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METHOD structural optimization of case furniture

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On the basis of the existing criteria optimization of mechanical systems optimize the method of case furniture designs from lychkovanyh chipboard. An example of the way.

Lychkovani particle boards, forecasting, durability, strength kinetic theory of optimal design.

One way to optimize the furniture designs furniture is to achieve minimum weight design that can withstand the allowable load. Thus the goal of optimization is to find the minimum value of a function of several variables satisfying some additional requirements [1]. This is called the target, and additional requirements - design restrictions. The objective function Z and function limitations f1, f2, ... fn should be expressed in terms of structural variables X1, X2, ... Xn:

$$\begin{aligned} Z &= Z(x_1, x_2, \ldots x_n), \\ f_1 &= f_1(x_1, x_2, \ldots x_n), \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, \\ f_n &= f_n(x_1, x_2, \ldots x_n). \end{aligned} \tag{1}$$

In elastic systems that are in tension-compression, which include contract furniture structural variables - is usually cross-sectional area or size, and the objective function - mass system Z:

$$Z = \sum p_i \cdot L_i \cdot b_i \cdot h_i, \tag{2}$$

where ρi - the density, Li - length, bi - width, hi - thickness of detail.

Explanatory variables during optimization will take the dimensions of parts. As restrictions are most commonly used: allowable stress values; allowable movement in certain locations

design; effort or intensity loss of strength; size sections [1].

The disadvantage of this method is that it does not consider the impact in the design allowable loads on the durability of mechanical systems. Thus optimal in terms of the strength of the mechanical system during its existence behaves unpredictably. That may be destroyed in an unexpected time.

There is also a method of optimization is to ensure that all elements rivnomitsnosti mechanical system to achieve its minimum weight that can withstand the permissible load [2]. The method considers the parameters of different nature. For example, the geometry (length, height, width, thickness, area, location and so on.), Physico-mechanical (elastic modulus, Poisson's ratio, coefficient of linear thermal expansion, yield strength, hardness, the density, specific heat, etc.). The method is also considering parameters such as operating conditions (safety factor, rigidity, stability, etc.). Coefficient of safety design reflects many factors unaccounted for in the physical model, approximate duty operation tasks, proximity analysis methods of system status and others. Performance criterion or objective function can be expressed with a quantitative indicator. In particular, can be mass index construction, cost, reliability and so on. The objective function must satisfy certain constraints parameters. Workable (permissible) is with such a system, for which the conditions are not exceeded these limits. Restrictions accepted: restrictions on the stress state; restrictions on the strain state; restrictions on local conditions of stability; restrictions on the conditions of the general stability of the system; restrictions on the natural oscillation frequency; restrictions on the amplitude of mechanical vibrations; limitations on the speed of the system is deformed; restrictions on the parameters [2].

The method does not take into account the changing state of materials that make up the mechanical system (s) in time, and therefore can not predict how it will behave designed for optimal design in this way at the time.

The purpose of researchis improved method optimization furniture designs furniture in order to be able to stage their design, optimization know their potential. This technical result is also improving the accuracy and reliability of predicting longevity optimal mechanical system (furniture products).

Materials and methods research. Put technical problem is solved by the fact that, in a way optimization of mechanical systems is to achieve such minimum weight design that can withstand the permissible stress value as an additional restriction is used minimally acceptable durability of mechanical system (furniture product). Thus, the method of optimization designs of furniture is defined minimum weight design that can withstand the stress allowable values under allowable loads. In order to improve the accuracy and reliability of the results of optimization, set planned lifetime of case furniture designs from lychkovanyh chipboard, [τ]; thermoactivated define specifications of products such as: U0 - maximum activation energy of destruction kJ / mol; γ - structural - mehanichnyy option kJ / (molhMPa); T m - maximum temperature being solid state (temperature degradation), K; τ_m - Minimum durability (period fluctuations of kinetic units - atoms, atom groups and segments) s; perform calculations predicting the durability of cabinet furniture designs from lychkovanyh chipboard formula [3]:

$$\tau = \tau_m \exp\left[\frac{U_0 - \gamma\sigma}{R}\left(T^{-1} - T_m^{-1}\right)\right] \quad (1)$$

where τ - time to fracture (durability) s; τm, U0, γ and T m - thermoactivated material parameters; R - universal gas constant, kJ / (mol · K) - stress, MPa; T - temperature, K.

