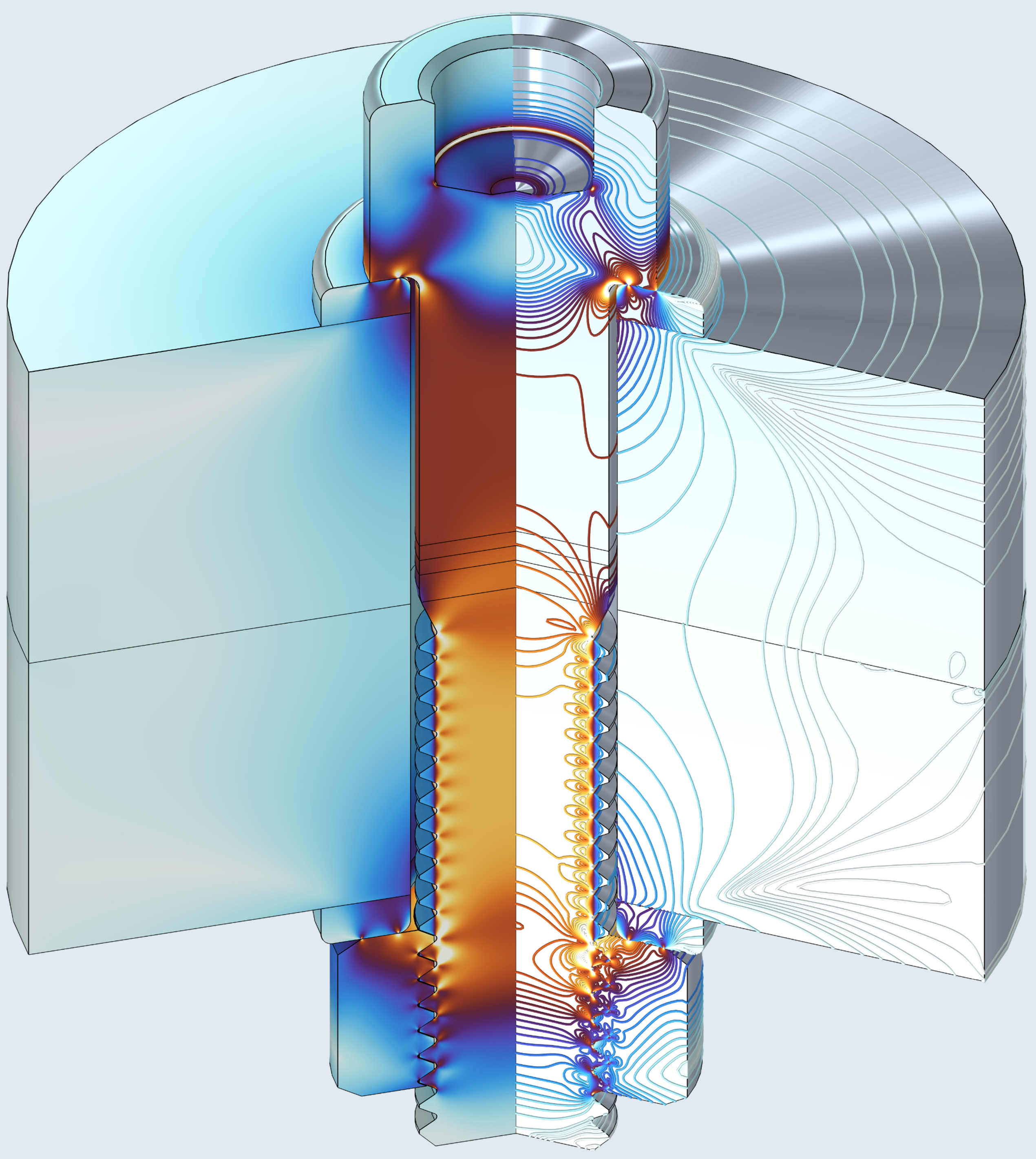

Analysis of the Stress and Load Distribution of an Assembled Screw Including Threaded Contact

In accordance with VDI Guideline 2230 Sheet 2, simulations are performed here applying model class IV as the most accurate and demanding model class. The thread contact pressure besides the stress distribution is simulated here with high accuracy.

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Introduction & Goals

The goal of this work is to determine reliable results of the stress and contact pressure distribution of a bolted joint using studies that are as accurate as possible in terms of material and geometry. For this purpose, a bolted joint including geometric details has been considered. A 2D-axisymmetric view of the bolt has opened up the possibility of very finely meshing the system and also simulating it in other respects with very high accuracy. Material nonlinearity was considered. Comparisons have been made with geometrically simplified threads to show the importance of geometrical details for the accuracy of the simulation results. This and linear elastic studies for comparison have shown even higher notch or stress concentration effects. The most probable locations of mechanical failure of a bolted joint, namely in the fillet of the first thread and at the transition to the bolt head, are shown. The load distribution on the threads simulated in this work is more uniform than others have determined. Additional studies have been conducted to identify ways to equalize the thread pressure distribution (to see in the corresponding scientific paper). Similar work with partly not so detailed displayed simulation results or without modeling the complete screw has already been done by other authors (Ref. 1 & Ref. 2).

