

Stress Concentration and Stress Concentration factors

Grooves, fillets, holes, or other abrupt changes in cross section or any disruption of a smooth surface causes increased stresses around these areas. Notch is a general term meaning any or all of the above.

Imagine that the flow of force is like the flow of water. An obstruction in a flow field would cause the water's velocity to increase around the obstruction. The same is true for force except that the stress increases around the "obstruction". The stress is said to concentrate around these obstructions, or notches.

The amount of stress around a notch is:

$$\sigma_{\max} = K_t \sigma_{\text{nom}}$$

K_t is called the theoretical stress concentration factor and σ_{nom} is called the **nominal stress**.

In the case of shear stress:

$$\tau_{\max} = K_{ts} \tau_{\text{nom}}$$

The nominal stress, whether shear or axial, is calculated using the net cross section.

In the case of static ductile loading, it is not uncommon to ignore stress risers. Can you think of why this would be o.k. to do?

Stress risers in brittle materials are not ignored, whether loading is dynamic or static, nor are stress risers ignored in ductile materials under dynamic loading.

The theoretical stress concentration factors can be determined by using Table A-15 in your text book.

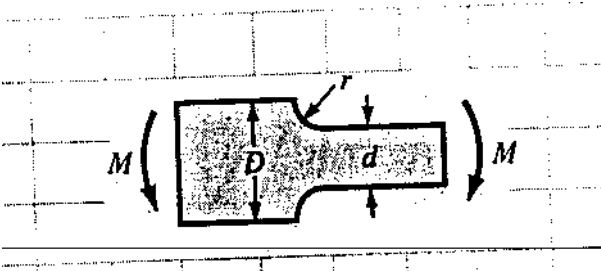
Once the theoretical stress concentration has been determined, we can account for a reduction in fatigue life due to a notch by introducing a Marin factor for notches.

$$k_{\text{miscellaneous}} = 1/K_f$$

In addition to surface treatments, loading type, temperature, reliability, size, environment, notches must be accounted for in determining the fatigue strength of a part.

$$S_f = k_{\text{size}} * k_{\text{load}} * k_{\text{temp}} * k_{\text{reliab}} * k_{\text{surf}} * k_{\text{misc}} * (.5 * S_{ut})$$

Example:



The bar shown above is loaded in bending. Calculate the nominal stress and the maximum stress. Maximum stress determination will require you to first calculate the stress concentration factor, K_t , that accounts for the reduction of cross-sectional area, and the notch sensitivity, q .

$D = 2$ inches

$d = 1.5$ inches

$r = 0.15$ inches

$t = 0.375$ inches

$M = 1000$ in-lb

$S_{ut} = 100$ ksi

See A-15-6 (page 747)

Notch sensitivity

$$q = (K_f - 1) / (K_t - 1).$$

Generally, q is between 0 and 1. If q is zero, then $K_f = 1$ and the material is not sensitive to notches at all. On the other hand if $q = 1$, then $K_f = K_t$ and the material has full notch sensitivity. K_t is determined from geometry. If there is any doubt about the value of q , use $q = 1$.

Ductile materials tend to be less sensitive to notches, where as brittle materials tend to be very notch sensitive. Geometry plays some role too. Large radii reduce notch sensitivity.

Notch sensitivities may be determined from charts given on page 218.

Example:

A rotating shaft is made of 42 x 4 mm AISI 1018 cold-drawn steel tubing and has a 6-mm hole drilled transversely through it. Estimate the factor of safety against fatigue and static failures using the following loading conditions:

a).

The shaft is subjected to completely reversed torque of 120 N-m in phase with a completely reversed bending moment of 150 N-m.

b).

The shaft is subjected to a pulsating torque fluctuating from 20 to 160 N-m and a steady bending moment of 150 N-m.

