Stress Concentration Effect

Fatigue Stress Concentration

The existence of irregularities or discontinuities, such as holes, grooves, or notches, in a part increase the magnitude of stresses significantly in the immediate vicinity of the discontinuity. Fatigue failure mostly originates from such places. Hence its effect must be accounted and normally a fatigue stress-concentration factor K_f is applied when designing against fatigue, even if the materials behavior is ductile.

Fatigue Stress Concentration Factor

Recall that a stress concentration factor need not be used with ductile materials when they are subjected to only static loads, because (local) yielding will relieve the stress concentration. However under fatigue loading, the response of material may not be adequate to nullify the effect and hence has to be accounted. The factor K_f commonly called a fatigue stress concentration factor is used for this. Normally, this factor is used to indicate the increase in the stress; hence this factor is defined in the following manner. Fatigue stress concentration factor can be defined as

$$k_f = \frac{\text{Fatigue strength (limit) of unnotched specimen}}{\text{Fatigue strength (limit) of notched free specimen}}$$

The other form of use, where necessary is the miscellaneous-effects factor k_e applied as a strength reduction factor on the fatigue limit value. With this approach we define

$$k_e = \frac{1}{K_f}$$

Geometric stress concentration factor K_t and Fatigue Stress Concentration factor K_f

This form of definition needs that the fatigue stress concentration factor or the endurance strength values for different notch geometries on each of the material to be used should be evaluated. However once sufficient data was available a simple approach, useful at preliminary design stages was evolved to determine the fatigue stress concentration factor value from the geometrical (theoretical) stress concentration values, data charts for which is readily available, using a notch sensitivity relation.

Notch Sensitivity

Notch sensitivity q is defined by the equation

$$q = \frac{K_f - 1}{K_t - 1}$$

$$\frac{\textbf{Actual intensification of stresses over nominal stress}}{\textbf{Theoretical intensifcation of stress over nominal stresses}}$$

The values of q are between zero and unity. It is evident that if q=0, then K_f =1, and the material has no sensitivity to notches at all. On the other hand if q=1, then $K_f = K_t$, and the material has full notch sensitivity. In analysis or design work, find K_t first, from geometry of the part. Then select or specify the material, find q, and solve for K_f from the equation

$$K_f = 1 + q(K_t - 1)$$

Notch sensitivity curves