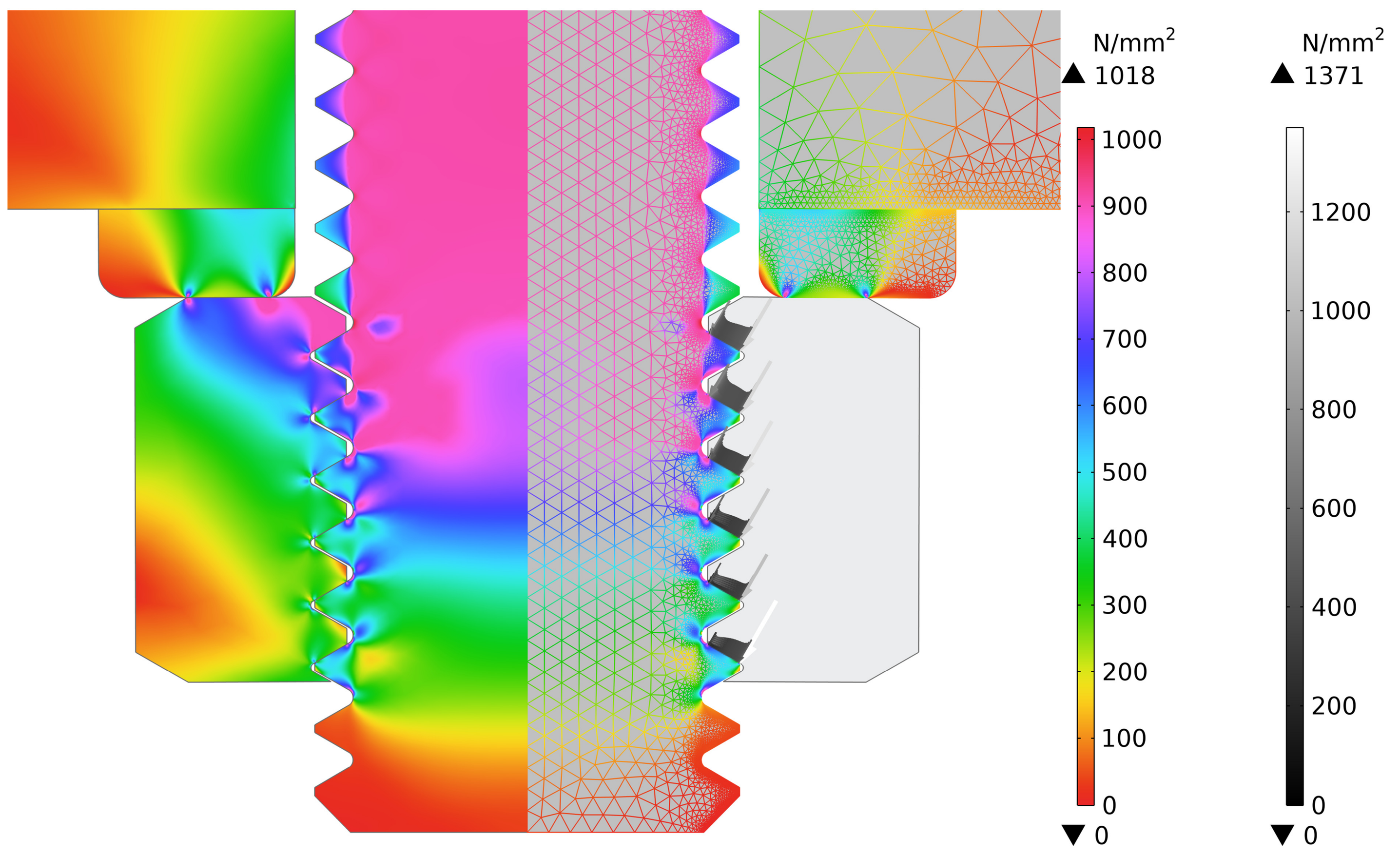

FIGURE 1. Nonlinear Simulation result for a high preload of $F_{preload}$ = 75 kN; display of the equivalent stress according to von Mises σ_v (left color scale) with wireframe rendering in the right half; contact pressure T_n representation at the threads (right color scale)

Methodology

In the modeled system, all mechanical contact pairs were considered. That are not only the six contact pairs at the threads, but e. g. the contact of the nut to the washer, too. Linear elastic simulations follow the equation $\sigma = \varepsilon \cdot E$ for a constant Young's modulus E. Here, a bilinear model including two different elastic moduli was applied and some studies are additionally compared to linear elastic calculations. A bolt with steel as material and a high strength class of 10.9 has been considered. All contact pairs were defined with the contact method "Augmented Lagrangian" in contrast to the less accurate "Penalty" method. A mesh with a side length of Δs = 30 µm of the tetrahedrals at the threads has been created (partially to see in Fig. 1). An even 3-times finer FE-mesh and a pure quadrilateral mesh was used for simulations for comparison. The discretization 'Lagrange 3rd order' has been chosen, which is higher compared to default to increase the accuracy.

