Impact of contact surface model in screw joints on the clamping force value

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The thesis presents the issue of mapping the shape of contact surfaces of screw joint elements and the impact of such mapping on the obtained stress distribution in the stereomechanical analysis using the finite element method. The analysed case presented the decrease in the clamping force in the screw fastening the aluminium wheel of the car wheel to the hub.

The model developed for the purposes of the analysis concerned only the rims. The impact of the screw in the mounting socket was modelled by applying to the nodes on the contact surface the screw head - the screw seat in the rim, the corresponding displacements in the material of the rim coming from the clamping force of the bolt.
Assuming the symmetry of the model (geometric, load), a half-model was used to carry out the numerical analysis of the connection. The model was discritized with CTETRA and CHEXA finite elements with a total number of 72361 (fig. 1.).

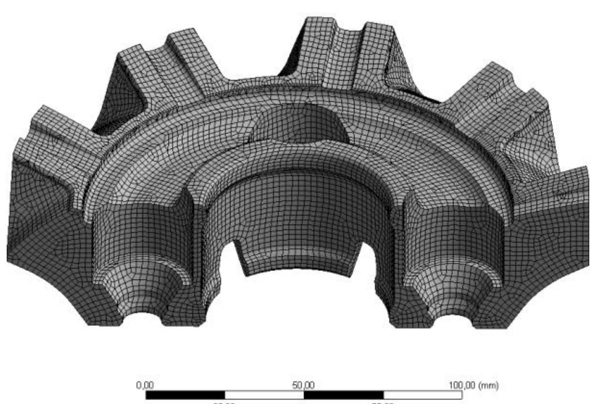
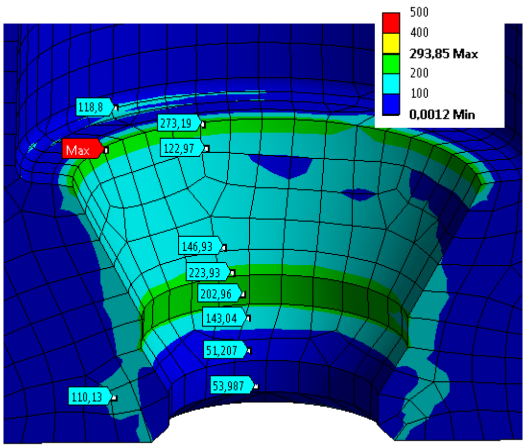
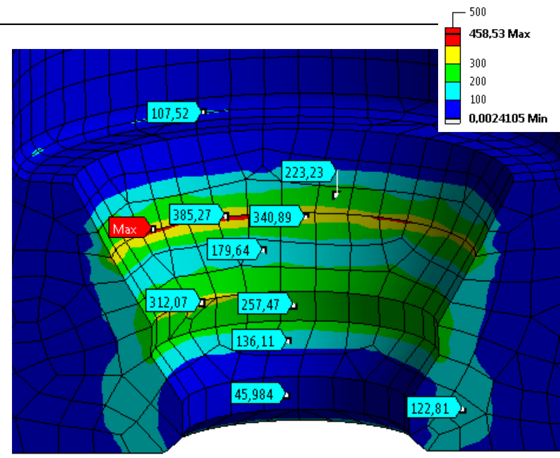


FIGURE 1. Model view with superimposed grid of finite elements

For the purposes of the task, it was decided to adopt a model that allows taking into account the phenomenon of stress relaxation in the material. The commonly adopted method of describing the phenomenon of stress relaxation occurring in a viscoelastic material is a generalized Maxwell model.

For the analysis, two load states were adopted, consisting in the task of displacing the bolt - rim contact surface so that the reaction force as a result of the assumed deformation after the time t = 1 [s] was 110 kN (force exerted by the bolt securing the rim to the hub). In the first variant (A), it was assumed that the surface of the screw head's socket is present on the entire cone forming part, while in the second variant (B) only on its half. Such acceptance of the boundary conditions of the model load resulted from the nature of the screw head impression in the socket observed during the experimental tests (not being the subject of this publication).

<table>
<tr><th>Time [s]</th><th>Variant A</th><th>Variant B</th></tr>
<tr><td>3000</td><td>
</td><td>
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As shown in the results stresses reduced in the contact zone of the cooperating elements (screw - socket), i.e. when only half the surface of the bolt adjoins the socket surface, amount up to 180 MPa. This is a value close to the yield strength (190 MPa). This indicates that in the case of a real condition of the socket, there may be local material plastication in the socket, and thus a decrease in the elastic force caused by the deformation of the socket while tightening the screw. In this situation, re-tightening the screw results in the head sticking on the larger surface, then the stresses are reduced at a level much lower than the yield strength, i.e. about 150 MPa (see column - variant A), and consequently the reaction force does not change, i.e. the screw in the socket does not become loose. The effect of the relaxation stress phenomenon in the analysed task was not significant and did not result in the loosening of the screws.

MES models built on the basis of solid CAD models usually have perfectly flat surfaces, without inequalities resulting from the production technology of a given element. While in the case of, for example, the construction of MES model rims for strength calculations, modelling the surface as perfectly flat will not have significant consequences, for example in the analysed example, the quality of the surface at the joint has a significant impact on the results.