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Progress Report 1, for the Period 01/01/93 to 06/30/93

For the Project Titled "Graphite Fiber Textile Preform/Copper
Matrix Composites
NAG3-1432, NASA Lewis Research Center

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(NASA-CR-193797) GRAPHITE FIBER
TEXTILE PREFORM/COPPER MATRIX
COMPOSITES Semiannual Progress
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SUMMARY

This project has the objective of exploring the use of graphite fiber textile preform/copper matrix composites in spacecraft heat transmitting and radiating components. The preforms are to be fabricated by braiding of tows and when infiltrated with copper will result in a 3-D reinforced, near net shape composite with improved specific properties such as lower density and higher stiffness. It is anticipated that the use of textile technology will result in a more robust preform and consequently better final composite; it is hard to anticipate what performance tradeoffs will result, and these will be explored through testing and characterization.

During this initial period two principal tasks have been addressed;

a. Design work has proceeded on a thin (2 mm) flat panel. The tow sizes and braiding parameters have been decided, materials ordered, and braiding machine set-up begun.

b. To establish a baseline and transfer characterization and testing methods used here, a preform/specimen configuration used for graphite/epoxy specimens will be fabricated, substituting a copper matrix. The preform has been braided, an epoxy sample fabricated, and samples of both submitted to a vendor for quotes on fabrication cost; the specimens are in the process of pressure infiltration. Characterization and testing will be performed on these learning specimens to both analyze the material and develop processing methods.

INTRODUCTION

This project has the objective of exploring and developing the use of 3-D textile technology to improve the fabricability and performance of copper matrix heat transmitting and radiating components. It is proposed that integrated, near-net shape composites will confer robustness in fabrication and improved specific properties. There are many structural, functional, and fabrication interdependencies which will have to be explored and understood before these materials are commodified.

The work for this early phase of the project divides itself into two complementary tasks;

a. To establish a baseline and utilize characterization and testing experience develop for epoxy matrix textile composites, copper will be directly substituted for epoxy for our standard-reference (braided) composite. This will provide comparison on such points as fiber volume and preform disruption during infiltration, and on the general mechanical properties.

b. Design of a first stage thin (2 mm) panel. The tow size and braiding procedure had to be modified to produce such a thin part, and there are also machine limitations to the tow size which can be used for a reasonably sized part.

MATERIALS AND METHODS

The textile preforms for the reference composite used in our laboratory are braided from 12 K, 7 μm Ceylon G30-500 graphite fibers. The preforms are braided by a 4-step process in a 3x14 pattern to give an interlocked 3-D structure. All preform fabrication is at the NCSU School of Textiles in Raleigh, NC. Although the preform structure can be characterized from a textile point of view, such is only partly descriptive of the final composite as fabrication and handling induce substantial alterations. Figure 1 shows a preform and fabricated composite, with a tracer tow to reveal the braiding pattern. Based on multiple sectionings of this composite a volume-to-surface mapping was made, Figure 2, which allows the surface to be diagnostic of the internal structure. This depicts an idealized tow which lies on a diagonal tow plane and sinuously spans the specimen thickness. These tow planes underestimate the surface pattern by some 2°.

The cross sections of braids are usually designed to the final net shape cross section, with the preform or composite requiring sectioning or machining only perpendicular to the braid axis. The diamond-like surface patterns mirror, although with rotational offset, the fiber directions and the internal tow crossing and crimping points. Additional details of this braid structure can be found in the article by Filatovs et al in NASA Conference Publication 3176.

The preforms will be fabricated by ACC Electronics (formerly P Cast) of Pittsburgh, PA, into 6 in long bars, with a total of 8 such bars expected from a batch.

For mechanical characterization, a specimen based on ASTM E399 is used. This is shown in Figure 3, and indicates the expected final dimensions of the bar. This compact tension-type specimen may have a blunt or sharp side notch and is used in two lengths, depending on the phenomenon investigated.

