1. Two samples (deviation from flatness of the furniture board in direction along the fibers S_l and deviation from flatness across the fibers S_b), the two placing schemes of the structural elements (parallel and perpendicular) does not belong to the same total population and the difference between two sample means and two selective variances of these variables cannot be explained by random errors.

2. Relative difference between the average values of the deviations from flatness in different directions (A and B) in the case of parallel placement makes up 160 %, while a similar difference for perpendicular arrangements of the structural elements makes up only 12%.

3. For the experimental samples of the furniture boards with perpendicular arrangement scheme of structural elements, with a significance level q = 0,01, it can accept the hypothesis that there is no statistical correlation between the two these values of the deviations from flatness in the direction A and direction B, that together with conclusion 2 may indicate a better shape stability of furniture boards with perpendicular placement of structural elements in comparison with similar furniture boards that are made by the parallel scheme.

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УДК 691.11:674.8:531.717.8 ***Аспір. І.О. Кійко – НЛТУ України***

Вплив розміщенняструктурних елементів клеєних щитів на їх формостійкість

Меблеві щити, виготовлені з кускових відходів деревини, мають ряд суттєвих економічних та екологічних переваг щодо використання їх у меблевому і деревооброблювальному виробництвах у порівнянні із класичним меблевими щитами, виготовлених з ламелей шляхом з'єднання у меблевий щит у розмір за довжиною за допомогою зубчастих шипів і у розмір за шириною – за допомогою склеювання на гладку фугу. Одним із імовірних недоліків меблевих щитів, виготовлених із структурних елементів невеликих розмірів є відхилення від площинності, що інколи може перевищувати допустимі значення. дійснено порівняння величини відхилення меблевих щитів від площинності у напрямках вздовж і поперек волокон для двох різних схем розміщення структурних елементів – паралельної і перпендикулярної. Здійснено висновок про кращу формостійкість меблевих щитів, у яких структурні елементи розміщені за перпендикулярною схемою.

Ключові слова: клеєний щит із кускових відходів, відхилення від площинності, паралельна і перпендикулярна схеми розміщення структурних елементів.

UDC 674:630 ***Senior teacher I.Z. Pylypiv; assoc. prof. O.I. Dumanskyy – UNFU***

BUILDING MATHEMATICAL MODELS DEPENDING ON BEND RADIUS FIBER BOARDS CONCERNING ITS THICKNESS AND HYDRATION TIME

Submitted by processing experimental studies necessary for the production of curved pieces of furniture with fiberboard. Found a mathematical dependence studied processes using methods of interpolation and approximation. Presented minimum radius curved pieces of furniture in the thickness of plates and different moisture conditions adhesive.

Keywords: curved furniture element, fiberboard, minimum radius, interpolation, approximation.

Recently, the development of design and construction in order to improve consumer properties of furniture products significantly changed the approach to the formation processes of production and management domain-spatial environment of human life. The design of contemporary furniture unacceptable standard solutions. The important here, individual and small batch projects, the implementation of which must be based on new technologies. Essential in the production of modern furniture elements becomes artistic design, one of the areas in the production of curved furniture items.

To solve the problem of forming the set of bends in furniture elements, currently, we have a very limited number of theoretical - experimental studies. This is due to the fact that the phenomenon that leads to reshape the curved block, you cannot clearly describe the mathematical model, and they are determined to unmanageable, often forcing manufacturers forced condone the advent of low-quality product even in strict compliance with a given technology and accordingly plan the cost of production. In the present work the treatment of experimental studies conducted to construct curved furniture items from fiberboard panels, according to which the mathematical model in the form of empirical formulas for setting minimum permissible bending radii of the furniture elements with different thickness plates [1-16].

