MODELLING OF DRYING TIMBER AREA SN END PART OF LUMBER

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The developed model of drying the face of the timber. It is shown that non-uniform field distribution along the length of the material humidity results in a bending deformation of wood fibers , characteristic only of end zone assortment , which is the main cause of mechanical cracking timber. Experimental study of the distribution of shrinkage, deformation and residual elastic strain in the face area of timber. Investigated modes lumber drying solid hardwood that prevent cracking of face .

Wood moisture transfer mechanism , volohoprovidnist , longitudinal movement of moisture, elasticity deformation , residual deformation modes drying

Mechanical Zone timber, unlike the central zone assortment is characterized by two factors - increasing intensity drying due to growth volohoprovidnosti along the grain and character of deformation of wood during drying. According to most scholars the intensity drying of end zone is a major cause of end cracks. Meanwhile, it is known that an increase in the coefficient of the gradient field volohoprovidnosti humidity decreases, which should lead to a reduction of internal pressure , the cause rupture of the ends to be found in the characteristics of deformation of wood in the area.

The purpose of research - the study of the causes and patterns of mechanical cracking of solid hardwood timber , which has the following stages:

- Study volohoprovidnist wood along the grain ;

- The features of the drying process and the deformation of wood in the face area of timber ;

- Set dependence of mechanical cracking of the regime and size factors

Research Methodology - based on the solution of differential equations wet providnosti.Dlya analysis of the drying process of end sections look lumber board, which consists of three areas - central and two end . Problem field distribution of moisture in the material, which is dried considered in the differential equation is solved volohoprovidnosti : [1]

$$\frac{\partial u}{\partial \tau} = a'\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) \qquad (1)$$

by the boundary and initial conditions:

$$u = u_{in}, \quad \tau = 0\ ; \quad a'\left[\frac{\partial u}{\partial x}\right]_{x=x_s} = \beta\left(u_s - u_{eg}\right) \qquad (2)$$

An important fact is that the thicker and longer assortments , the process to a greater extent limited volohoprovidnistyu , that there is a boundary condition of the first kind .

For unlimited the width of the plate and the problem reduces to the solution of the equation

$$\frac{\partial u}{\partial \tau} = a'_{ac}\frac{\partial^2 u}{\partial x^2} + a'_{al}\frac{\partial^2 u}{\partial z^2} \qquad (3)$$

where - coefficient volohoprovidnosti across and along the wood fibers.

Graphic-analytical solution of this equation with boundary conditions of the first kind can be obtained by taking into account the known thermal conductivity of the theory according to which criteria the resulting humidity is the product of the corresponding criteria in two mutually perpendicular directions , ie [2].

On the basis of the equation derived nomogram for calculating the moisture field in the longitudinal direction.

To find the Fourier criteria in the calculation necessary to determine the coefficients of moisture conductivity of wood in the longitudinal direction.

Theoretical and experimental studies

Research moisture conductivity of wood along the grain carried wood pine, oak and beech at a temperature of 700C and 20.50 by the method of stationary current moisture. Experimental studies have shown that the main factor that affects volohoprovidnist wood along the grain , as in the transverse direction are: humidity , temperature, wood species and its position in the trunk [4].

As a result of generalization and mathematical processing of experimental data obtained equations for determining the coefficients volohoprovidnosti along the grain of wood core and ripe wood (4) and sap wood and sap species (5).

$$a_{al}^{'} = 0{,}62 \cdot 10^{-42} T^{18} \rho^{-2{,}35} \exp(-0{,}122W) \qquad (4)$$

$$a_{al}^{'} = 0{,}255 \cdot 10^{-41} T^{18} \rho^{-2{,}55} \exp(-0{,}122W) \qquad (5)$$

It was previously shown that the wood drying chamber convection temperature difference between the surface and the center of the material is negligible , so the calculations it can be ignored . However, with increasing intensity of evaporation of moisture from the ends of timber temperature difference should increase, which may affect the accuracy of the calculations.

