CLADDING STRESS AT FAILURE

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D. L. Hagrman
EG&G Idaho, Inc.

Idaho National Engineering Laboratory
Idaho Falls, Idaho 83401

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EG&G Idaho, Inc.

One of the principal objectives of fuel behavior research is the prediction of the configuration of fuel after severe transients. A recent revision of the cladding failure criteria contained in the MATPRO materials properties package has clarified several aspects of the experiment data and promises to place analytical code predictions on a much sounder basis than has previously been possible.

The new cladding failure criterion is true tangential stress. Arguments are presented which demonstrate that cladding failure should be predicted by comparing the tangential component of true stress to the failure stress. Heating rate and strain rate do not affect this criterion but irradiation and cold work increase it somewhat. The failure stress as a function of temperature is given by the following expressions.

For temperatures less than or equal to 750 K,

$$\sigma_{\theta F} = 1.36\ K_A \qquad (1)$$

For temperatures between 750 and 1050 K,

$$\sigma_{\theta F} = 46.9\ K_A \exp\left(- \frac{2.0 * 10^6}{T^2} \right) \qquad (2)$$

For temperatures greater than or equal to 1050 K,

$$\sigma_{\theta F} = 7.7\ K_A \qquad (3)$$

where

$\sigma_{\theta F}$ = tangential component of true stress at burst (Pa)

K_A = strength coefficient for annealed cladding as determined with the MATPRO CKMN subcode (Pa)

T = temperature (K).

For cold-worked or irradiated cladding the failure stress is increased by four tenths of the increase of the strength coefficient due to irradiation and cold work.

The new failure criterion has been coupled to a modified version of the BALLOON code to show that cladding shape at burst is dependent on all the variables which affect the cladding deformation history. Burst temperatue, burst pressure, axial temperature gradients, and circumferential temperature gradients play a major role in determining the final cladding shape.