A Behavioral Model for the Fracture of Surface Hardened Components

Dorle W. Dudley

Messrs. Ebert, Krotine, and Troiano have proposed a very interesting analytical model of the fracture behavior of a surface hardened component. The results of the tests reported indicate that this model has some real validity. The writer would like to make some comments relative to the behavior of case hardened gears. They are as follows:

1. A high core strength is needed for maximum load-carrying capacity. The optimum core hardness for many critical gear applications seems to be in the range of 38 to 42 Rockwell C hardness.

2. Under impact conditions, gears with a thin case depth will take more shock loading than those with a deep case.

3. The highest capacity gears used in aerospace work and certain other fields are relatively rich in alloy content with 3 percent or more of nickel.

The foregoing comments all seem to tie in with the paper. A strong core would tend to reduce the triaxial stresses as well as require a higher stress to cause fracture. Fig. 4 shows that the bar with the thinnest case had the best ductility. This would certainly predict the best impact capacity. Fig. 4 shows a considerable improvement in the ductility transition curves with the richer alloys. This trend would predict greater gear tooth strength since more ductility would reduce the stress riser effect of the gear tooth root fillet.

Authors' Closure

The authors are grateful to Dr. Dudley for his comments on the work presented in the paper. The interpretations of the authors' results by Dr. Dudley in light of his experience in the use of these metals, appears to collaborate the conclusions reached in the paper.

Externally Pressurized Foil Gas Bearings

W. E. Langlois

The author has made a significant inroad into the very difficult subject of foil bearing theory. Perhaps we can prevail upon him, further, to elucidate a potentially troublesome point relating to the asymptotics of the underlying elasticity theory.

Basically, I should like him to codify the terms "thin" and "very thin" as applied to the foil bearing problem. Although this is a pedestrian exercise in nonlinear plate theory, not every lubrication engineer shares the author's expertise in that subject.

By way of example, the author treats the foil as a cylindrical shell, rather than as a rectangular plate predeformed into a cylinder; this is correct "since the foil is thin," but many of us could profit from seeing the details.

In a similar vein, the relative size of \( w \) for further discussion, especially in the way it pertains to the "very thin foils." Passing from equations (9) to (17) involves a singular perturbation which manifests itself—I'll let the author tell you how—in Figs. 3, 4, and 5.

C. H. T. Pan

The author is to be congratulated for having made a worthwhile contribution to the subject of foil bearings. Limiting its attention to an axially symmetric problem, this paper provides examples that illustrate the essential behaviors of finite width foil bearings. A most important conclusion that has been reached is that the perfectly flexible solution does not represent an adequate approximation to the problem of a thin foil bearing. The significance is that the definition of thinness needs some scrutiny. The discusser wishes to make some remarks on this point.

The perfectly flexible solution, equation (23), is the asymptotic solution of the reduced equation, equation (17). The inadequacy of the perfectly flexible solution can be traced to the fact that the reduced equation is an algebraic equation containing one unspecified parameter, \( F \), whereas the original equation is a fourth order differential equation. Consequently, many boundary conditions are violated. To avoid confusion, the subscript "iv" will be used in terms related to the perfectly flexible solution, which are summarized in the following:

\[
W_{iv}(0 < X < b) = 0
\]

\[
\frac{X - b}{1 - b} = \frac{[1 - (1 - W_{iv})^4] \left[ 1 + \frac{\lambda_{iv}}{1 - \frac{4W_{iv} + 1}{5F_{iv}}} \right] + \frac{4W_{iv}}{5F_{iv}}}{[1 - (1 - F_{iv})^4] \left[ 1 + \frac{\lambda_{iv} \left( \frac{1}{5} - \frac{1}{5F_{iv}} \right)}{5F_{iv}} \right] - \frac{4}{5} \lambda_{iv}}
\]

for \( b_i < X < 1 \)

\[
F_{iv} = F_i
\]

\[
G_{iv} = \frac{1}{4(1 - b_i)} \left[ 1 - (1 - F_{iv})^4 \right] \times \left[ 1 + \frac{\lambda_{iv} \left( \frac{1}{5} - \frac{1}{5F_{iv}} \right)}{5F_{iv}} \right] + \frac{4}{5} \lambda_{iv}
\]

Further, to elucidate a potentially troublesome point relating to the asymptotics of the underlying elasticity theory.

\[ F_{iv} = F_i \]

\[ G_{iv} = \frac{1}{4(1 - b_i)} \left( 1 - (1 - F_{iv})^4 \right) \times \left( 1 + \frac{\lambda_{iv} \left( \frac{1}{5} - \frac{1}{5F_{iv}} \right)}{5F_{iv}} \right) + \frac{4}{5} \lambda_{iv} \]

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