For the treatment of experimental studies and construction mathematical dependences, studied processes used methods of interpolation and approximation. In particular, interpolation method is that in most cases to show the functional dependence of the investigated process using polynomials of Lagrange and Newton. However, these formulas have certain disadvantages. In particular, Lagrange's formula is rather cumbersome and not so common, because if there is a need for improved precision interpolation, then the increased experimental values, you must re-perform all calculations, because one of the variables Lagrange's formula does not apply. With respect to Newton formula - there no such problems, it is quite comfortable. However, if the value of the experimental data, which are variables formula arguments, form an arithmetic progression is not always able to get them. We believe that in some cases, do not require high precision convergence of functional dependencies built with experimental, we can interpolate these dependences as a simple polynomial of a certain order, but no higher than fifth, because of the increasing number of nodes is growing and the degree of interpolation polynomial. However, this interpolation polynomial becomes more accurate approximation table function. Moreover, such a polynomial harder to work through his awkwardness. It is important to use the Taylor polynomial interpolation to build dependencies, which can more precisely express a mathematical model of the process. Experimentally investigated fiberboard bending it with the following geometrical characteristics: l-length, h-width, d-thickness of the plate. In addition, l >> h and l >> d, that is a plate form the core of certain geometrical dimensions (Fig. 1).

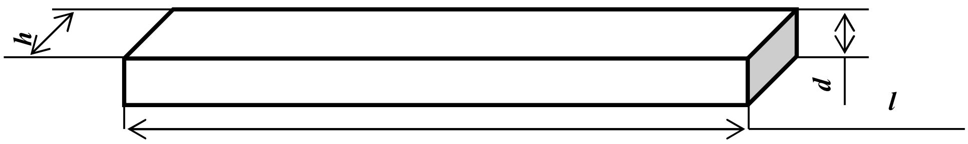

Fig. 1. Experimentally investigated fiberboard

Plate is hinge-reliance and under the influence of the horizontal point load force (Fig. 2).

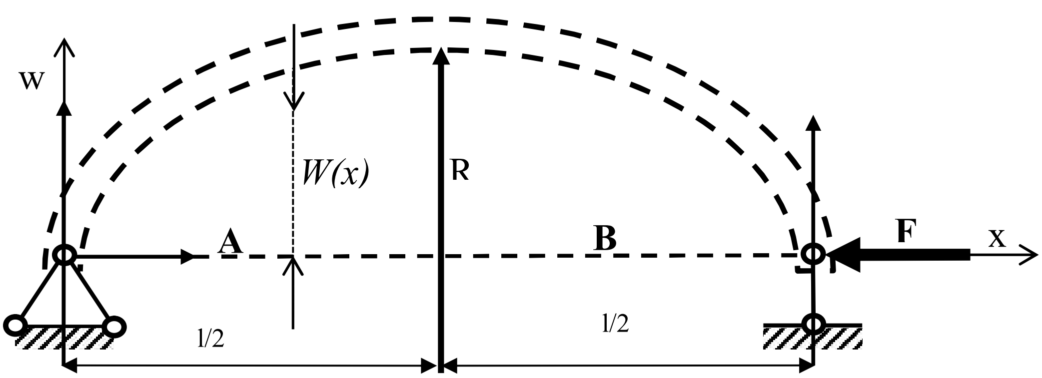

Fig. 2. Plate is hinge-reliance

Are the two processes of wetting adhesive layer plates: a) on the one hand, and b) on both sides. According to experimental studies set the radius R of bending plate depending on the thickness d and time t wetting glue plates, which presented graphically in Fig. 3.

