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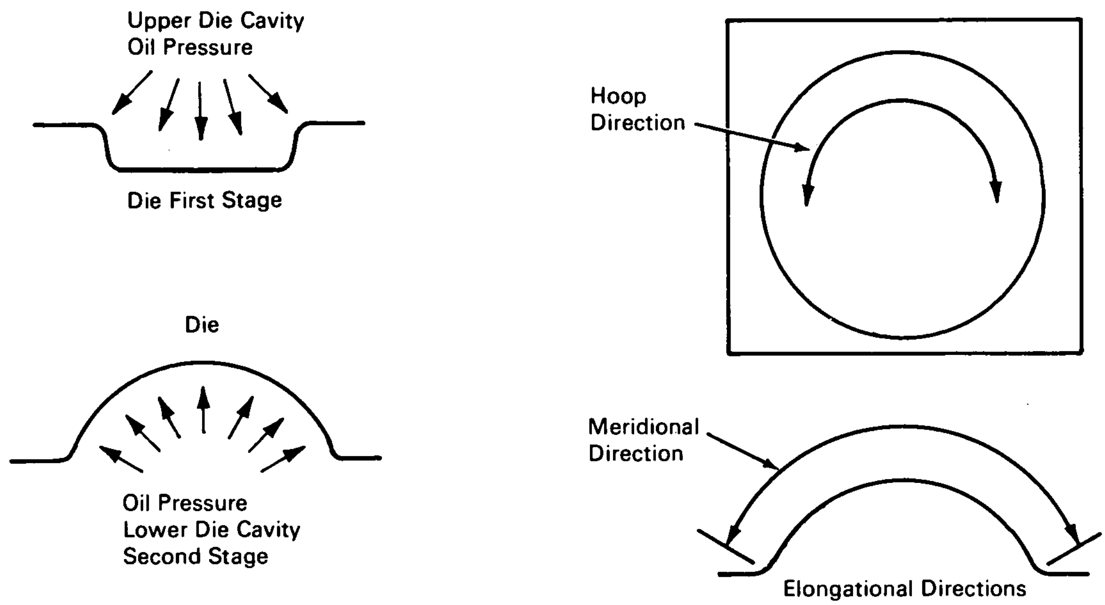
Analytical Prediction of Reverse Buckling Pressure for Thin Shells



An analytical technique has been developed for the prediction of reverse buckling in thin curved shells. Empirical equations were obtained from burst-disk testing. Major considerations were material, material thickness, dome diameter, dome height, forming pressure, and reverse buckling pressure. Test data indicated that this technique predicts the actual reverse buckling pressure within 10%, and should be of use for analytical prediction of reversed condition failure for problems such as explosive decomposition through vacuum failure.

This method is based on empirical information obtained from tests in forming hemispheres by extrapolation from test data on reverse snap buckling of the hemisphere. Initial data were obtained on elongation and yield strength of Inconel 600 foil along with the forming and reverse snap buckling pressures and the dome heights. The elongation in the shell takes place in the meridional and hoop directions (see fig.); meridional and hoop elongations were assumed to be equal, then combined and subtracted from the initial material elongation to provide a residual elongation. The residual elongation was used to determine the equivalent yield stress from data (a curve) established from other research (see Ref.). The forming pressure required could then be calculated from the equation for a hemispherical pressure vessel.

The reverse snap buckling pressure is a nonlinear function; an empirical curve was established, but was limited to a geometrical parameter λ equal to ten where λ is a nondimensional ratio of the chord, thickness, radius and Poissons ratio. For the tech-

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nique being described, λ varied from 30 to 44, but combined data indicated a good correlation.

Chord lengths were obtained by measuring the reflected image of the hemisphere on a comparator, and the material thickness was obtained by measuring with pin micrometers. The radius, half angle, and arc length were calculated from equations. The dome-wall (diaphragm) thickness from the chord to the crown varied from approximately 17% to 33% respectively. The mean thickness value was empirically determined to be at the centroid of the dome where one-half the included angle is equal to 38°. This averages out to 23.5% thinning of the initial material thickness. The variations in thinning from chord to crown indicate that the cold work varies directly as the thinning rate. For these reverse buckling calculations, the empirical thinning value of 23.5% indicated reverse buckling pressures within 10% of tested values.

Reference:

Kaplan, A.; and Fung, Y. C.: A Nonlinear Theory of Bending and Buckling of Thin Elastic Shallow Spherical Shells, NASA-TN-3212, 1954.

Notes:

1. Future mathematical solutions will be developed to predict the individual thinning value. Additional testing and refinement of the equations should enhance the accuracy in predicting the forming and reverse snap buckling pressures.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Kennedy Space Center
   Code AD-PAT
   Kennedy Space Center, Florida 32899
   Reference: B70-10582

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

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