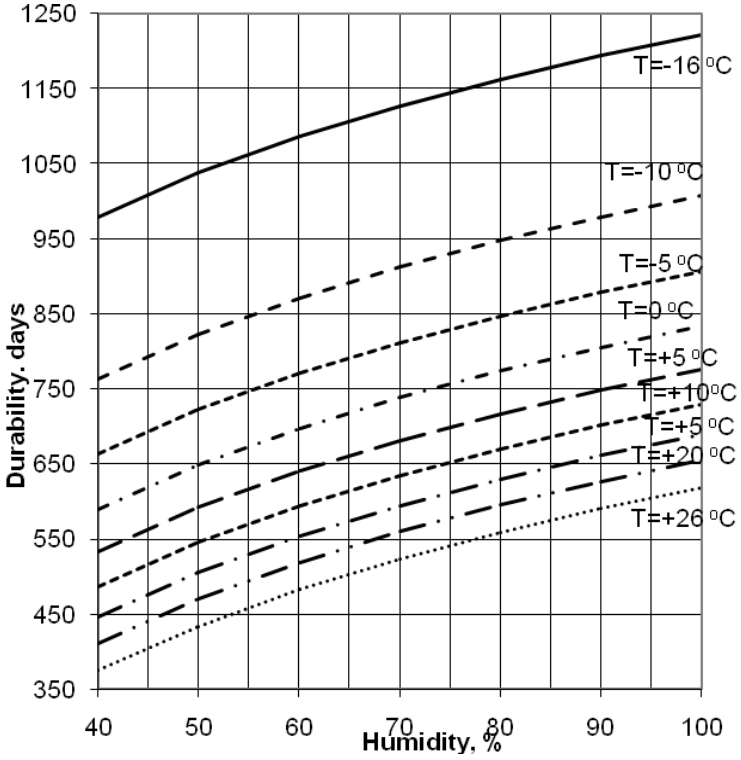

Fig. 4. Prediction of the durability of adhesive pine wood joints glued with cross-linked adhesives with the degree of load D4 depending on humidity and temperature changes

Similar results of prediction of the durability can be obtained using a mathematical model for pine wood glued with uncross-linked thermoplastic adhesives. Thus, an increase in ambient temperature results in reduced durability of thermoplastic polyvinyl acetate adhesive pine wood joints with the degree of load D4, while an increase in ambient humidity, on the contrary, leads to a slight increase in durability of such adhesive joints.

Conclusions. By using mathematical modeling, prediction was implemented for durability of thermoplastic adhesive pine wood joints. Analyzed was the effect of the ambient temperature and humidity on the durability of these adhesive wood joints. Identified were quantitative indicators of durability of thermoplastic polyvinyl acetate adhesive joints of pine wood depending on the operating conditions.

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Прогнозування довговічності термопластичних клейових з'єднань деревини сосни

Наведено результати прогнозування довговічності термопластичних клейових з’єднань деревини сосни за допомогою математичної моделі. Здійснено аналіз отриманих результатів, на основі якого встановлено, що при підвищені температури навколишнього середовища, довговічність термопластичних полівінілацетатних клейових з'єднань деревини сосни із ступенем навантаження D4 - зменшується. А при підвищені вологості навколишнього середовища навпаки, довговічність незначно зростає.

Ключові слова: довговічність, клейове з’єднання, математична модель, прогнозування, міцність, вологість, температура.