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Reactor Design

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From T. F. Hengstenberg
Engineering Mechanics

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Subject Tension Test on Fiber-
Graphite Prototype Tie Rod

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The first tension test on a fiber-graphite prototype tie rod has been completed. The specimen prepared by Basic Carbon Corp., was a cylindrical dumbbell shape as shown in the first photo. The parallel portion or gage length section was approximately 6 in. in length with an average diameter of 0.460 in. This specimen broke at a load of 210 lb which was much lower than expected.

The rod was instrumented with two Type A-9, 6 in. wire strain gages, 180° apart. These were connected in series in one arm of the bridge measuring circuit to give the average tensile strain.

Special adapters were made in which the ends of the specimen were potted with a low melting point Eutectic alloy. Special precautions were taken to insure axial alignment of the specimen and adapters. This was checked prior to the test by reading the two strain gages separately under very low loads. Approximately 2% bending was present in the setup. The second photo shows a view of the complete loading linkage in the tensile test machine. The output of the strain gages and load cell were recorded on an X-Y plotter.

The specimen broke at a load of 210 lb which is an average tensile strength of 1,260 psi. The fracture strain was 980 microinches per inch. The load-strain plot was slightly curved, which yielded a secant modulus of elasticity at the failure load of 1.28×10^6 psi.

The fracture process was not evident until the specimen had pulled apart enough to reveal the exact nature of the fabrication method used in preparing the specimen. As seen from

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the fractured specimen in the third photo, the sample is composed of a solid graphite core around which the fiber-graphite cloth is wound with little or no bond between the cloth shell and core.

Failure was indicated by a sudden release of load to less than one-half the maximum value but with no evidence of surface cracking. Upon further movement of machine crosshead, the graphite cloth weave showed separation and eventually broke as shown in the last photo. Thus, failure was initiated in the brittle core. After slicing the tapered end of the specimen, it was found that the initial failure was in a cement joint at the end of the solid core.

It is apparent from results of this test that the fabrication technique used in this first tie rod prototype will not produce the desired strength capabilities of the graphite fibers. We would recommend the following improvements to overcome apparent deficiencies in the present designs:

1. If the solid core is used, the tapered end plugs could be made as an integral part of the rod or a shear cement joint could be employed.
2. A bundle of axial graphite fibers could be substituted in place of solid graphite core.
3. The outer covering could be wound with graphite fibers in the axial direction in place of the present 45° angle.

Although the test results fell far below expectations, this was the vendor's first attempt at fabricating this type of component. Subsequent models are expected to show marked improvement.

T. F. Hengstenberg
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Reactor Assembly & Dynamic Experiments

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Attachments

Short Fiber Graphite Proto-Type

Tie Rod #1

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