Aspects of stress in optimal shaft shoulder fillet

Shafts are among the most common machine elements. The typical shape used to reduce stress concentrations is circular arches due to the simplicity. A shaft is typically loaded by axial, bending, and torsional loads in different combinations. The stress concentration factors are found in tables and charts. The circular design is not optimal from a strength point of view, and the strength can be increased using shape optimization. It is in this article shown how the maximum stress from the combined loads can be minimized, when the shape is parameterized using the simple super ellipse. This makes the resulting optimized designs easily transferable to practical design. The stress evaluation is numerically performed using the finite element method using harmonic elements that facilitates an axisymmetric model although the loading is unsymmetric. The stresses are reduced by up to a factor of 15%.