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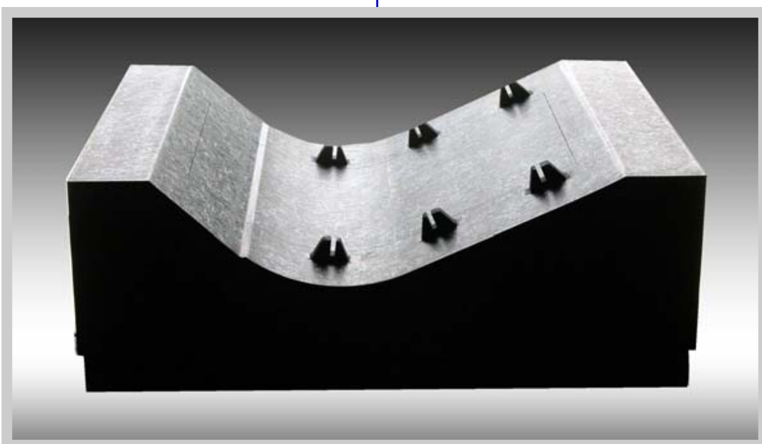
CFOAM® Tooling System

Technology Overview

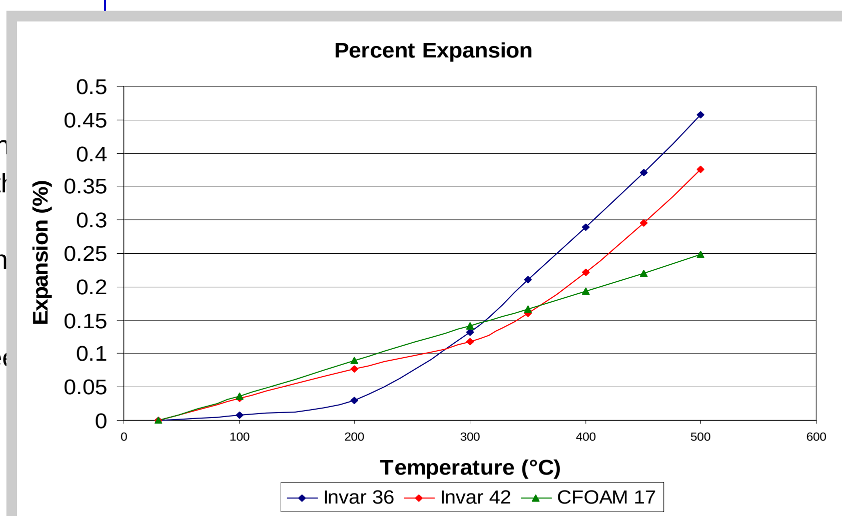
Construction of aircraft, spacecraft, missile surfaces, automobiles, and other structures is rapidly moving to carbon fiber-reinforced thermoset and thermoplastic resins, resulting in higher strength-to-weight ratios and less subjection to corrosion and fatigue. Tooling is critically important as tools must be low-cost, rigid, and durable and must offer a coefficient of thermal expansion (CTE) that matches the composite part. Long lead times and material availability are also growing concerns with the current method. Industry is in need of new tooling options for current and future carbon composites.



Carbon Innovations, LLC. has designed a carbon foam-based composite tooling product. Carbon foams (CFOAM®) manufactured by Carbon Innovations have a tremendous advantage over oth materials in that they have very high compressive strength and a low coefficient of thermal expansion are lightweight and easily machined.

A new carbon foam manufacturing process has bee developed resulting in a low-cost, high-strength material that has proved attractive for creating of tooling for composite parts.

Composites are stronger, lighter, and less subject to corrosion and fatigue than materials that are currently used for fabrication of advanced structures. Tools to manufacture these composite parts must be rigid, durable and able to offer a CTE closely matching the composites. Current technology makes it difficult to match the CTE of a composite part in the curing cycle with anything other than a carbon composite or a nickel iron alloy such as Invar®. As seen below, CFOAM has very uniform thermal expansion when compared with Invar 36 and 42, thus enabling post-curing of composite parts on the tool with high-temperature BMI resins.



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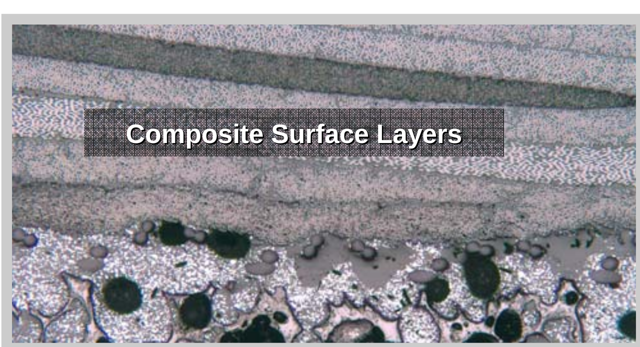
Carbon Innovations performed a comprehensive benefit analysis comparing the use of CFOAM versus Invar, aluminum and steel tools. The findings identified that the use of CFOAM would not just be a suitable alternative to the current method but would also provide the following advantages:

- Lower coefficient of thermal expansion more closely matching composite part
- Lower fabrication costs
- Lightweight tooling
- Tooling easier to modify/repair
- Improved performance durability
- Cycle time reduction - due to lower mass energy requirements in an autoclave cure

Carbon Innovations has developed unique process methods for manufacturing advanced carbon foam composite tooling systems. Both rapid and durable tooling methods have been developed and have been successfully tested for performance. Important developments were made in tooling surface coatings including continuous and chopped fiber with BMI resins. CFOAM Composite Tools are currently in service today and are successfully being used at commercial composite lay-up production facilities.