Results

Some expected results have also emerged from these studies here. That is especially the fact, that the rounding at the first thread, the thread run-out and the transition of the bolt to the bolt head due to the notch effect resp. stress concentration are the most highly stressed areas (to see in the header picture at the top and partially to see in Fig. 1 & 2). Studies with linear elastic calculations and studies with neglecting the root radii resp. fillets at the threads show even much higher stress concentration. A rather uneven contact pressure distribution at the washer on the bolt head was found (see Fig. 2). The load distribution on the threads simulated in this work is more uniform than others have determined. In Fig. 1 there occurs a load share of the 1st thread of φ_1 = 19.4 %. The load distribution using aluminum as material of the nut is more uniform und it was found that the use of a so-called Solt-thread (Ref. 3) leads to an even more uniform load distribution. Results not displayed here are provided in the corresponding paper.

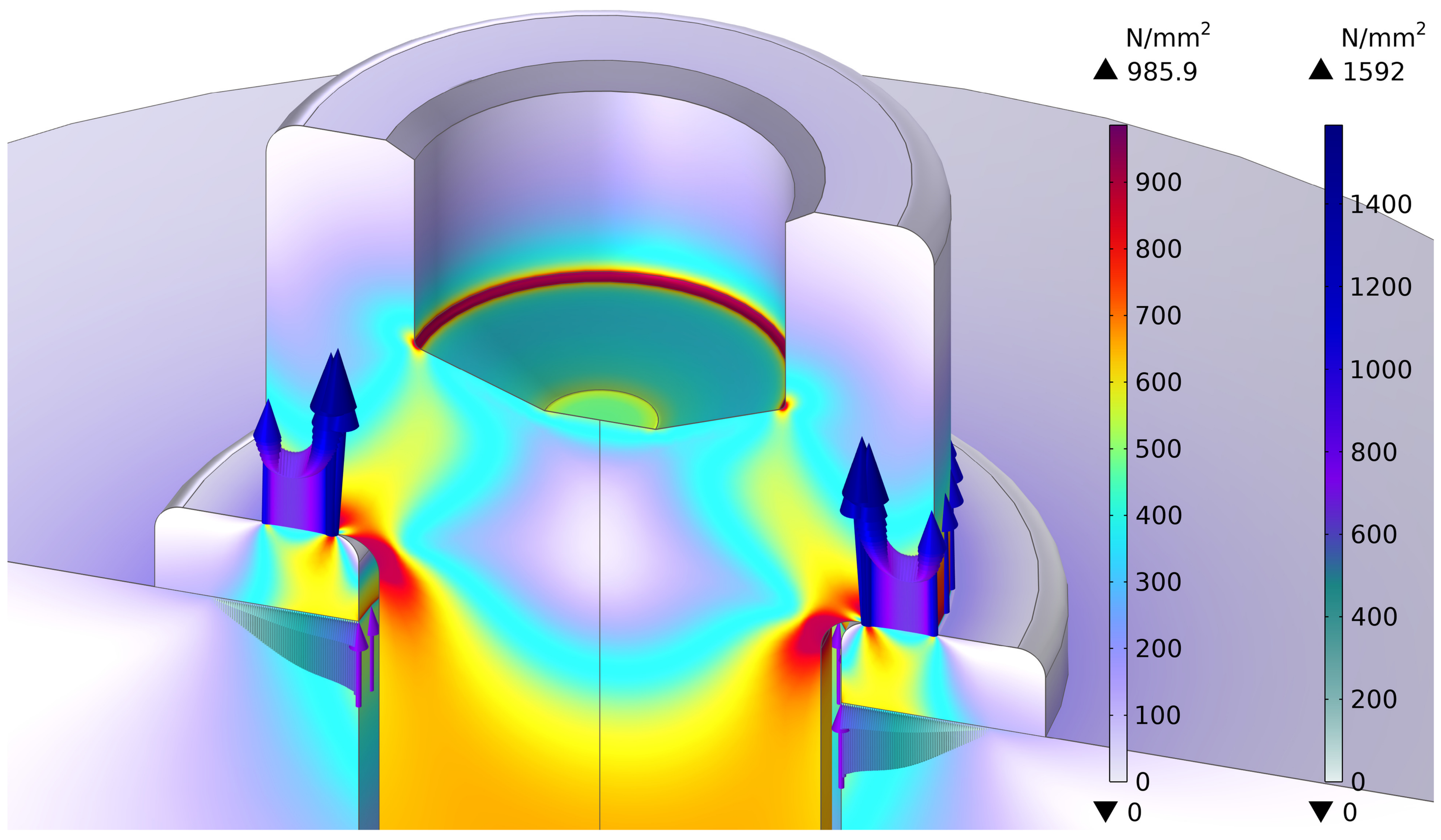

FIGURE 2. Nonlinear Simulation result for a high preload of $F_{preload}$ = 75 kN; display of the equivalent stress according to von Mises σ_v (left color scale); contact pressure T_n representation at two contact pairs (right color scale)

REFERENCES

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