vapor as a single phase fluid solving equations (2), (3), and (4) along with a vapor equation of state which takes into consideration the presence of both the monomer and dimer constituents. A rough estimate of the maximum rate of heat transfer can be obtained from equation (14). This quantity appears to be relatively insensitive to the particular equation of state which is used.

Stress-Concentration Factors in Shouldered Shafts Subjects to Combinations of Flexure and Torsion[1]

N. L. SVENSSON[2]

This paper provides an interesting study of a problem having considerable significance in shaft design problems. The value of the contribution would, however, be greatly improved through some analysis which provides a more general determination.

Using the observation that the directions of principal stress are not changed by the presence of the discontinuity it may be shown that

$$(\sigma_{a\theta})_{\max} = K_T \cdot \frac{16M_T}{\pi d^3}$$

and

$$(\sigma_{a\alpha})_{\max} = K_b \cdot \frac{16M}{\pi d^3}$$

where K_T, K_b are stress-concentration factors in torsion and bending, respectively. M_T, M are torque and bending moment, a, θ, axial and circumferential coordinates.

The authors' work shows that the location of these maximum stresses is not identical. However, it is apparent that the stresses are not changing rapidly in the vicinity of the maximum stress point. It is expected that as r/d is decreased, this separation becomes smaller.

[1] By H. G. Rylander, et al., published in the May, 1968, issue of the Journal of Engineering for Industry, pp. 301–308.

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Therefore, assuming that peak stresses occur in the same location, the stresses are additive and we have

$$\tau_{\max} = \frac{16M_T}{\pi d^3} [K_T^2 + K_b^2 R^2]^{1/2}$$

where $R = \dfrac{M}{M_T}$.

The nominal maximum shear stress

$$\tau = \frac{16M_T}{\pi d^3} [1 + R^2]^{1/2}$$

Therefore the stress-concentration factor under combined load is

$$K_C = \left[\frac{K_T^2 + K_b^2 R^2}{1 + R^2}\right]^{1/2}$$

This expression takes values intermediate between K_T and K_b as R varies from 0 to ∞. The relationship then forms the basis for a theoretical appraisal of the authors' experimental results.

Authors' Closure

The discussion presented by Mr. N. L. Svensson does provide an interesting analytic method of data evaluation and extrapolation within the framework of the stated assumptions. Several methods of evaluation were studied by the authors but each was discarded, since the only accurate evaluation would be relative to a theoretical solution for the three dimensional stress distribution in the region of maximum stress.

Subsequent theoretical solutions show highly nonlinear stress variations with a radial position in the section. These radial stress variations couple with stress variations along the shaft to produce fluctuations of maximum stress at the surface. Therefore with only slight position changes in location, it is possible to change the maximum combined stress several percent. The rate of change of the stress concentration factor is quite rapid in some cases as typified by a 2.5 percent change in a z/d shaft length of only 0.023 for a d/D ratio of 0.84 and r/d of 0.40.

Until such time as a reliable and accurate theoretical solution for three dimensional stress distribution in the region of maximum stress becomes available, the authors must look upon Mr. Svensson's procedure as a very good approximation but not necessarily descriptive of actual quantitative stress conditions in real shaft prototypes.