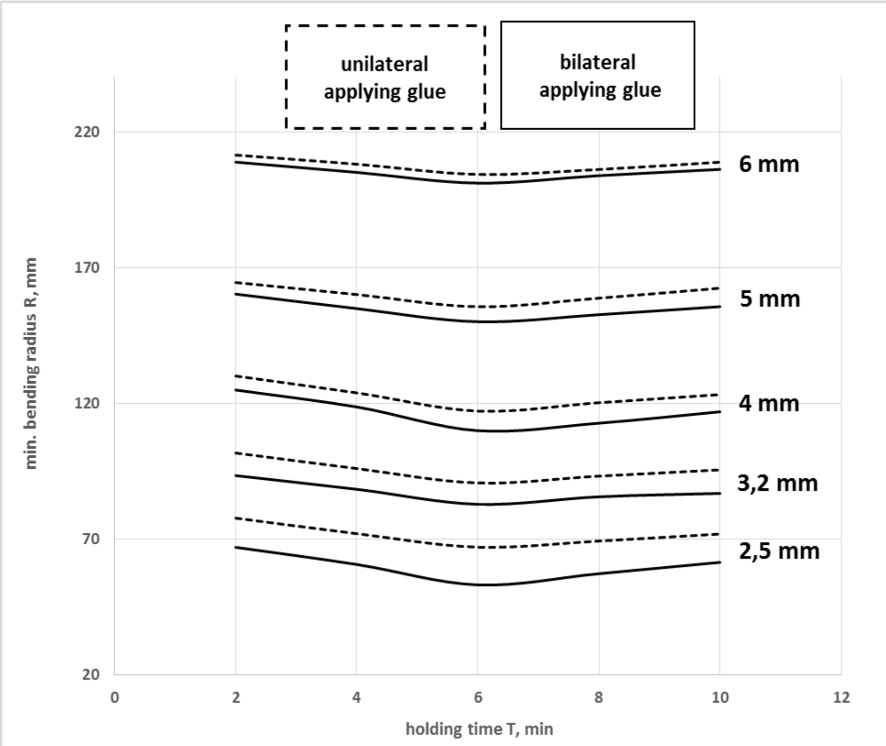

Fig. 3. Minimum bending radius fiberboard panels of different thicknesses

To construct the empirical formula dependencies plate-bending radius R of time t changes wetting glued at the appropriate thickness d of used methods of interpolation and approximation. For polynomial interpolation, used Taylor 4-th order polynomial is the following form:

$$g[x] = a_0 + a_1\frac{x}{1!} + a_2\frac{x^2}{2!} + a_3\frac{x^3}{3!} + a_4\frac{x^4}{4!} \tag{1}$$

Or for our research in appropriate thickness plates

$$R(t) = a_0 + a_1\frac{t}{1!} + a_2\frac{t^2}{2!} + a_3\frac{t^3}{3!} + a_4\frac{t^4}{4!} \tag{2}$$

Coefficients a_i ($i=0-4$) approximating polynomial (2) placed under the following system of equations:

$$\begin{cases} a_0 + a_1\frac{t_1}{1!} + a_2\frac{t_1^2}{2!} + a_3\frac{t_1^3}{3!} + a_4\frac{t_1^4}{4!} = R_1, \\ a_0 + a_1\frac{t_2}{1!} + a_2\frac{t_2^2}{2!} + a_3\frac{t_2^3}{3!} + a_4\frac{t_2^4}{4!} = R_2, \\ a_0 + a_1\frac{t_3}{1!} + a_2\frac{t_3^2}{2!} + a_3\frac{t_3^3}{3!} + a_4\frac{t_3^4}{4!} = R_3 \\ a_0 + a_1\frac{t_4}{1!} + a_2\frac{t_4^2}{2!} + a_3\frac{t_4^3}{3!} + a_4\frac{t_{14}^4}{4!} = R_4. \end{cases} \tag{3}$$

Thus, the following empirical formula (mathematical models) changes the radius of bending plates with unilateral glue wetting:

- ✓ at $d=2{,}5mm$, $R = 59.470 + 16.333t - 12.707t^2 + 4.95t^3 - 0.829t^4$;
- ✓ at $d=3{,}2mm$, $R = 89.633 + 6.325t - 6.401t^2 + 2.638t^3 - 0.446t^4$;
- ✓ at $d=4mm$, $R = 115.3 + 35.749t - 25.019t^2 + 9.44t^3 - 1.569t^4$; (4)
- ✓ at $d=5mm$, $R = 154.733 + 20.042t - 14.462t^2 + 5.513t^3 - 0.913t^4$;

When two sided, adhesive application built following empirical formula:

- ✓ at $d=2{,}5mm$, $R = 34.733 + 35.155t - 24.647t^2 + 9.279t^3 - 1.533t^4$;
- ✓ at $d=3{,}2mm$, $R = 79.6 + 7.601t - 7.556t^2 + 3.123t^3 - 0.531t^4$;
- ✓ at $d=4mm$, $R = 96.667 + 37.242t - 26.039t^2 + 9.688t^3 - 1.583t^4$; (5)
- ✓ at $d=5mm$, $R = 145.3 + 17.897t - 13.55t^2 + 5.242t^3 - 0.875t^4$;
- ✓ at $d=6mm$, $R = 220.7 + 19.019t - 13.618t^2 + 5.208t^3 - 0.871t^4$.