The thin plate specimen will likewise have a 3x14 braiding pattern. The initial specimen will be a tube which will be split to produce the flat preform. The tow size will be reduced to 3 K. This is a compromise size based on the balance between the need to reduce the thickness and the increase with machine requirements with smaller tow size. The infiltration pressure is also expected to increase with smaller tow size.

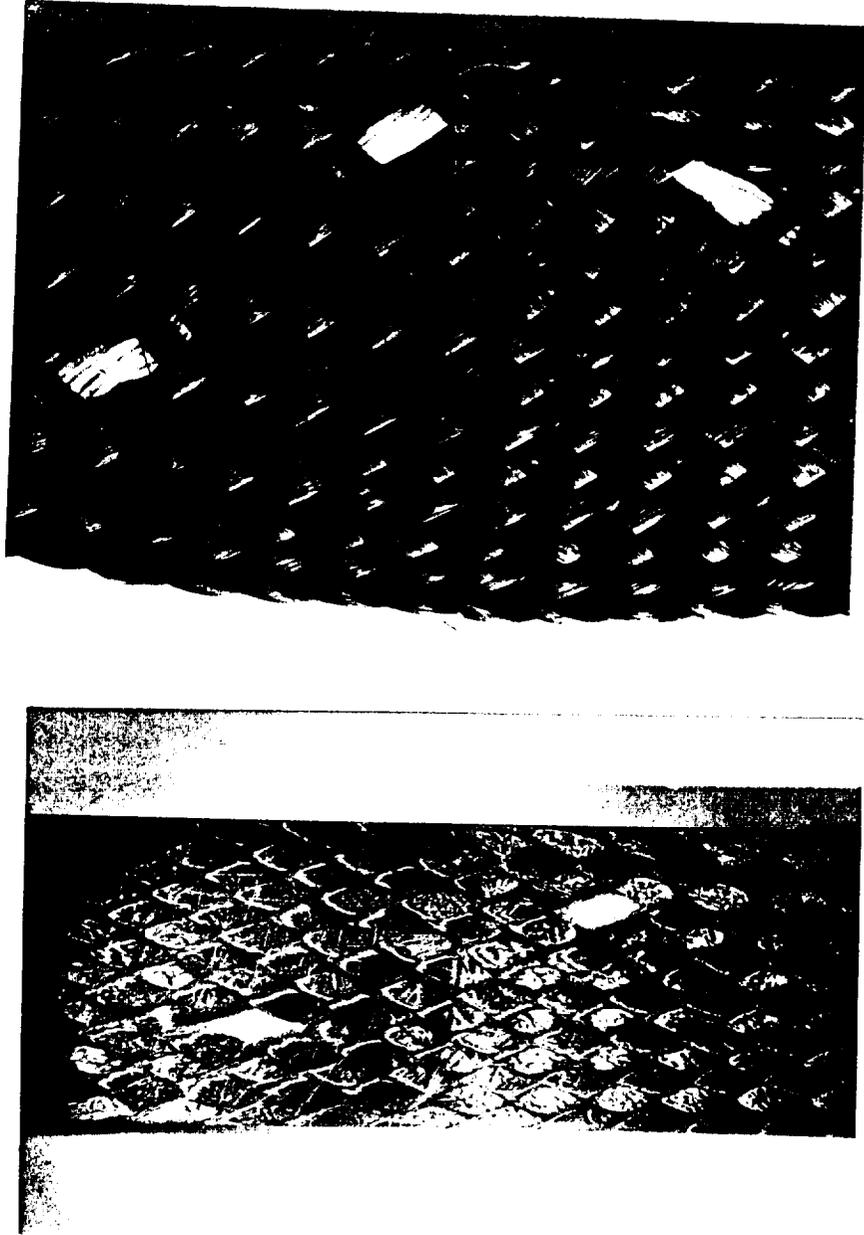


Figure 1. Braided preform (top) and molded epoxy composite (bottom). The tracer tow reveals the distinction between the surface pattern and tow plane angles.