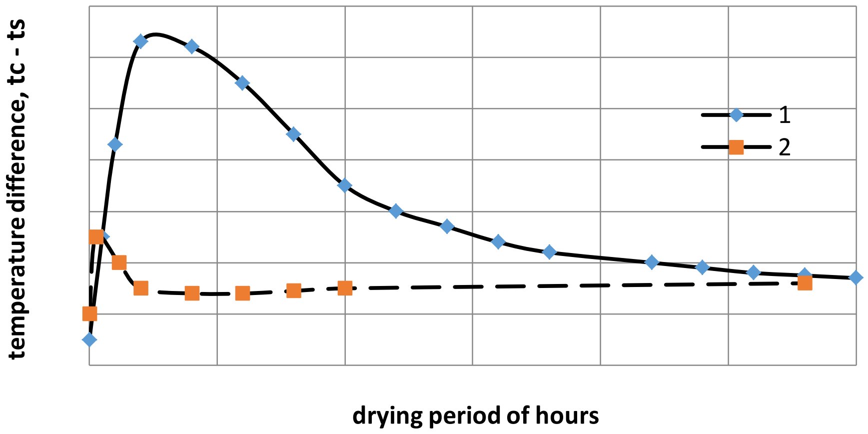


Figure 1. Temperature field in the longitudinal (1) and transverse (2) directions assortment

Comparative determination of the temperature field in the longitudinal and transverse directions assortment that dried in a medium with the same operating conditions showed similar patterns of change of the temperature field in the surface layer and the end zones . The difference was in absolute terms - in the longitudinal direction of the assortment , it was much higher than cross . The duration of a significant temperature drop along the length of the material is about 10% of the total length of drying.

Conducted additional experimental studies verify that the calculated and actual values of the field moisture showed that the calculated data with sufficient accuracy to meet the pilot , which makes it possible to compare the moisture content in the field of face zone based on the calculated data . Calculations moisture fields in the longitudinal direction saw performed in different thicknesses showed that the thicker timber, the more moisture is close to field moisture field semi-infinite body , fields where moisture gradients in the longitudinal direction of the maximum. This shows in the fact that with increasing thickness of the timber security mechanical cracking increases.

Comparison of moisture fields in the longitudinal and transverse directions assortment calculated by appropriate coefficients moisture conductivity shows that the moisture gradient field in the longitudinal direction is less than the cross (Fig. 2).

This makes it possible to predict the probability of violating the integrity of the wood. Other things being equal , the violation of integrity should be observed in the reservoir area of the board that is not confirmed in practice. Therefore , given that the different conditions of end moisture and reservoir surface slightly affect the field distribution of moisture , especially moisture of end sections show no preferential causes cracking of wood end zone .

Payments security regimes for mechanical drying surfaces were carried out by known methods [5] have not received experimental confirmation. Given that the reliability of these estimates depends largely on the reliability of the determination of elastic modulus and residual strain was hypothesized different character deformations of wood in the surface layer and the end zones .

