

BEHAVIOR OF ANNEALED TYPE 316 STAINLESS STEEL UNDER MONOTONIC AND CYCLIC BIAXIAL LOADING AT ROOM TEMPERATURE*

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SUMMARY

This paper addresses the elastic-plastic behavior of type 316 stainless steel, one of the major structural alloys used in liquid-metal fast breeder reactor components. The study was part of a continuing program to develop a structural design technology applicable to advanced reactor systems. Here, the behavior of solution annealed material was examined through biaxial stress experiments conducted at room temperature under radial loadings ($\sqrt{3}\tau = \sigma$) in tension-torsion stress space. The effects of both stress limited monotonic loading and strain limited cyclic loading were determined on the size, shape, and position of yield loci corresponding to a small offset strain (10 microstrain) definition of yield.

After establishing an initial yield surface, behavior under monotonic loading was investigated by prestressing radially 50% beyond initial yield and then conducting sixteen probes to establish the new yield surface. An apparent softening was observed, the area of the new yield surface being reduced from that of the initial yield surface. This effect was confirmed by conducting similar experiments with 100% prestressing beyond initial yield.

The yield behavior under cyclic loading was investigated in two stages. In the first stage, the specimen was prestrained to an equivalent strain of about 0.45% and then yield surfaces were determined as before. This procedure was repeated in the negative sense so that an equivalent strain range of 0.9% was covered. After five cycles over this range, yield loci were again determined. It was found that the strain cycling had very little effect, yield surfaces determined before and after cycling being almost identical. In the second stage of strain limited experiments, the above procedures were repeated for an equivalent strain range of about 2.0%. Strain cycling was conducted for ten cycles with yield surface determinations being made at five cycle intervals. Some hardening was observed during this stage of cycling, the areas of the tenth cycle yield loci being larger than those of the first cycle.

Regarding the monotonic data, the apparent softening was found to result mainly from the use of a small offset definition of yield. Relatively abrupt yielding in the annealed state gave way to a more rounded-off behavior with subsequent plastic straining. This resulted in a marked reduction in the range of linear stress-strain behavior which coupled with the 10 microstrain definition of yield, led to the apparent shrinking of the yield locus. It is believed that under a more gross definition of yield no such softening would be indicated.

Regarding the cyclic data, it was concluded that the prior monotonic load history had effectively eliminated the capability for cyclic hardening at 0.9% equivalent strain range. Further, it was concluded that, apart from the apparent softening described above, the inelastic behavior of the material was to the first order "kinematic" in nature. The yield loci were basically translated in stress space with minor changes in enclosed area. However, in some cases, the yield surfaces suffered considerable distortion. Generally, this distortion was characterized by an elongation of the yield curve in a direction in stress space normal to the radial loading path.

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