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HYDRIDE ORIENTATION AND MECHANICAL PROPERTIES OF THIN-WALLED ZIRCALOY TUBING

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INTRODUCTION

Studies of factors that influence the orientation of zirconium hydride platelets in thin-walled Zircaloy tubing are being conducted at the Savannah River Laboratory. These studies will define the relationship of fabrication techniques and associated Zircaloy structures to susceptibility of tubing to preferred hydride orientations. The work will also assess the effects of various aspects of hydride morphology, orientation, platelet size, and cluster size on the mechanical behavior of tubing.

SUMMARY

The effects of applied stress and Zr texture on the orientation of grain boundary hydrides and intragranular hydrides were determined using simultaneous analyses of hydride orientation and hydride location. Samples of tubing E, F, and C after various stress-orientation treatments were analyzed on a metallograph at 1000X using the Platelet Orientation Analyzer (DPST-64-83-11). Separate orientation-frequency distributions for intergranular and intragranular hydrides were developed from the data by computer analysis. The preferred hydride orientations as measured by the f_{48}* parameter are given in the table. These distributions confirm earlier conclusions that the preferred hydride orientation and stress-orientation susceptibility of a material cannot be predicted from a knowledge of the Zr texture alone. Furthermore, because of the complexity of the hydride distribution, both in orientation and in location, correlations of hydride orientation with stress and with strain history will be the only relationships obtainable in the near future.

The data in the table show that hydrides precipitated within the grains were more susceptible to stress-orientation than grain boundary hydrides. The increase in f_{48} for hydrides within grains with stress-orientation was 10% to 50% higher than for grain boundary hydrides and showed no correlation with Zr texture.

The fraction of hydrides within the grains varied considerably, both from tube to tube, and, after stress-orientation, within a single type of tubing. For example, in Tubing E with no applied stress, 55% of the hydrides were within the grains; after stress-orientation at 32 ksi the fraction had increased to 88%. Whereas, in Tubing F, 36% of the hydrides were in the grains, but after stress-orientation at 33 ksi the fraction had not changed significantly.

*f_{48}: the fraction of hydrides oriented between 48° and 90° to the reference direction. The selection of 48° as a limit was based on the frequency class limits set up in the computerized orientation analysis program.

The Zr texture in these tubes appeared to exert only a small influence on the preferred hydride orientation (f_{48}). The very strong textures in Tubing E and F changed the f_{48} values before stress-orientation from random by 4 to 21 points. (The value of f_{48} for randomly oriented hydrides is 47%.) In the tubing with no stress-orientation treatment the data indicate a slight preference of hydrides for basal planes and grain boundaries parallel to basal planes. After stress-orientation, the hydrides preferred different crystallographic planes in different tubes.

COMPARISON OF HYDRIDE ORIENTATION TO HYDRIDE LOCATION
(Circumferential specimens)

Tube	Preferred Orientation of Zr Basal Poles	Applied Stress	Preferred Hydride Orientation (f_{48}), per cent: All Hydrides	Preferred Hydride Orientation (f_{48}), per cent: Intragranular Hydrides	Preferred Hydride Orientation (f_{48}), per cent: Grain Boundary Hydrides	Fraction of Hydrides Within Grains, per cent
E	Circum. direction (strong)	0	47	52	40	55
		24 ksi	77	80	67	76
		32 ksi	86	88	73	82
F	Radial direction (strong)	0	30	34	27	36*
		26 ksi	48	49	47	45*
		33 ksi	50	62	44	35*
C	Uniform in transverse plane	0	40	40	40	68
		24 ksi	61	64	56	51
		30 ksi	68	74	60	55

* These three samples were rechecked and found to be reproducible within 2 to 3%.

NOTE: These data are based on counts of at least 400 hydride platelets in each specimen.

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