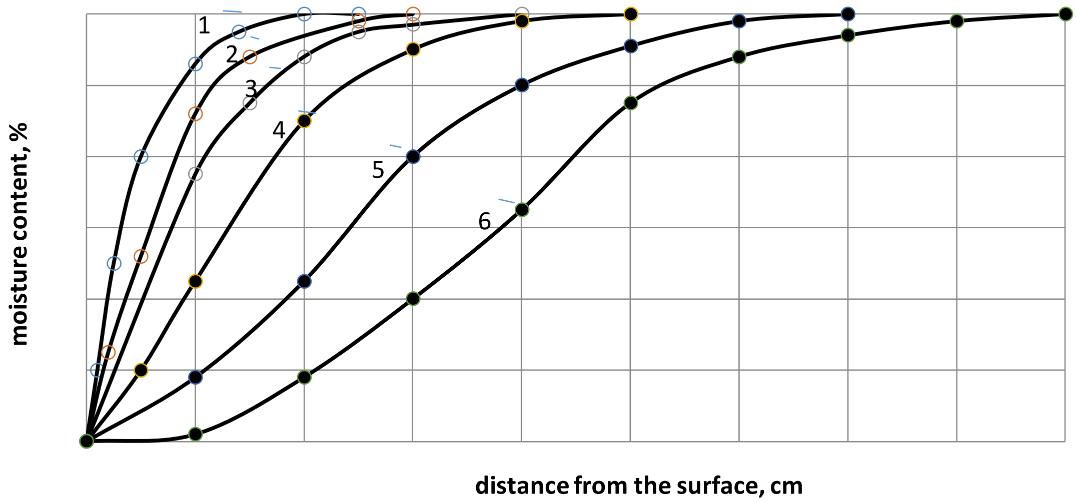
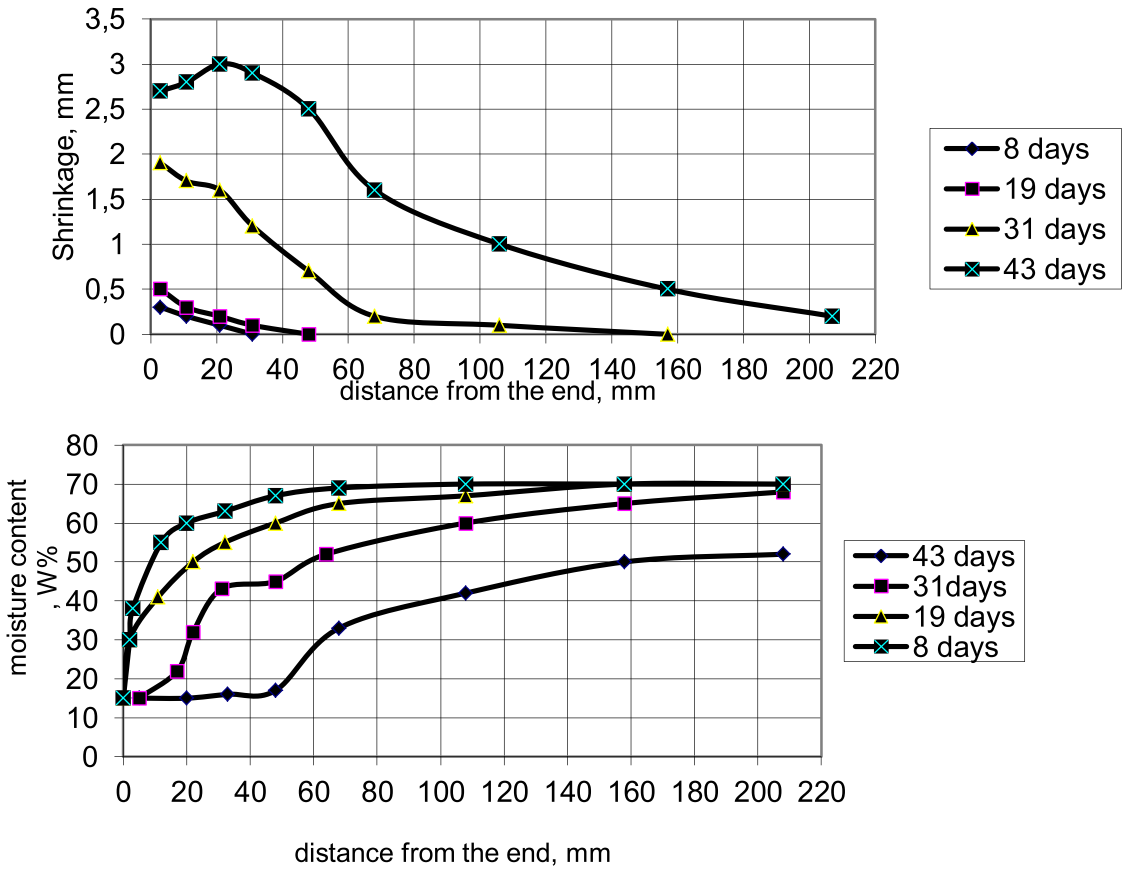


