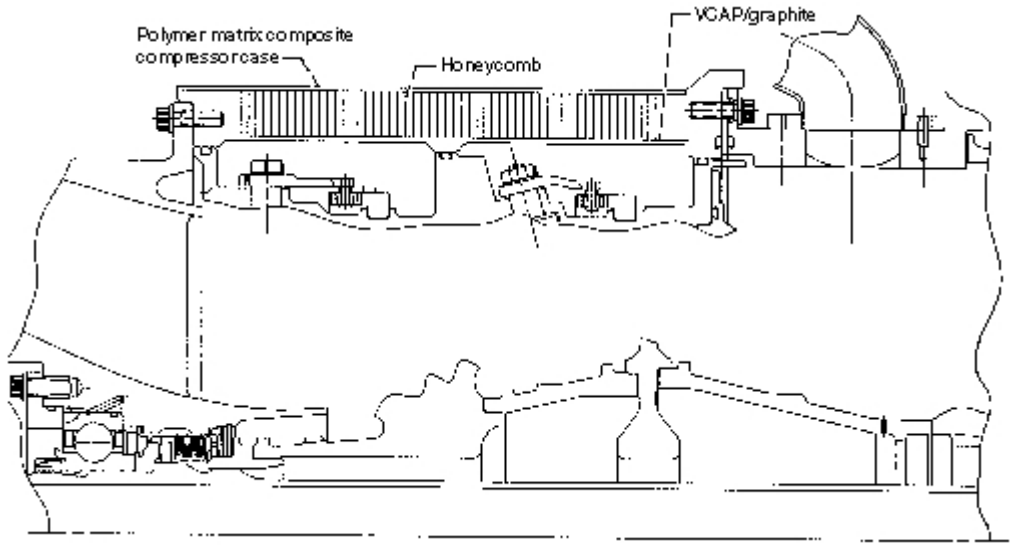
Compressor Case Manufactured Using High-Temperature Polyimides

High-temperature polymer composites (PMC's) offer lighter weight and higher specific strengths than titanium alloys for advanced aircraft engine applications-especially in fan and compressor components, where temperatures do not exceed 550 °F (288 °C). VCAP, a polyimide resin developed at the NASA Lewis Research Center, was filament wound at Lincoln Composites in Lincoln, Nebraska, with graphite and glass fibers to produce a lightweight compressor case for an Integrated High Performance Turbine Engine Technology (IHPTET) engine. This engine application requires a PMC that can withstand air pressures (60 psi) and temperatures exceeding the degradation limits of other high-temperature polyimides, such as PMR-15.



Integrated High Performance Turbine Engine Technology (IHPTET) compressor cross section.

In addition to increased performance characteristics, current commercial and military engine applications require low-cost fabrication methodologies. Two filament-winding processes were used to evaluate low-cost manufacturing techniques for the VCAP compressor case: "dry" powder tow and wet tow winding. In the dry tow process, a tow of graphite fibers (typically 3000 to 12,000 strands) is drawn through a bath of resin and then passed through a furnace to dry the solvent from the resin-soaked tow.

The product of this process, spools of graphite-fiber tow impregnated with a resin, can be shipped and handled without the safety concerns associated with hazardous residual solvents. Similar to the dry tow process, wet winding methods pass a tow of graphite fibers through a resin bath, but then the wet tow is placed on the tool used to shape the compressor case. Wet filament winding techniques are an established procedure for many aerospace fabricators, whereas dry tow winding is not. Four VCAP compressor cases have been produced, and the highest quality case was obtained when a wet filament

winding method was used.

VCAP compressor case after thermal/pressure rig testing at AlliedSignal Engines.

Finite element analysis modeling of the VCAP compressor case simplified the design and demonstrated the in situ mechanical and thermal loads for the compressor case. Static rig tests were performed by AlliedSignal Engines in Phoenix, Arizona, to verify the finite element analysis model and build a data base for further engine tests. Finally, the successful combination of NASA Lewis high-temperature polyimides, well-established manufacturing techniques, and the rigorous application of finite element analysis models enabled a 30-percent weight reduction for the PMC compressor case in comparison to the titanium case.

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