Overall bolt stress optimization

The state of stress in bolts and nuts with International Organization for Standardization metric thread design is examined and optimized. The assumed failure mode is fatigue, so the applied preload and the load amplitude together with the stress concentrations define the connection strength. Maximum stress in the bolt is found at the fillet under the head, at the thread start, or at the thread root. To minimize the stress concentration, shape optimization is applied. Nut shape optimization also has a positive effect on the maximum stress. The optimization results show that designing a nut, which results in a more evenly distributed load along the engaged thread, has a limited influence on the maximum stress due to the stress concentration at the first thread root. To further reduce the maximum stress, the transition from bolt shank to the thread must be optimized. Stress reduction of up to 34% is found, still with the standard International Organization for Standardization thread. The design changes suggested in this article also have the positive advantage of reducing the joint stiffness factor. The reduction in the bolt shank directly reduces the bolt stiffness but the design change to the bolt head and the nut has the positive indirect effect of increasing the member stiffness, all leading to a smaller joint stiffness factor.