Thermoactivated parameters determined by the formula [4]:

$$\lg\tau_m = (\lg\tau_3(\lg\tau_2 - \lg\tau_4) - \lg\tau_4(\lg\tau_1 - \lg\tau_3))/(\lg\tau_2 - \lg\tau_4 - \lg\tau_1 + \lg\tau_3)\ ; \quad (2)$$

$$1000/T_м = x_2 + (x_1 - x_2)(\lg\tau_m - \lg\tau_3)/(\lg\tau_1 - \lg\tau_3\ );\quad (3)$$

where $x_1 = 1000/T_1, \quad x_2 = 1000/T_2;$

where τ1, τ2, τ3, τ4 - time to fracture each sample s;

$$\gamma = (U_1 - U_2)/(\sigma_1 - \sigma_2); \quad (4)$$

$$U_1 = 2{,}3R(\lg\tau_1 - \lg\tau_2)/(T_1^{-1} - T_2^{-1})\ ;$$

$$U_2 = 2{,}3R(\lg\tau_3 - \lg\tau_4)/(T_3^{-1} - T_4^{-1});$$

$$U_0 = \gamma\sigma_2 + U_2 . \quad (5)$$

Comparing calculated and planned service life and optimum choice of furniture design is carried out under the condition: τ ≤ [τ].

When solving the optimization problem by using the objective function was adopted minimum value of the product. This product performance throughout the planned service life shall be provided a minimum effective volume of material in its production.

$$V_{еф} \rightarrow \min \text{ At } \sigma_{\max} = k[\sigma]; \tau = [\tau] \quad (6)$$

where Vef - effective quantities lychkovanoyi chipboard, perceiving workload; σmax - tension in the effective volume; to - safety factor; [Σ] - allowable stress; τ - projected estimated longevity; [T] - planned service life of the product.

Research results. The problem of optimizing the design of case furniture designs from lychkovanyh particle board according to the order of LLC "Partner". Project modular system consists of five furniture items that can help you to design layouts to forty different design and functionality. The design project is shown in Fig. 1.

Fig. 1. Design Project modular furniture system of universal purpose.

Initial conditions: 1) geometric model of the product according to the design project (Fig. 1). Material for furniture, laminated strand board having thermoactivated parameters [5]: U0 = 260 kJ / mol, γ = 15,6 kJ / mol · MPa, τm = -0,72, Tm = 443 K; thickness of material $h \le [h] = 16$ mm; allowable stress [σ] = 14 MPa. 2) Operation of the product is planned in terms of: load onshelf q = | 1250 Pa; average operating temperature of 25 ° C; humidity 60%. The planned service life of the product [τ] = 30.

With the object of study adopted maximum section size. To calculate the stresses we apply finite element method (FEM). For the first version of the calculation, we assume that the thickness of laminated chipboard 16 mm, Dimensions 300h300h600 section (mm), the back wall is not shown. The calculation results are shown in the diagram by Mises equivalent stress (Fig. 2), the maximum stress | stress | up σ = 4,50 MPa.

To refine distributed load in dowels, hide the side wall and explore the region edges at the site dowels. Diagrams of load distribution in dowels shown in Fig. 3.