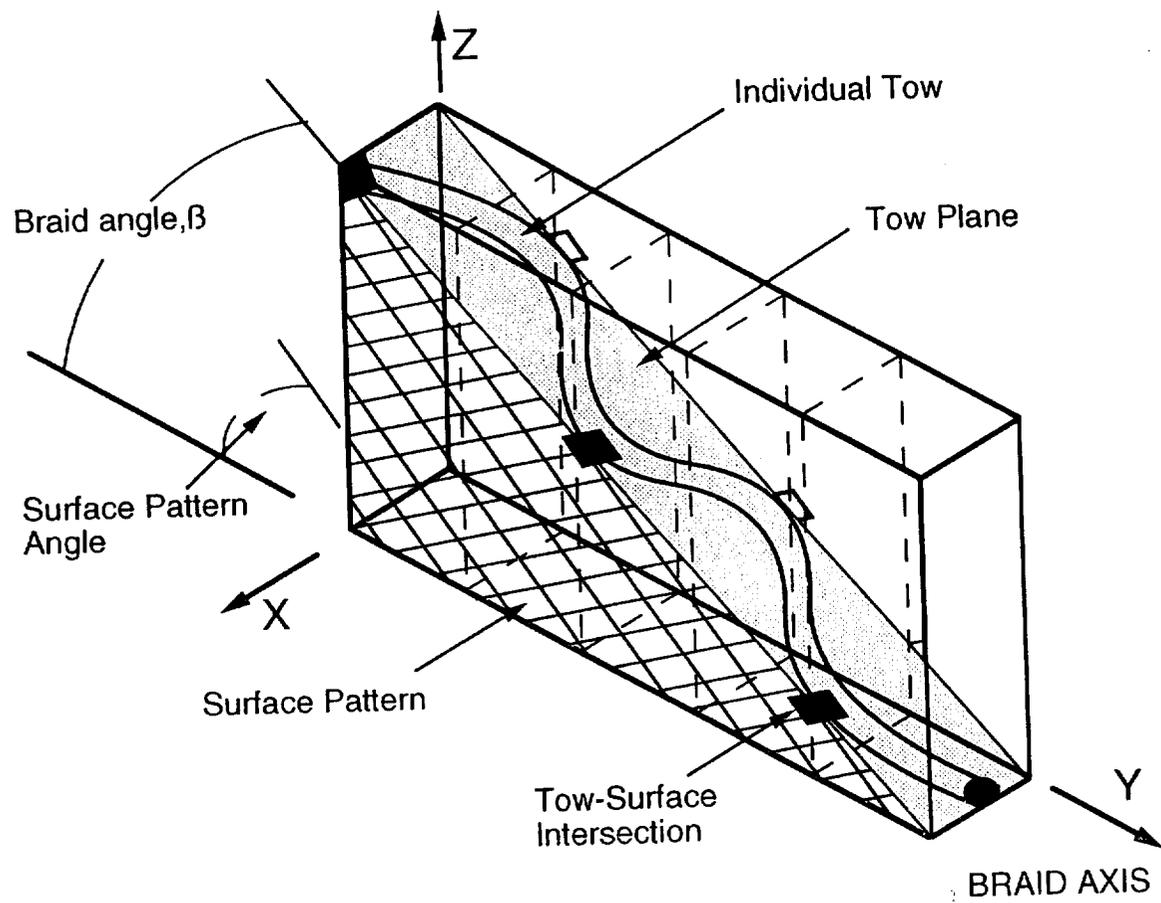


Figure 2. Surface / Volume mapping of composite of Figure 1.