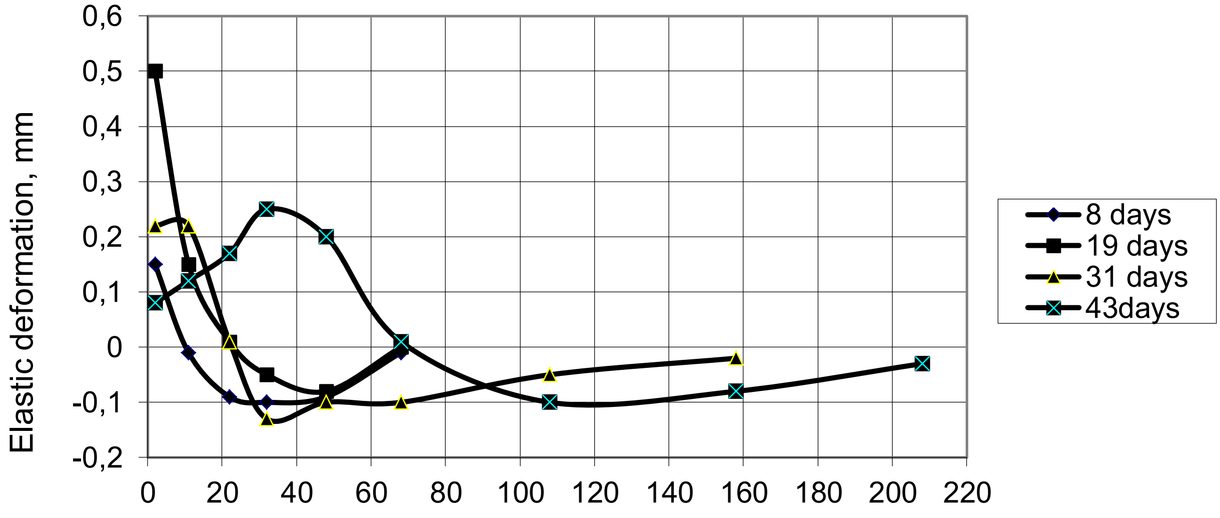
Figure 2 . Field distribution of moisture in the wood of oak in the initial stage of drying (td = 57^{0}C , tw= 54^{0}C): 1,2,3 - transverse direction , 4,5,6 - longitudinal direction , 1.4 - 10 hours , 2.5 - 24 hours, 4.6 - 48 hours

In contrast to the central area of the board where the timber is deformed in the plane perpendicular to the length of the fibers in a face character deformation station changes. In addition to the transverse strain during drying of the surface areas of specific end there is buckling of the fibers. Such bending deformations are unique to a face area assortment . The gap size modulus and transverse bending deformation leads to a sharp increase in stress in the surface layers compared to the end of stresses in the surface layers of the reservoir . Based on these links may calculate that the deformation found in nature is the main reason for the gap in the area of wood end.

The presence of non-uniform cross-section and length for the material field moisture , and thus nonuniform strain field leads to complex stress state of the material at the end zone . Existing methods of quantitative evaluation of stresses for a given section of the material can not be applied , so it is advisable to identify the qualitative aspect of the phenomenon. For this purpose, the experimental study of deformation of wood end sections of lumber during drying. The elastic and residual strain , and right humidity and shrinkage was determined by sequential removal of layers of strained material. (Figure 3 , Figure 4).



Rice . 3. Distribution of moisture content and shrinkage in the longitudinal direction assortment



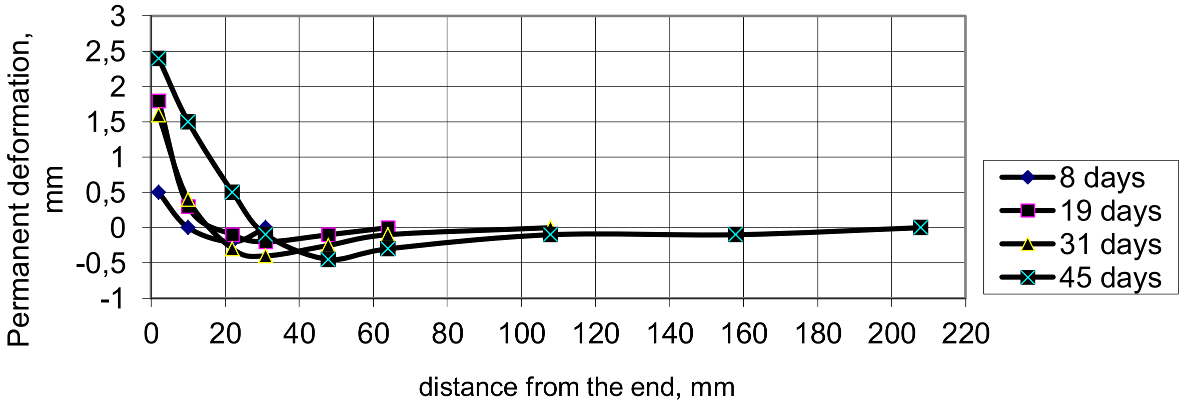


Figure 4 . The distribution of elastic and residual strain in the longitudinal direction of wood assortments