CFOAM SEM Image

Fabrication Techniques

Before work can begin, it is necessary to know dimensions for the tool, the geometry and dimensional requirements. When size is determined, CFOAM blocks are then bonded together to the desired finished part geometry.

Block Bonding

CFOAM bonding adhesive is used to adhere all of the blocks together in the proper form. A notched trowel works well to insure a sufficient amount of adhesive has been applied. The adhesive is applied to both the surface and the edges where any of the blocks are touching each other. It is important to ensure that the adhesive supplier’s curing protocol is followed.

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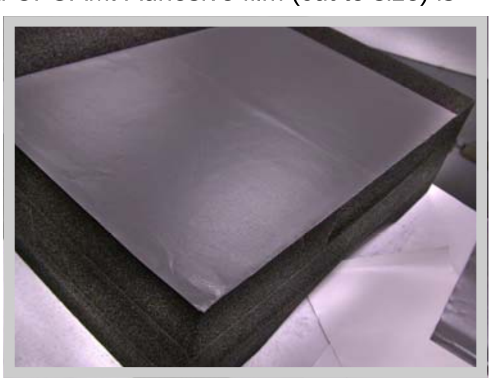
Rough Machining

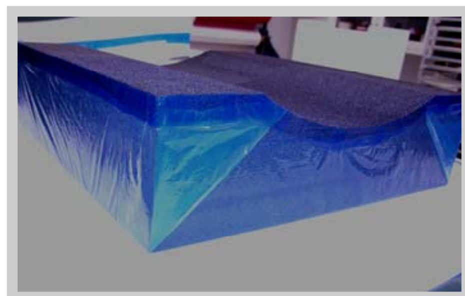
After the adhesive has dried, the resulting CFOAM block can be machined into the desired geometry; however, this machined product should be undersized from the actual dimensions to allow room for expansion of the composite material. The specific under-cut will vary depending upon the type of surface being applied. Several different surfacing materials have been developed and tested. Touchstone's technical support should be consulted for information on specific surfacing materials.

Adding Composite Surface

The unfinished tool is now ready for the application of the adhesive and materials applied to the surface of the rough-machined CFOAM. Adhesive film (cut to size) is applied to the bottom of the tool. In this example a bi-directional carbon pre-preg is used. The weight of this material varies and should be adjusted as needed. The amount of material will be primarily driven by the tool's durability and handling requirements. The pre-preg is cut to size and applied to the bottom of the tool and is then cut slightly larger than the actual measurements to allow for trimming. Each individual piece is trimmed before the next layer is applied.

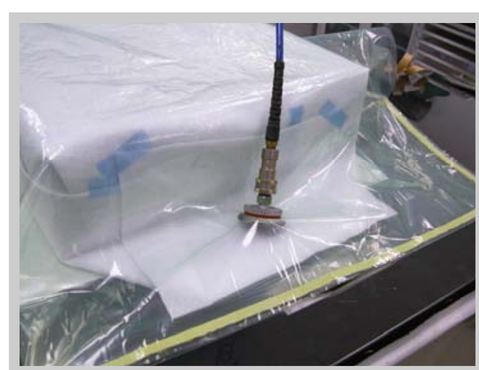


Once all the pieces are applied to the bottom, work is begun on the sides of the tool. The adhesive film is applied as before, and the same process is followed until all sides are covered. The tool is flipped over, and the adhesive is applied to the top surface. This process can be done in sections if the tool has a complex geometry to ensure that it adheres properly. The tool is pressed firmly to avoid air pockets behind the adhesive. The tool is now ready for application of the surface material. As with the adhesive it should be applied in sections per the engineering ply layout.



Final Preparation and Processing

The tool is now ready to be placed into a vacuum bag and autoclave cured. Vacuum bagging materials and procedures are dependent upon specific resin systems and may also be varied depending upon part geometries.



A vacuum line is attached to the tool inside the autoclave, the door is sealed shut, and the program is set to the required surface curing temperatures.

The tool is taken from the autoclave and the vacuum bag is removed. It is now ready to be machined to size.

When the tool is completed in the mill, a seal coating is applied to the top surface, filling any pinholes or scratches on the surface. The tool is wet sanded and a final seal coat is applied and polished. Mold release is best applied just prior to part lay-up.