AEC-NASA TECH BRIEF

Wall-Thickness Changes Predicted in Hollow-Drawn Tubing

A theoretical analysis for prediction of changes in wall thickness in hollow-drawn tubing is reported (1). Material composition, parameter influence, and die-angle are incorporated as determining factors in derivation of the theoretical model.

This theory for hollow-tube drawing or tube sinking is based on the concept of a continuous distribution of dislocations. More-important facets of this mode of tube-drawing are the dimensional changes, primarily in wall thickness, that occur during reduction, and the parametric effects on these changes. Classical interpretation has been only moderately successful in prediction of the hollow-drawing behavior of "thin-wall" tubes; even then, there are parametric discrepancies between theory and experiment.

Three earlier experimental studies provide the bulk of the information available on the dimensional behavior of hollow-drawn tubes. From these studies two theoretical analyses developed in endeavors to explain some of the experimental observations. Particular attention was given to the increase in wall thickness observed during the early stages of the reduction sequence, followed by thinning of the walls at the heavier reductions. The effect of γ_0 on wall-thickness behavior, where γ_0 is the ratio of the initial wall thickness to the initial outer radius, was included.

Regarding the influence of γ_0, two facets cannot be explained by the analyses. Firstly the analyses result in a differential-slope solution that predicts that the wall thickness must increase during the initial stages of deformation, or the reduction sequence. While the analyses were based primarily on "thin-wall" considerations, experimental evidence from "thick-wall" tubes of several materials has shown various degrees of thinning of the wall at all stages of reduction. A more general theory would have to predict both thickening and thinning behavior of the wall. Secondly the theory predicts for an infinitely thin-wall tube a thickening before thinning behavior over a reduction range of approximately 0.5. However, experimental observations of thin-wall tubes suggest that thickening should continue until reductions reach almost 100 percent.

Both theories consider the parametric influence of die-angle and work-hardening on the changes in wall thickness. Experimental evidence shows that an increase in the die-angle produces a greater wall-thinning tendency, but a greater wall-thickening tendency for a material having a greater work-hardening capacity.

The theoretical analysis presented (1) incorporates the parametric influences on the wall-thickness changes for the tube over the entire tubing range $0 \leq \gamma_0 \leq 1$. There are several aspects of the hollow-drawing process that make the application of continuum-dislocation theory seem very promising. One advantage is that the dislocation-density distribution is a state quantity; this property is independent of the path used for a final reduction.

Reference:

1. T. Mura and J. E. Flinn, "A continuum dislocation theory model for predicting the wall thickness changes of hollow-drawn tubing" (Argonne National Laboratory, August 1967).

Notes:

1. This information may interest metallurgical researchers or manufacturers of metal tubing.

2. Inquiries concerning this innovation may be directed to:

Office of Industrial Cooperation
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439
Reference: B69-10428

Source: T. Mura of
Northwestern University
under contract to
National Laboratory
(2) J. E. Flinn
Metallurgy Division
(ARG-10425)

Patent status:
Inquiries concerning rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439