An analysis of stresses in the surface areas of the assortment , the maximum stress in the end zone occurs earlier than in the area of the reservoir . Therefore, at the initial stage of drying regime advisable to target based on the integrity of the wood in the area end. To determine the operating parameters of the initial stage of the drying process were conducted experimental research to identify patterns of end cracks in the planning were applied mathematical methods for planning experiments , Drying of samples was carried out in the experimental dryer.

As a result of the research was disclosed as the impact of each factor and their interaction on the value of face cracks.

Mathematical treatment of research results allowed to obtain the regression equation , reflecting the dependence of the depth of face cracks on the temperature difference between the drying psyhrometrychnoyi and thickness of lumber. Based on these equations dependences , reflecting the process parameters, which are obtained by the same crack length for a given thickness of the timber . These equations have the form:

For oak planks :

$$Z_{cr} = -45{,}53 + 11{,}42\Delta t + 0{,}102S + 0{,}258t_w + 0{,}082\Delta t \cdot S - 0{,}05\Delta t \cdot t_w - 0{,}012S \cdot t_w - 0.003S \cdot t \cdot t_w$$

For beech blanks:

$$Z_{cr} = -64{,}83 + 15{,}13\Delta t + 0{,}83S + 0{,}73t_w + 0{,}078\Delta t \cdot S - 0{,}16\Delta t \cdot t_w - 0{,}0053S \cdot t_w - 0.00106S \cdot t \cdot t_w$$

The dynamics of cracks depending on the moisture content shows that the size of the stabilization of fractures occur at an average moisture content equal to 35-45 %. Thus , taking as a basis the acting company profiles drying and given the nature of stresses in the timber, which is dried , the recommended mode has an additional degree that is built taking into account the stresses in the face area of timber and regulating of the process to the average moisture content of 40%.

Designed modes efficiently used for mass drying of lumber Solid hardwood when the extension process and the associated increasing cost less than the cost of drying wood loss due to mechanical cracking. Calculations show that the use of the recommended drying mode is appropriate if the size of a lack of drying more than 1 %. For lumber thickness over 40 mm it is advisable to use protective moisture zamazok , as the process of extending the term , subject to the application of these modes of drying, resulting in a significant increase in its cost.

Conclusions

1. Timber of face zone is characterized by the movement of water in two directions - along and across the grain , leading to the formation of an uneven field of humidity in the longitudinal and transverse directions assortment . The uneven field of humidity in the transverse direction decreases when close to the end. and increases in the longitudinal direction along the axis of the assortment .

2. The possibility of applying the method of calculation of moisture fields in end zone for their lumber moisture within the boundary of hygroscopicity of wood - based solutions of differential equations moisture conductivity.

3. The uneven field of humidity in the longitudinal direction results in a bending deformation of wood fibers , characteristic of end zone timber, which is the main cause for the formation and development of face cracks ..

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МОДЕЛЮВАННЯ ПРОЦЕСУ СУШІННЯ ТОРЦЕВОЇ ЗОНИ ПИЛОМАТЕРІАЛІВ

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Розроблена модель процесу сушіння торцевої частини пиломатеріалів. Показано, що нерівномірний розподіл поля вологості за довжиною матеріалу приводить до утворення згинаючих деформацій волокон деревини, характерних тільки для торцевої зони сортименту, що є основною причиною торцевого розтріскування пиломатеріалів. Проведені експериментальні дослідження розподілу усадки, деформацій пружності та залишкових деформацій в торцевій зоні пиломатеріалів. Досліджені режими сушіння пиломатеріалів твердих листяних порід, які запобігають торцевому розтріскуванню.

Деревина, механізм переносу вологи, вологопровідність, повздовжній рух вологи, деформації пружності, залишкові деформації, режими сушіння