ME102: Subunit 2.3.4: Stress Concentration

Stress concentration refers to the elevated stress that occurs near defects or manufacturing features such as holes, notches, grooves, corners, or even scratches. This local stress can be much larger than that in the majority or remote regions of the component or part. Hence, these regions near stress concentration are susceptible to failure. Stress concentration factors, $K = \sigma_{local}/\sigma_{remote}$, are tabulated from experiment and numerical predictions for many common manufacturing geometries. These values of K can then be used to estimate the maximum stress expected in a part or component during use, and thereby avoid premature component failure.

It is important to note that the effects of stress concentrators upon part failure depend strongly on the elasticity of the material of construction; plastic materials tend to be less sensitive to the effects of stress concentrators than brittle materials.

Methods for estimating stress concentrations for various materials and geometries include the following.

1. Numerical simulations, typically done with finite element analysis because of the complex geometries involved. You will learn more about finite element methods in ME205: Numerical Methods for Engineers.
2. Macroscopic strain measurements, in which a grid is printed on a part before the part is subject to large enough stress to deform the part significantly. Local strains are then estimated from the grid deformation and used to estimate local stresses.
3. Brittle coating fracture. As noted above, brittle materials are most sensitive to the effects of stress concentration. The method involves mapping regions of fracture of thin brittle coatings on parts undergoing stress tests.
4. Birefringence imaging or photoelasticity. Some materials exhibit stress-dependent birefringence (polarization-dependent refraction). In this method, the part must be made from an optically transparent material and is subject to stress in polariscope. Observations of local optical properties then permit deduction of stress contours in the part.