MECHANICAL PROPERTIES OF RVD GRAPHITE FROM ROOM TEMPERATURE TO 5500°F*

G. T. Yahr
Oak Ridge National Laboratory
Oak Ridge, Tennessee

C. D. Pears
Southern Research Institute
Birmingham, Alabama

F. J. Witt
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Abstract

The mechanical properties of RVD graphite have been examined at temperatures ranging from room temperature to 5500°F. The majority of the tests was performed by Southern Research Institute under subcontract to Oak Ridge National Laboratory. The room temperature strain data were obtained using strain gages, while the elevated temperature results were obtained from optical strain analyzers.

Ordinary uniaxial tensile and compressive tests were performed in both principal directions at nine temperature levels. Complete stress-strain diagrams were obtained. For the tests above room temperature (1000°F to 5500°F) five specimens were tested at each condition except at 4500°F where 20 with-grain and 10 across-grain tensile tests were performed so that the data scatter at high temperature could be examined. Approximately 20 tensile and compressive specimens were tested at room temperature. The majority of the tests from 1000°F to 5500°F was performed at a strain rate of 0.02 in./in./min in a helium atmosphere. At three temperature levels (3000, 4500, and 5500°F) with-grain tensile tests were performed at strain rates of 0.001 and 0.10 in./in./min. A few tests were performed at 4500°F where the strain rate was increased as quickly as possible from 0.001 to 0.01 in./in./min or from 0.01 to 0.10 in./in./min.

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Creep tests were performed at 3500, 4000, 4500, and 5000°F with the emphasis placed on tensile creep. Tests were performed at 1/2 and 3/4 of the failure strength and in some instances at 1/4 of the failure strength. Tensile relaxation tests were run at 4500°F with strains corresponding to the stresses at 1/4, 1/2, and 3/4 the failure strength. Torsion tests were performed at 4500°F on specimens with tensile preloads in order to examine the behavior of graphite under multiaxial stress states. Cyclic tensile tests were also performed at 4500°F. The cycling was performed at 1/2 and 3/4 of the failure strength. The moduli of elasticity were determined at 1000, 2000, and 4000°F using the vibrating reed method. Strain ratios were measured throughout the temperature range. The bulk density of each specimen was measured.

The more significant results of the tests are summarized below. The tensile strength at fracture for a strain rate of 0.02 in./in./min was seen to increase up to 5000°F and then decrease to 5500°F. The tensile strain at failure at 5500°F exceeded 2%. The compressive strength at fracture increased steadily with temperature. At 5500°F compressive failure was not obtained; instead the specimen merely shortened until the maximum range of the test rig was exceeded. The strain ratios also increased with temperature exceeding 0.25 in some cases. The elastic modulus decreased above 3500°F. The dynamic modulus and the modulus obtained by measuring the initial slope agreed very well.

Different behaviors at 4500°F were noted between the tensile tests at different strain rates. The failure strengths were consistently higher for the slower rates at 4500°F, while at 5500°F the faster rates yielded higher strength values. Very little difference in behavior was noted where the strain rates were changed during the tests. The cyclic tests indicated that plastic strains occurred at each cycle. In the creep tests the strains increased as a function of temperature and markedly so at around 5000°F.

The torsional tests at 4500°F indicated that tensile failure rather than shear was the principal failure mode. A good correlation was found between density and strength with the strength increasing linearly with density. The data were seen to exhibit more scatter at 4500°F than at room temperature.