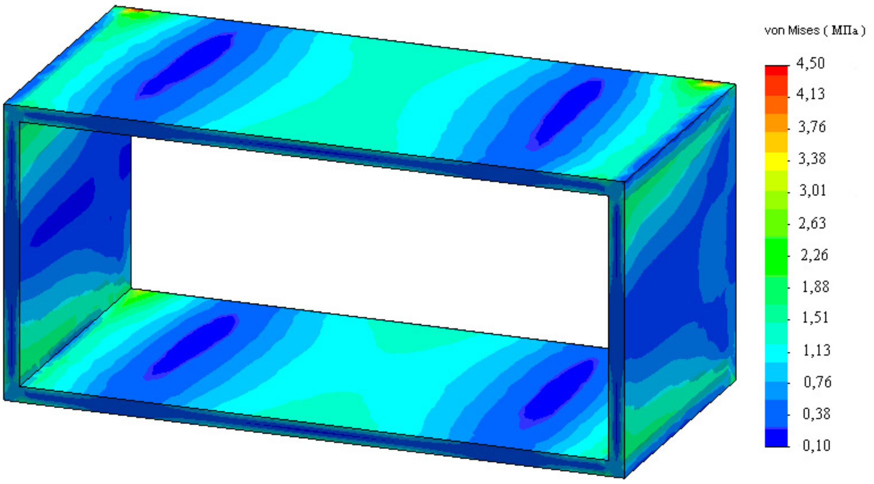

Fig. 2. Diagrams for Mises equivalent stress in the section of maximum size (thickness of laminated chipboard 16 mm).

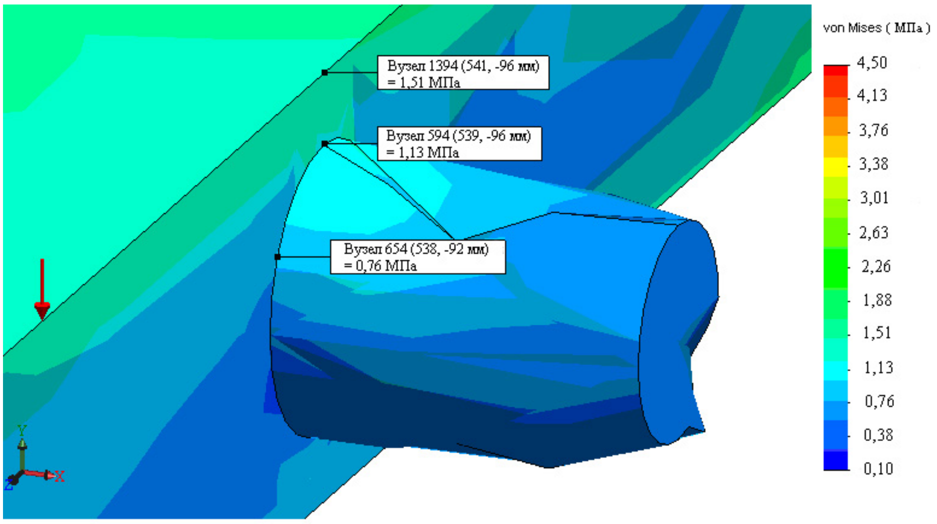

Fig. 3. Diagrams of load distribution in the dowels.

As shown in the diagram (Fig. 4), the tension in the region below the permissible dowels, so take into account the value of the maximum equivalent stress in the posterior wall mounting.

As can be seen from the diagram equivalent stress, | stress | σek maximum value = 4.50 MPa, which is less acceptable, $\sigma_{ek} < \sigma_{max} = 0{,}65 \cdot 14 = 9{,}7$ MPa. Theoretical durability sections, in this circuit the load is calculated by the formula (1) is about τr = 489 years.

Since furnished operated in non-stationary conditions, ie manufacturing operation occur during fluctuations in temperature, humidity and load, the amendments following [6]:

$\Delta_T = -0{,}0021T + 1{,}159 = 1{,}11$; $\Delta_W = -0{,}002W + 1{,}105 = 0{,}99$;

$\Delta\sigma = -0{,}0041\sigma + 1{,}0704 = 1{,}05$.

Durability incl conditions:

$\tau = \tau_p / \Delta_\Sigma = 489 / 1{,}02 = 479$ years

where $\Delta_\Sigma = \sqrt{\Delta_W \cdot \Delta_T \cdot \Delta_\sigma} = \sqrt{0{,}99 \cdot 1{,}11 \cdot 1{,}05} = 1{,}02$.

Because $\tau = 479 > [\tau] = 30$ and $\sigma_{eк} = 4{,}50 < \sigma_{\max} = 11{,}7$ As is the ability to change the effective volume of the material by changing the thickness of laminated chipboard 16 mm to 12 mm and make a new calculation of durability and strength.

The calculation results are shown in the diagram by Mises equivalent stress (Fig. 4).

