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HYDRIDE ORIENTATIONS AND MECHANICAL PROPERTIES OF THIN-WALLED ZIRCALOY TUBING

USAEC-AECL COOPERATIVE PROGRAM

MONTHLY PROGRESS REPORT

SEPTEMBER 1963

by

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INTRODUCTION

Additional study of the orientation of zirconium hydride platelets in thin-walled Zircaloy tubing is being sponsored at the Savannah River Laboratory (SRL) by the Technical Advisory Committee of the USAEC-AECL Cooperative Program. The SRL study will first define the relationship of the fabrication techniques and associated Zircaloy structures to the susceptibility of the tubing to preferred hydride orientations. Second, the work will assess qualitatively the effects of oriented hydride platelets on the mechanical behavior of tubes under several stress conditions. The various types of tubing being used in this program are described in the table on page 3.

SUMMARY OF PREVIOUS WORK

Previous tests on circumferential specimens of the six types of tubing had indicated that the susceptibility to stress orientation of the hydride platelets varied widely between tubing from different fabrication processes and, in one case, between tubing made by different vendors using nominally the same process. The structural factor in the Zircaloy that controls the susceptibility has not been defined, but tubing with similar textures that were estimated mainly from the anisotropic strain behavior during tensile tests have shown different susceptibilities to stress orientation of the hydrides.

SUMMARY OF LATEST WORK

Results from stress orientation tests at 18,000 and 30,000 psi confirmed previously reported results at lower stress levels. These tests completed the stress orientation tests on circumferential specimens with 50 ppm hydrogen.

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*The reports in this program are documented as the DPST-(year)-74-(month) series. The first report covered the work in June 1963 and was published as DPST-63-74-6.

Discussion

As described previously, the several types of tubing have exhibited large differences in susceptibility to stress orientation of the hydrides. This variability is shown in Figure 1, which illustrates the effect of stress level on the fraction of hydride platelets that precipitated perpendicular to the stress axis, f_N. The data from a previous program have been included in the figure to provide data on additional lots of tubing.

Four general types of tubing have been tested thus far: roll-formed, tube-reduced, drawn, and as-extruded. The as-extruded tubing was the most susceptible to stress orientation, but only one lot of material has been examined. Additional samples of as-extruded tubing will be tested.

Two lots of roll-formed tubing exhibited low susceptibilities to stress orientation in spite of the fact that prior to the roll-forming operation tubing A was formed by extrusion and tube reducing, while tubing A' was formed by extrusion and drawing. The two lots of drawn tubing, tubing E and E', exhibited high susceptibilities to stress orientation. On the other hand the stress orientation observed in tube-reduced tubing, lots B, C, and F, ranged from the low susceptibility of the roll-formed tubing to the high susceptibility of drawn tubing. The causes for these differences in behavior are being sought by texture measurements and by analysis of the details of the fabrication history, such as the type of constraint or the directional metal flow during forming.

The stress orientation results may be summarized as follows.

Fabrication	Level of Susceptibility to Stress Orientation	Lot to Lot Variation
Roll-formed	Low	Small
Tube-reduced	Low to high	Large
Drawn	High	Small

PROGRAM

Stress orientation tests of longitudinal sections will begin next month, and some analyses of the microstructural features of the circumferential sections may be possible. Tests of additional lots of as-extruded, drawn, and roll-formed tubing will be made when samples are available. Texture measurements by X-ray diffraction will be made to confirm the predicted textures as indicated on Figure 1.

Summary of Fabrication Processes for Zircaloy Tubing

Tubing Code	Fabrication Process	Predicted Texture*
A	Tube reduced and roll formed	Radial (X,TS)
A'	Drawn and roll formed	Radial (M)
B	Tube reduced } By different vendors	Radial (TS)
C	Tube reduced } By different vendors	Radial (M,TS)
D	Extruded	Circumferential (L,TS)
E	Drawn	Circumferential (X,TS)
E'	Drawn	Circumferential (M)
F	Swaged and tube reduced	Radial (M,TS)

*The direction listed is the estimated predominant orientation of the poles of the basal plane [0001], based on the sources of data as noted.

X - texture measurement on similar material

L - literature review of texture measurements of a variety of material

TS - analyses of strain anisotropy in sheet tensile specimens at SRL

M - texture measurement by X-ray diffraction

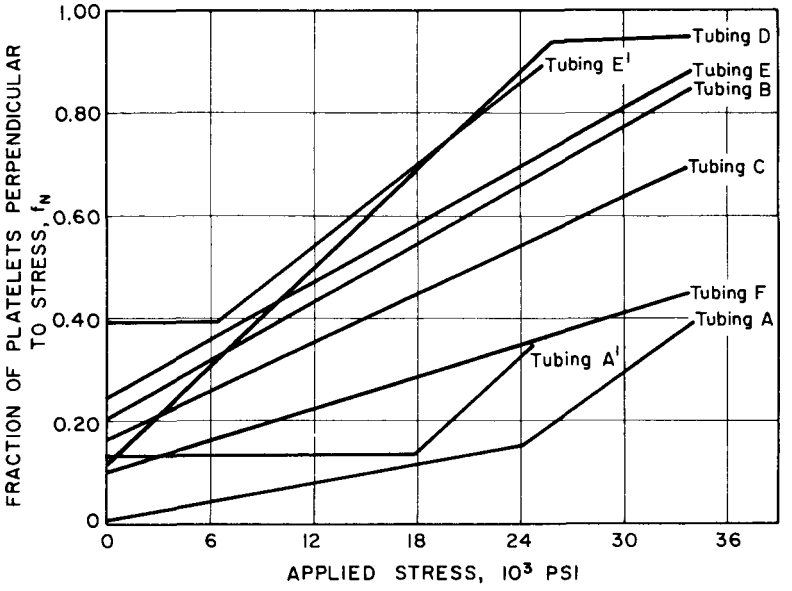

FIG. 1 STRESS ORIENTATION OF HYDRIDE PLATELETS IN DIFFERENT TYPES OF ZIRCALOY TUBING

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