Sandwich Composite Production Cost Reduced 52% with Direct Digital Manufacturing

"We can produce a new sandwich composite first article ready for testing in about one-third the time and half the cost of others using traditional methods."
— Ronald Jones, CTO, Aviradyne Technologies

Aviradyne Technologies' patented revolutionary composite production technology, trademarked under the name Digital-Direct Advanced Composites, or D-DAC®, was developed to produce durable sandwich composite parts in a fraction of the time and cost required by traditional methods. Aviradyne, through its subsidiary, Wind Sweeper Turbines, Inc., plans to take advantage of these capabilities to build next generation wind turbine blades.

Sandwich composites are innovative advanced materials. Adding a core between two facing skins increases stiffness dramatically over composite laminates while adding only a minimal amount of weight. Increasing the thickness of a sandwich composite part by a factor of two typically raises the stiffness by a factor of 12 and bending strength by a factor of 6.

How Does FDM Compare to Traditional Methods for Aviradyne?

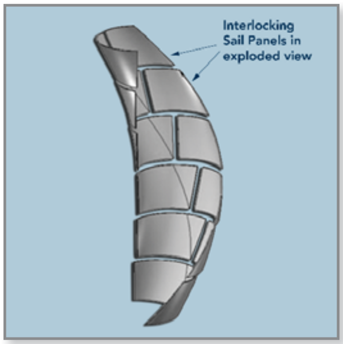
Method	Cost Estimate	Time Estimate
Conventional fabricating	$27,000	18 Days
Direct digital manufacturing with FDM	$13,000	6 Days
SAVINGS	**$14,000 (52%)**	**12 Days (67%)**

The aerospace industry was one of the first to take advantage of sandwich composite parts. Latest generation aircraft reap substantial fuel savings and performance improvements by using carbon fiber sandwich composites in wings, fuselages, nacelles, floors, interior panels and other components. Other industries using sandwich composite parts include wind energy, automotive, marine, sporting good, and others.

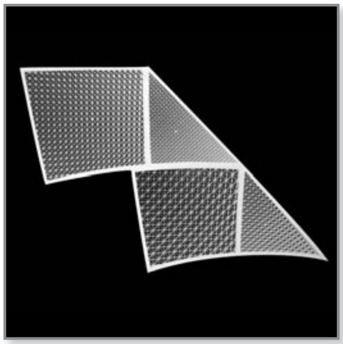
Real Challenge

Up to now, producing first articles of composite sandwich parts with compound curved geometries has been an expensive process requiring long lead-times. The lightweight cores used in sandwich composites are not strong enough to withstand the loads and temperatures encountered during the lay-up, vacuum bagging, and curing process. So producing a compound curved sandwich composite structure requires designing and building part- specific tooling, such as open molds, clamshell molds, and mandrels to provide a rigid, strong surface with the required 3D geometry to mold the structure. Compound curved sandwich composites require more tooling work than laminates because the core material must also be shaped to fit the mold. Traditional core materials like foam or Nomex honeycomb are milled using a tool path program and CNC equipment to sculpt the desired shape. Holding fixtures are required in this process to hold the material firmly during the milling process.

Using graphite-reinforced-polymer tooling, it typically takes about 9 days and, for a small part measuring less than 2 cubic feet, costs about $16,000 to build a tool set to fabricate a geometrically complex sandwich composite part. It takes another 6 days



Aviradyne's subsidiary, Wind Sweeper Turbines, Inc. plans to build next generation wind turbine blades with the help of FDM direct digital manufacturing.



This revolutionary composite core design is produced with FDM.

After the skin is laid up onto the FDM core, the composite is placed into a vacuum bag.

and costs an additional $6,000 or so to write the tool path program and build the CNC fixtures. Finally, laying up the same part in carbon fiber pre-preg followed by vacuum bagging and curing adds another three days and $5,000 for a total of 18 days and $27,000 to build a first article using traditional methods.

Real Solution

The D-DAC method relies on 3D-CAD driven additive fabrication technologies like FDM to produce parts. Using FDM, Aviradyne can produce a first article in roughly 6 days and at a cost of about $13,000. D-DAC designed cores made from engineering-grade thermoplastics like ABS, PC and PPSF on FDM platforms can include closed internal passages, joining receivers, component housings and other internal features without degrading the composite core's structural integrity. This ability can be used to create wiring conduits, component-assembly alignment features, seats for internal electrical or mechanical components, or other things. Producing these features with conventional core materials and fabrication methods is difficult or impossible due to the complex geometries involved.

The wind turbine blades will employ a sandwich structure instead of the more traditional skin-over-rib design used by most turbine blade manufacturers. Using FDM and a high modulus material like Polycarbonate, net shaped cores can be fabricated with the shear and compression strength needed to withstand the temperatures and pressures of about 250° F / 50 psi, which the part undergoes during curing.

Real Benefits

Aviradyne Chief Technology Officer Ron Jones says that in comparative studies, D-DAC produced carbon fiber sandwich composites with cores made from Polycarbonate thermoplastic on a Fortus 3D Production System tested up to 30% lighter than carbon fiber sandwich composites of equal strength made using industry "gold standard" Nomex® honeycomb core materials. In the composites industry, the higher the strength-to-weight ratio, the more desirable the part. The company plans to design the cores as solid models and then produce them using the FDM process. Multiple plies of carbon fiber pre-impregnated ("pre-preg") epoxy skins will then be laid-up onto the FDM-produced core, eliminating the need for expensive and time-consuming custom tooling to produce wind blades. "We can produce a new sandwich composite first article ready for testing in about one third the time and half the cost of others using traditional methods," he says.

"Our D-DAC process is being used in several key defense programs that we are not at liberty to discuss," says Jones. "We are also building on the D-DAC technology, which is as much a new approach to product design as it is a new production system, to create structural composites that are impossible to make otherwise. We do so by taking advantage of FDM's ability to handle geometrically complex internal core architecture, including integrated features and deliver functionality not possible with traditional composite fabrication."

One of several interlocking "sail panels" used to construct a wind turbine blade.

The first article is completed in one third the time and half the cost of traditional methods.

An example of Aviradyne's capability is covered in the July 2009 edition of High Performance Composites Magazine. Written by Michael LeGault, the article entitled, "Wind Turbine Redesign Taps Benefits Of Additive Fabrication" is about Aviradyne's ground breaking R&D work to develop the world's first anti-icing-capable small wind turbine blades.

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