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SECTION 7. Mechanics and machine construction.

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ESTIMATING METHOD OF CALCULATIONS ACCURACY FOR DEFORMATION CLADDING BY CAE ANALYSIS

***Abstract**: This report describes the mathematical model describing the process of deformation cladding by flexible tool for flat surfaces. The proposed method of evaluating mathematical model can significantly save time and money spent on development process, because it identifying errors in calculations by the fast and cheap CAE analysis. We did assessment of this mathematical model of the proposed method, which showed a high degree of conformity between the calculated and experimental data.*

***Key words**: flexible tool; wire tool; cladding; strength; deflection.*

***Language**: English*

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The performance of surface layer of friction pairs is one of the most important factors of reliable work of equipment, which determined by the process of their manufacture. Finishing operations, such as cladding by flexible tool, make great contribution to surface layer creation. Deformation cladding by flexible tool apply for transfer the alloy material from donor surface to detail surface layer by the thermomechanically with help a rotating wire brush [1-4].

We need a mathematical model describing the cladding process and having highly accurate calculations for enhance the technological capabilities and successful resolution of questions about increase tool life. The mathematical model has been created [5] with help the theory by flexible elastic rods [6]. This model connects the main parameters of the contact zone. According the model the algorithm has been created for calculating geometrical and force parameters of the contact zone [7]. It is consist of cycles with consistent increase accuracy of calculations. The output data of the algorithm are the main parameters of cladding process, such as:

The strength in the contact zone compressed-bent wire with surface of detail, P_i:

$$P_{Li} = \beta_i^2 \frac{EJ}{l_H^2} g^4, \qquad (1)$$

where β_i - the power factor of similarity; E - elastic modulus, Pa; J - axial moment of inertia, mm^4; l_H - curving length of wire, mm; g - coefficient of wire tool dynamics [3].

The deflection by flexible tools wire:

$$y_{Li} = \left[\frac{2}{\beta} k_i \cos(\psi_{0i})\cos(\zeta_{0i}) - \left(\frac{2}{\beta}(E(\psi_{Li}) - E(\psi_{0i})) - 1\right)\sin(\zeta_{0i})\right] \cdot l_H, \qquad (2)$$

where k - modulus of elliptic integral; $E(\psi_o)$ – Legendre's elliptic integral of second kind; $E(\psi_L)$ - Legendre's complete elliptic integral of second kind.

Each new mathematical model is required to undergo an experimental test. Different kinds of programs that implement calculations by the finite element method is used to detect errors and assess the adequacy of new models. These programs have highly accurate calculations.

We made CAE-analysis of stress-strain state of mechanical brush wire in the program NX Advanced Simulation to verify the adequacy of the developed model [8-10]. Schematic diagram of the study is shown in Fig. 1.

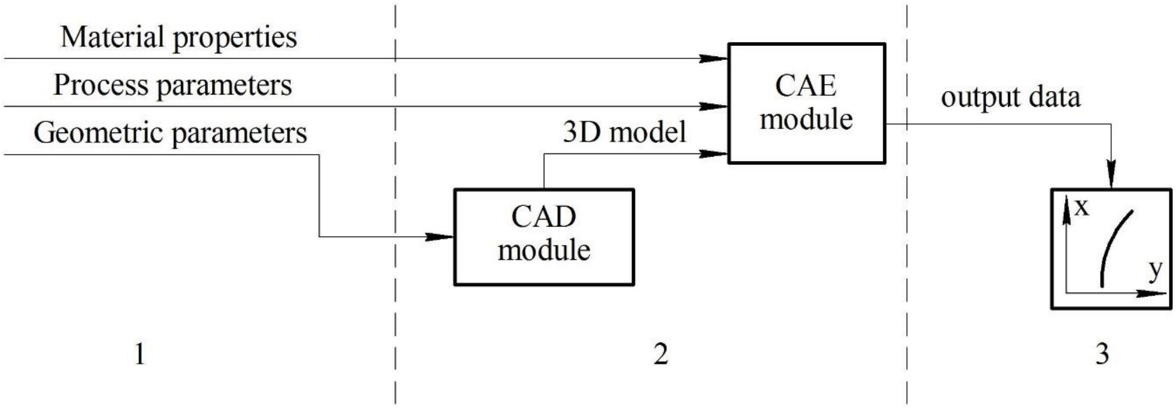

Figure 1 – Schematic diagram of the study:
1 – Pre-process (input data); 2 – process; 3 – Post-process (output data).

Pre-process is input data of cladding process, the geometric parameters of tool and material properties.

The modeling process in the program has two stages. The first stage is creation of 3D model of the tool based on set parameters in the CAD module. The second stage is stress-strain state calculation of created 3D model in the CAE module.

Post-process is a function of the output data of the simulation object, for subsequent analysis. According to this scheme (Fig. 1) we analyzed the data, calculated by the developed model. Input data: the detail surface is flat & process parameters: d=0,2 mm; l=60 mm; R=100 mm; N=1,5 mm. In the simulation, we used the contact force was calculated by the formula (1) and the deflection of the wire by flexible tool was calculated by the formula (2). The results of calculation and simulation are shown in Fig. 2.

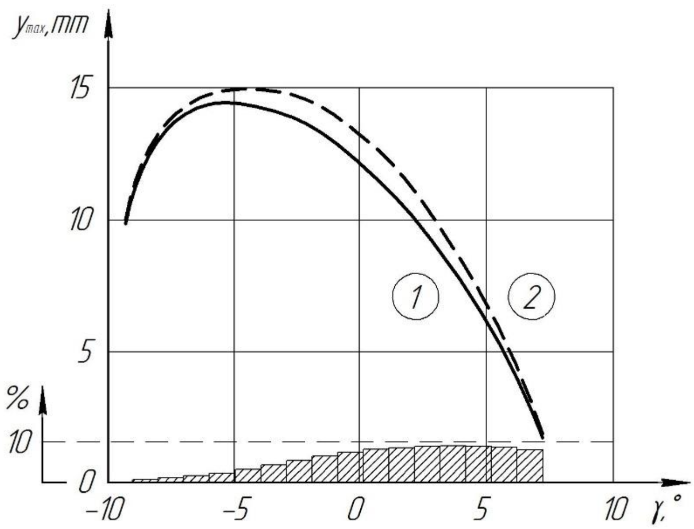

Figure 2 – Changing the wire deflection on the contact zone:
1 – the calculated values; 2 – the modeled values; error value.

Error in the calculations on the contact zone was 1...9%. That tells us about the high degree of correlation between the calculated and experimental data and the adequacy of the developed model.

After verification of the model in the CAE module, go to the more expensive step - experimental verification. Author [6] made a video shoot wire rotating brush in contact with the detail with help high-speed camera VS-FAST (5000 Hz). The discrepancy between the coordinate points of the elastic line calculation model and experimental results was 7...11%. We have this dispersion because flexible wires have a small change in the length.

The proposed method of evaluating mathematical model can significantly save time and money spent on development process, because it identifying errors in calculations by the fast and cheap CAE analysis. At the same time, we still need an experimental validation. The developed mathematical model showed a high adequacy at each stage of testing that does possible using of the model in further.

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