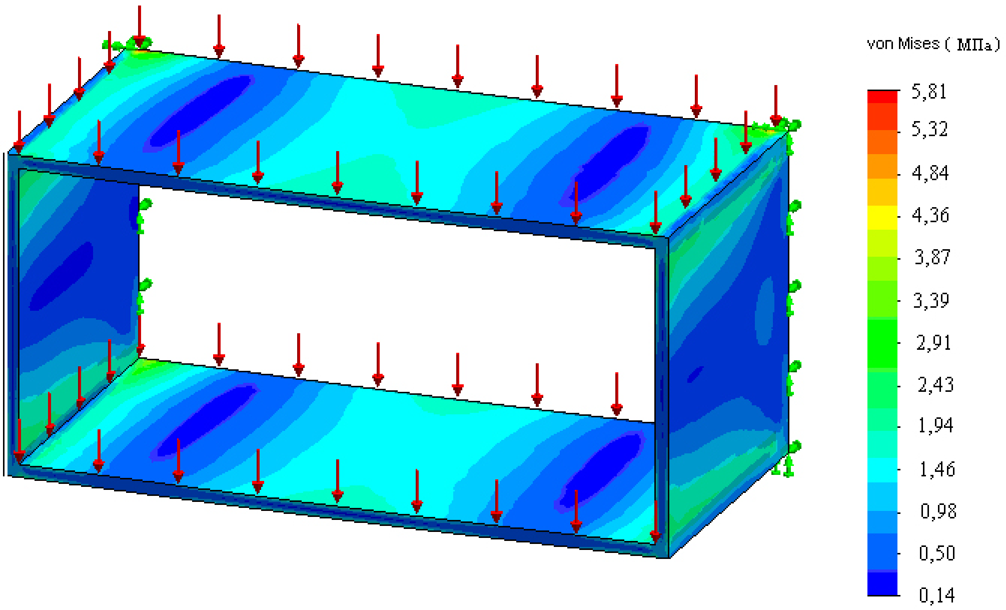

Fig. 4. Diagrams for Mises equivalent stress in the section of maximum size (thickness of laminated chipboard 12 mm)

As shown in Fig. 4, the maximum equivalent stress is 5.81 MPa = σek that is less than acceptable, $\sigma_{eк} < \sigma_{\max} = 0{,}65 \cdot 18 = 11{,}7$ MPa. Theoretical durability used in this circuit load is calculated by the formula (1) is about τr = 33 years.

Durability incl conditions:

$\tau = \tau_p / \Delta_\Sigma = 33 / 1{,}02 = 32$ years

As one of the criteria for optimal decision is made, namely $\tau = 32 \approx [\tau] = 30$ Because the optimal solution is found. At the same time, the second criterion, namely strength is far from acceptable value $\sigma_{eк} = 5{,}81 < \sigma_{\max} = 11{,}7$. This suggests that the use in finding the optimal solution is only one criterion is not enough, so we propose a new ways to optimize designs furniture

Conclusions

Experimental verification method optimization furniture designs furniture for Ltd. "Partner" has shown satisfactory results, indicating the possibility of its use in the design and certification of furniture products to select materialozberihayuchyh designs while achieving a given level of reliability regulated service life and quality. The method of finding the optimal design of furniture products lychkovanoyi joint venture based on the criteria of acceptable strength and durability. Using the criterion of durability can recommend limiting conditions of operation of furniture products to achieve a guaranteed period of operation. Implementation of the proposed method of evaluation of durability lychkovanyh JV furniture designs for medium output (about 400 thousand. UAH. Per year) will save per year over 32 thousand. UAH.

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Based on analysis suschestvuyuschyh kryteryev optimization of mechanical method of optimization proposals korpusnыh mebelnыh structures IZ oblytsovannыh drevesnostruzhechnye plates. Pryvedenы Implementation Examples ways.

Oblytsovannыe drevesnostruzhechnye stoves, prediction, Durability, kynetycheskaya Theory prochnosty, optymalnыe constructions.

Based on the analysis of existing criteria optimization of mechanical systems, the proposed method for optimization cabinet furniture constructions of the laminated particle board. There is the example of method realization.

Laminated board, forecasting, durability, kinetic theory of strength and optimal design.