According built empirical formulas of these relationships by the method of approximation. In this case, these dependences built into a Taylor polynomial, but the second order, as experimentally constructed curves correspond to the form of the quadratic function, according to what was selected approximant as follows:

$$R=c+bt+at^2/(2!) \tag{6}$$

The system of equations for the coefficients of the approximant based on the method of least squares, as a result, received the following system of equations for finding them:

$$\begin{cases} a\sum_{i=1}^{n} t_i^4 + b\sum_{i=1}^{n} t_i^3 + c\sum_{i=1}^{n} t_i^2 = \sum_{i=1}^{n} R_i t_i^2, \\ a\sum_{i=1}^{n} t_i^3 + b\sum_{i=1}^{n} t_i^2 + c\sum_{i=1}^{n} t_i = \sum_{i=1}^{n} R_i t_i, \\ a\sum_{i=1}^{n} t_i^2 + b\sum_{i=1}^{n} t_i + nc = \sum_{i=1}^{n} R_i. \end{cases} \tag{7}$$

Thus, the following empirical formula (mathematical models) changes the radius of bending plates with unilateral glue wetting:

- ✓ at $d=2{,}5mm$, $R = 82{,}787 - 5{,}779t + 0.422t^2$;
- ✓ at $d=3{,}2mm$, $R = 101.633 - 5.186t + 0.370t^2$;
- ✓ at $d=4mm$, $R = 161.087 - 7.258t + 0.533t^2$; (8)
- ✓ at $d=5mm$, $R = 181.853 - 5.316t + 0.42t^2$;
- ✓ at $d=6mm$, $R = 254.547 - 4.073t + 0.31t^2$.

When two sided, glue application built following empirical formula:

- ✓ at $d=2{,}5mm$, $R = 80{,}667 - 7{,}709t + 0.582t^2$;
- ✓ at $d=3{,}2mm$, $R = 93.453 - 5.802t + 0.417t^2$;
- ✓ at $d=4mm$, $R = 146.467 - 8.684t + 0.624t^2$; (9)
- ✓ at $d=5mm$, $R = 170.213 - 5.722t + 0.429t^2$;
- ✓ at $d=6mm$, $R = 245.407 - 4.355t + 0.336t^2$.

Deviation values empirical formula as the method of interpolation (formula 4, 5) and the method of approximation (formula 8, 9) is in the range of 3 to 5%.

By the method of approximation was constructed empirical formula depending on the radius R of bending plate, depending on the thickness of the plate d_i at a constant time of exposure coated with glue. In Fig. 4 The geometric interpretation of these relationships at time t = 6 and 10 min.

