Effect of Environment on Stress Rupture

This program to measure the stress rupture behavior of four candidate alloys for coal gasifier internals is being conducted at the Idaho National Engineering Laboratory (INEL). The INEL work complements the Phase V program at Southwest Research Institute (SwRI), which is directed by the Metal Properties Council, Inc. and was described in the December 1, 1979 issue of this newsletter.

The biaxial stress rupture tests at the INEL were conducted under conditions similar to the uniaxial stress rupture tests at SwRI. The four corrosion resistant alloys tested were Incoloy 800H; Alonized Incoloy 800H; Type 310 stainless steel; Haynes 188, and IN-657. These were supplied by SwRI, and the Alonizing was conducted in the same furnace batch with their uniaxial specimens. The axis of the tubular test specimens was at right angles to the rolling direction of the one-inch-thick plate from which the specimens were machined. The simulated coal gasification atmosphere (CGA) input composition was (in mole percent) 12 CO₂, 18 CO, 24 H₂, 39.5 H₂O, 5 CH₄, 1 NH₃, and 0.5 H₂S. The equilibrium gas composition at the test temperatures of 1200, 1500, and 1800°F is somewhat different from this input composition and varies with temperature. The CGA pressure was 1000 psi. Tests were also run in atmospheric pressure air to establish baseline behavior. The tubular specimens in both cases were pressurized internally with argon to produce the estimated stress required to cause rupture in one hundred hours. The target rupture life in the uniaxial tests at SwRI was varied between 100 and 10,000 hours.

Results

The biaxial stress rupture behavior for two of the alloys, Type 310 stainless steel and Haynes 188, is shown in Figures 1 and 2. The other two alloys show similar behavior. The rupture parameter, P, is an empirical quantity which reflects the simultaneous effects of both

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temperature and duration of applied stress on stress rupture. Based on these results, several trends are apparent.

1. The biaxial stress rupture tests show the same trends and approximately the same stress rupture values as uniaxial data obtained from the literature for each alloy tested.
2. Only for the Haynes 188 may the stress rupture strength/life in CGA have been significantly less than in air. But further testing has indicated there is probably no reduction of biaxial stress rupture strength/life in CGA even for this alloy.
3. The biaxial strain at rupture was small, typically only a few percent.

It is appropriate to mention that in the uniaxial stress rupture testing at SwRI, exposure to CGA generally resulted in a shorter rupture life than with testing in air. No explanation is yet available for the observed difference in behavior between SwRI and INEL test specimens.

Continuing Work

Similar one-hundred-hour biaxial stress rupture tests are being conducted in three simulated coal gasification pilot plant atmospheres using two of the alloys. The atmospheres selected exhibit a broad composition range. Tests will then be run for five hundred hours to measure the effects of longer test periods on biaxial stress rupture in CGA. Biaxial fatigue tests in CGA are then scheduled to follow. (Prepared by R.M. Horton, Materials Laboratory Supervisor, Fuels and Materials Division, EG&G Idaho, Inc., Idaho National Engineering Laboratory, Idaho Falls, ID.)

Fig. 1 Variation of rupture parameter for Type 310 stainless steel.

Fig. 2 Variation of rupture parameter for Haynes 188.