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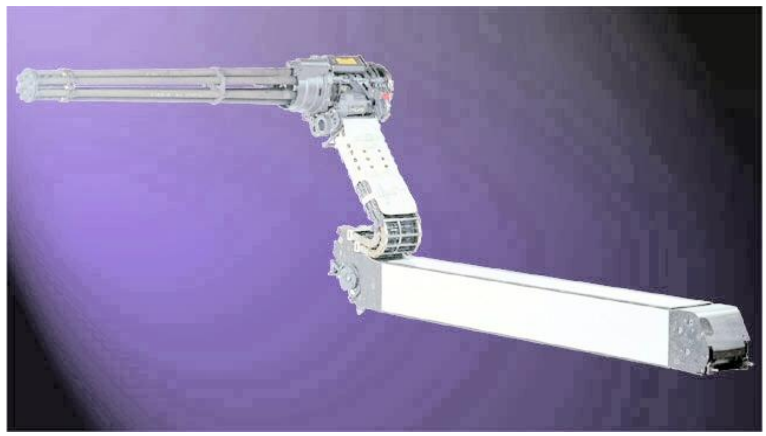
F22A aircraft weapon system gains the high performance of carbon/epoxy with the efficiency of compression molding.



When engineers at General Dynamics Armament and Technical Product (GDATP) recently designed the ammunition container for a new aircraft weapon system, they decided very early in the process to make the container's side panels from a carbon fiber/epoxy sandwich structure with continuous-fiber laminates and aluminum honeycomb core. The choice allowed this division of General Dynamics (Charlotte, N.C.) to meet "the extremely aggressive size and weight restrictions that were imposed on the design, while maintaining adequate structural stiffness," reports Peter Wolff, GDATP's project engineer for aircraft systems. That choice imposed engineering challenges that included development of panel edge closeouts and mechanical joints between the panels that were compatible with the panels' thermal expansion properties, to survive severe operating temperatures on the aircraft. But even more challenging was the manufacture of the weapon system's cartridge guides, complex parts in two sizes (approximately 200 mm/8 inches square and 300 mm/12 inches square), with curved vertical walls that form the channels through which ammunition rounds travel enroute from the container box to the weapon's firing chamber.

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Cartridge guides for General Dynamics Armament and Technical Products division display complex contours, vertical walls and varying thicknesses -- all produced successfully and efficiently by compression molding Quantum Composites Lytex 4149 Carbon reinforced Epoxy molding compound..

Carbon/epoxy was the preferred material choice for the ammunition guides because it would meet the weight restrictions and match the thermal properties of the container's carbon/epoxy side panels. Additionally, carbon/epoxy offered superior wear resistance, compared to metals, and would provide better vibration damping and fatigue resistance when jarred by ammunition rounds cycling at high-speed through each guide. But the appeal of carbon/epoxy was tempered by the design's processing challenges. Conventional aerospace practice would be to hand lay the parts with prepreg. The cartridge guides, however, range in thickness from 3mm/0.120 inch to more than 25 mm/1 inch, and these thicknesses must be controlled to within 0.127 mm/0.005 inch. Therefore, if it even proved possible to hand lay such subtle thickness differences, the ply schedule for the complex, curved ammunition pathways would require a large number of specially cut pieces -- 100 or more -- to create each cartridge guide. As a result, the cutting, kitting and layup processes would be both tedious and labor-intensive, raising costs significantly. Automating as much of the molding process as possible became a priority. But in what form would carbon/epoxy enable engineers to achieve the desired level of dimensional accuracy and do so cost-effectively, given the parts' complex geometry? It would be difficult with this complex shape to use prepreg cloth or resin transfer technology without having resin-starved or resin-rich areas, compromising performance.

For these reasons, General Dynamics investigated compression molding Quantum Composites' Lytex 4149 Engineered Structural Composite. Lytex 4149 is a carbon fiber-reinforced, structural-grade epoxy sheet molding compound (SMC) previously developed by Quantum Composites Inc. (Bay City, Mich.). Manufacturers of high-performance components commonly perceive SMC (typically compounded from chopped glass fiber and polyester resin) to be a commodity material, used primarily in nonstructural components. But Quantum reports that Lytex 4149 offers finished properties that approach those of carbon/epoxy prepregs. The material is compounded with 25-mm/1-inch 3K PAN-based carbon fibers (55 percent by weight) wet out with Lytex epoxy resin.

Conventional SMCs feature fiber loading of only 22 to 30 percent by weight, and their polyester resins exhibit favorable flow characteristics. Structural-grade SMCs like Lytex, with fiber loadings of 50 to 70 percent, offer less latitude. To take advantage of the performance benefits of structural SMCs, therefore, fabricators must carefully craft and control the compression molding process. In this case, the areas most critical to process control were mold design and the design and placement of the charge.

The H-13 steel mold displays the serpentine ammunition path-ways that are molded into the cartridge guides.

Chopped carbon fiber falls onto a Lytex resin during the manufacture of Lytex 4149 Engineered Structural Composite molding compound.

Lytex 4149 versions of the cartridge guides weigh about half as much as aluminum counterparts and about 30 percent as much as the same part in stainless steel (910g/2 lb for the two smaller cartridge guides and 1,590g/3.5 lb for the larger). Component cost also came in at a satisfactory level. The total manufacturing cost of such complex parts -- when fabrication from a prepreg is even feasible -- is typically lower with the structural SMC. In the case of the cartridge guides, costs were lower because the complex geometries, according to Wolff, "could be molded to net shape to the required tolerances, thus eliminating a significant amount of machining and minimizing the number of parts in the assembly. The use of Lytex 4149 for the cartridge guides allowed General Dynamics to meet its cost objectives."