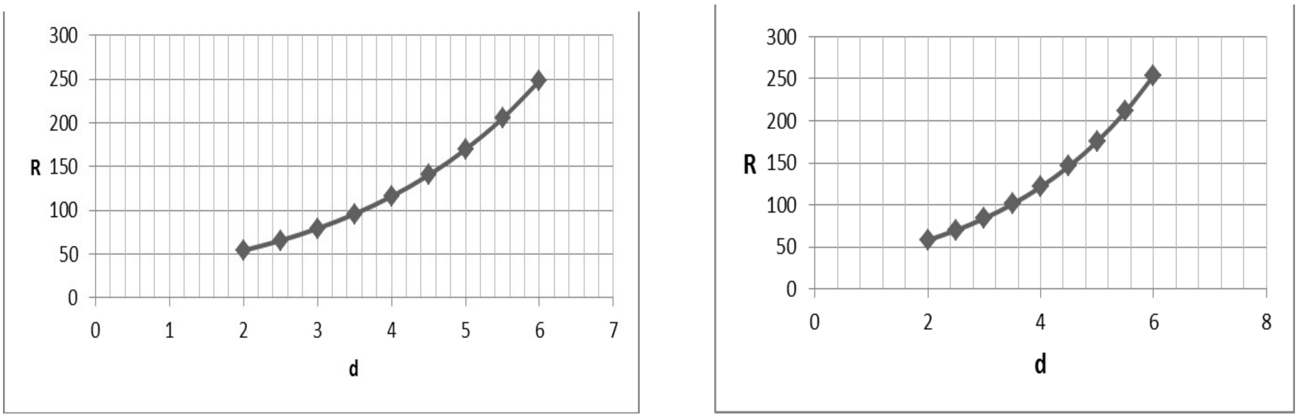

Fig. 4. Radius dependence on the thickness of plate at t = 6 min and t = 10 min

This dependence of the radius R of the bending plate of thickness d has exponential dependence: $R=be^{ad}$, (10)

Where the coefficients a and b were approximant according to the following system of equations:

$$\begin{cases} a\sum_{i=1}^{n} t_i^2 + B\sum_{i=1}^{n} t_i = \sum_{i=1}^{n} t_i \ln R_i, \\ a\sum_{i=1}^{n} t_i + nB = \sum_{i=1}^{n} \ln R_i. \end{cases} \quad B = \ln b \qquad (11)$$

Thus, the following empirical formula change the radius of bending plates of thickness at a constant exposure time of glue:

- ✓ at $t=6min$, $R = 25.309 \cdot e^{0.381d}$ (12)
- ✓ at $t=10min$, $R = 27.877 \cdot e^{0.368d}$

As we see both qualitative and quantitative changes in radius at various time of exposure of the coated glue did not significantly differ.

According to the methods of differential calculus were set value of time t soak glued with unilateral application (Formula 13), and two sided - (Formula 14), in which the obtained minimum value of bending radius R plates in their respective thickness d:

Sided glue application

- ✓ at $d=2,5mm$, $t=6,85min$, $R=63mm$,
- ✓ at $d=3,2mm$, $t=7min$, $R=76,95м$,
- ✓ at $d=4mm$, $t=6,81min$, $R=136,38mm$, (13)
- ✓ at $d=5mm$, $t=6,33min$, $R=165,03mm$,
- ✓ at $d=6mm$, $t=6,57min$, $R=241,17mm$.

\- double-sided glue application

- ✓ at $d=2,5mm$, $t=6,62min$, $R=55,14mm$,
- ✓ at $d=3,2mm$, $t=6,96min$, $R=73,27м$,
- ✓ at $d=4mm$, $t=6,96min$, $R=116,25mm$, (14)
- ✓ at $d=5mm$, $t=6,67min$, $R=151,13mm$,
- ✓ at $d=6mm$, $t=6,48min$, $R=231,30mm$.

Analyzing value, we can state that the length of time wetting as one-sided and double-sided and did not differ significantly on the average 7,14 min. With this timing will have the best minimum value of bending radius plates. It should be noted that these values are almost identical with those obtained experimentally; the deviation is about 1 - 2%. For bilateral applying glue on a plate thickness of 2.5 and 3.2 mm. there is a positive change in the minimum bending radius of 6 and 4 mm. respectively, compared with one-sided.

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Побудова математичних моделей залежності радіусу вигину ДВП стосовно її товщини та часу зволоження

Представлено обробке експериментальних досліджень, необхідних для виробництва вигнутих предметів меблів з ДВП. Знайдено математичну залежність, яка вивчає процеси, використовуючи методи інтерполяція і наближення. Представлено мінімальний радіус вигину предметів меблів залежно від товщині пластин при різних умовах вологості клею.

Ключові слова: різьблені елементи меблів, ДВП, мінімальний радіус, інтерполяція, апроксимація.

UDC 674.047

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ANALYSIS OF PHYSICAL FACTORS AFFECTING THE DRYING PROCESS OF LUMBER

An analysis of physical factors affecting the drying process of lumber has been done. Considered is their influence upon the drying rate and qualitative characteristics of the dried wood material. Also methods of moisture removal from wood have been examined. Described are equations for heat-