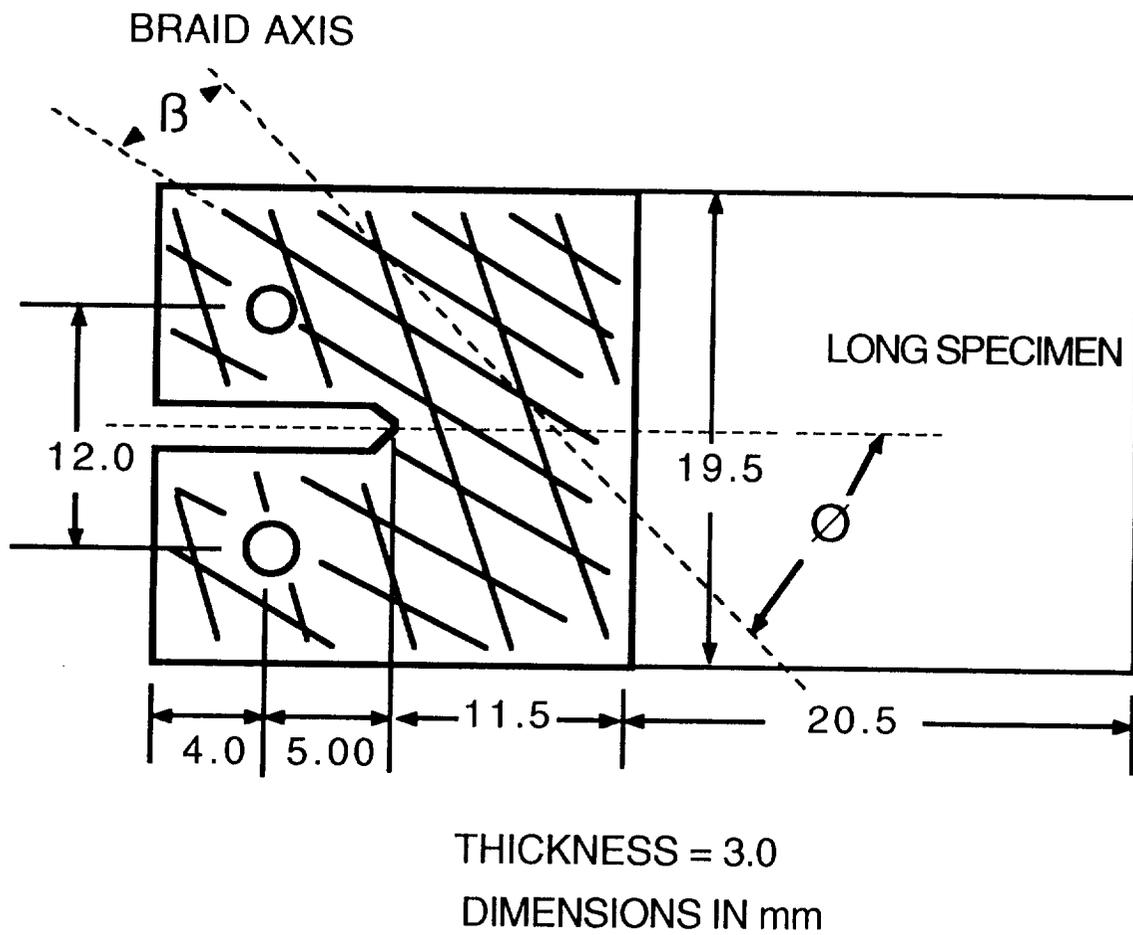


Figure 3. Specimen geometry and definition of parameters. \varnothing is the notch-to-braid axis angle.

CHARACTERIZATION AND TESTING

The first generation specimens will be sectioned and characterized as to porosity, grain size, fiber volume fraction, and amount of preform disruption. To assess the interface and observe the general failure process specimens will be tested using the configuration shown in Figure 3.

It is expected that information gained from these learning specimens will indicate needed modifications in materials, preform fabrication, and infiltration. For example, it is unknown whether the lower modulus fibers used, because of their lower carburizing temperature, will react excessively with the matrix or softer. It may be necessary to use higher modulus fibers, which may necessitate a change in braiding pattern or procedure.

Specimens from all batches will also be sent to NASA Lewis.

STUDENT TRAINING AND EDUCATION

Two students have been supported by this grant. Mr. Mike Watlington is a Junior in Mechanical Engineering and intends to continue with the project. Most of his activity has been learning of laboratory procedures and fabrication of a wide range of composites materials. Mr. Lowell Bass is a Senior in Mechanical Engineering, who intends to pursue his Masters degree with this grant. He has spent considerable time at the School of Textiles at NCSU learning about braiding technology, in addition to performing his laboratory duties at the Composites Center.