October 1969 Brief 69-10471

NASA TECH BRIEF

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A Biaxial Weld Strength Prediction Method

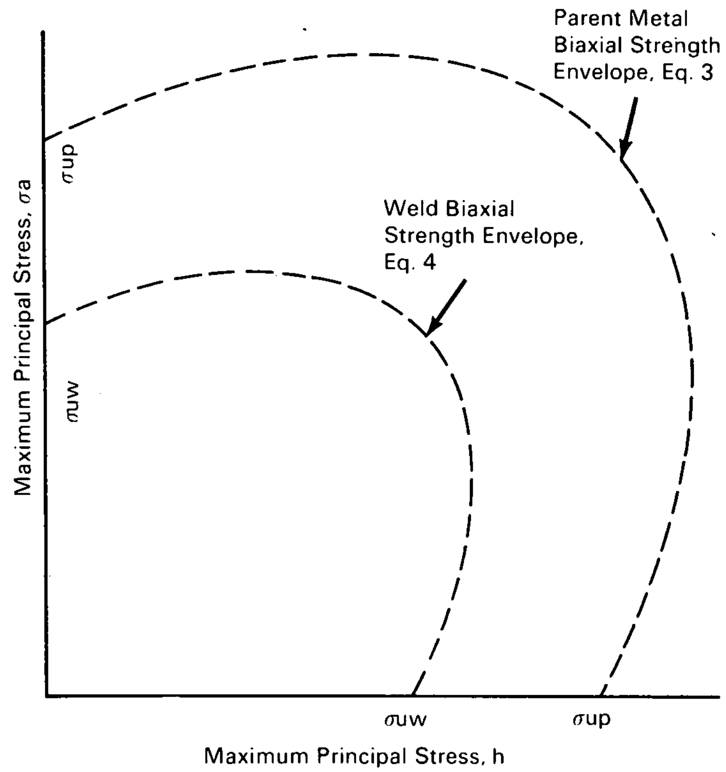

Figure 1. Plots of Eq. 3 and Eq. 4

This concept describes a method for design of structures which are subjected to multi-axial loading due to internal pressure. This application is especially relative to the design of liquid propellant tanks. The biaxial strength of a structure can be predicted by modifying the uniaxial formula (available in most handbooks) slightly. For welded structures in which the uniaxial and biaxial properties are essentially the same for the weld and parent metal, the biaxial strengths can be predicted by the following equation when the uniaxial strength is known:

$$\sigma_a^2 - \sigma_a \sigma_h + \sigma_h^2 = \sigma_u^2 \qquad (1)$$

where σ_a and σ_h = maximum principal stresses in pressurized structure at yield or at ultimate strengths (subscripts σ_a and σ_h pertain to axial and loop direction in a cylinder).

(continued overleaf)

σ_u = uniaxial yield or ultimate strength of material.

Because aluminum alloys usually have welds with different mechanical properties than those of the parent metal, a modification of formula 1 is necessary.

First the ultimate strengths of the parent metal σ_{up}, and the weld σ_{uw} must be determined. Secondly, the biaxial stress state (K) of the pressurized structure must be determined. K is the ratio of maximum principal stresses, as:

$$K = \frac{\sigma_a}{\sigma_h} \qquad (2)$$

The biaxial strength envelope for the parent metal in all tension stress states is plotted on a graph of σ_a versus σ_h by equation 1 using the value of parent metal uniaxial strength, σ_{up} for σ_u, as:

$$\sigma_a^2 - \sigma_a \sigma_h + \sigma_h^2 = \sigma_{up}^2 \qquad (3)$$

Next, the biaxial strength envelope for the weld in all tension stress states is plotted using the value of weld uniaxial strength σ_{uw} for σ_n in equation 1, as:

$$\sigma_a^2 - \sigma_a \sigma_h + \sigma_h^2 = \sigma_{uw}^2 \qquad (4)$$

These plots are shown in figure 1. A line (BC) joining the two plots is drawn parallel with the σ_a axis intersecting the parent metal biaxial strength envelope at point B and the weld envelope at C. Point B is determined by intersecting the parent metal biaxial with a slope K*, as:

$$K^{*2} - K^{*2} + 1 = \frac{\sigma_{up}}{\sigma_{uw}}^{2} \qquad (5)$$

The resulting line ABCD is the biaxial strength envelope for the structure. The biaxial ultimate strength for any value of K, such as 2, is determined from the plot by intersecting the plot with a straight line passing through the origin (Point 0 in figure 2) with the slope equal to the value of K. The coordinates of the point at which the intersection occurs are the predicted biaxial ultimate strengths in the two principal directions.

Note:

Requests for further information may be directed to:

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Reference: TSP69-10471

Patent status:

No patent action is contemplated by NASA.

Source: Richard A. Rawe of
Douglas Aircraft Company
under contract to
Marshall Space Flight Center
(MFS-20019)

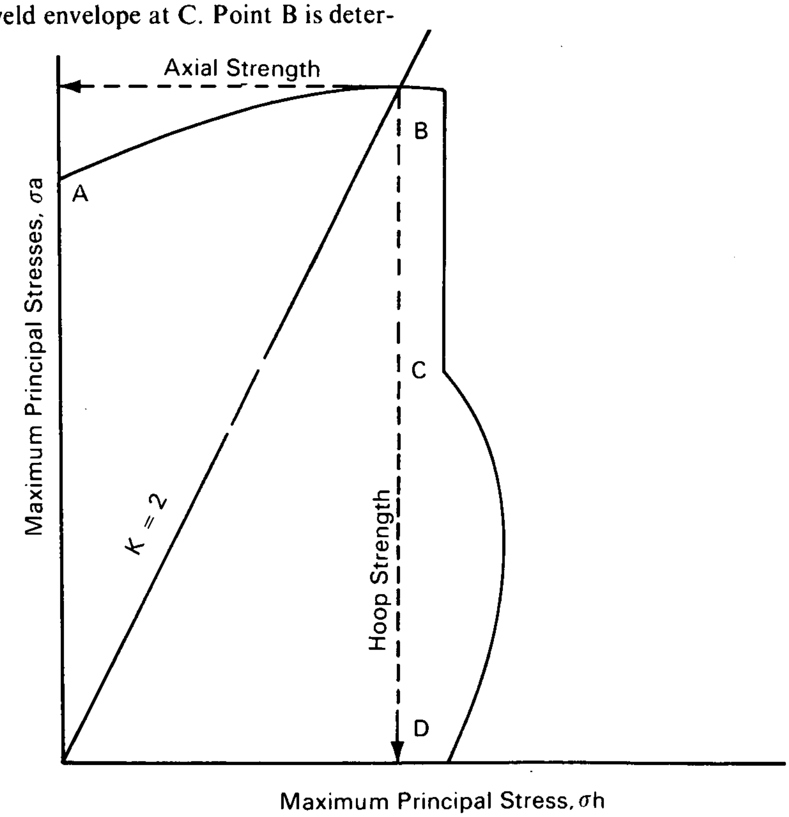

Figure 2. Demonstration of Method of Determining Biaxial (Axial and Hoop) Strengths for K = 2