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COMPOSITE APPLICATIONS IN AIRCRAFT GAS TURBINE ENGINES

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ABSTRACT

The earliest applications of composites in Pratt and Whitney gas turbine engines were on the JT9D beginning in 1970 with the certification of a fiberglass/epoxy nosecone. By 1981 the JT9D-7R4 certified an autoclave molded Kevlar/epoxy nosecone for additional weight reduction. The PW2037 took this a step further by using Resin Transfer Molding (RTM) for improved dimensional control. This same approach was used for the PW4000 94 inch and 100 inch fan models. However, for the112 inch engine the autoclave process was again used to take advantage of the higher mechanical properties that could be achieved. Nosecones rotate from 3000 to 4000 rpm, depending on the engine model, and must survive typical bird impacts of 2.5 lbs. at 225 knots. These components are approximately 0.25 inch thick and can weigh up to 25 lbs. Working our way back from the front of the engine, you will find compression molded fan rubstrips fabricated of Kevlar/epoxy/glass microballoons for anti-coincidence. Another rotating part that is critical for engine operation is the fan spacer. The PW4084/90/98 fan spacers are RTM carbon epoxy and represent a cost effective, highly complex component. From this point you will find injection molded Ultem fan exit guide vane ID and OD platforms and LPC ID shrouds in the PW2000 and PW4000 engines. The PW 4056/4168/4084 also have compression molded carbon/epoxy fan exit guide vanes. From here one encounters the splitter which separates the core air from the bypass air. These Kevlar/epoxy components are produced by RTM for controlling dimensions to +/-0.015 inch at a diameter of 36-48 inches. A metal leading edge is incorporated for erosion protection. At this point the bifurcation fairings on all PW4000 engines are Kevlar/epoxy. In addition, the PW2000 and PW4000 use a variety of composite liners for fan containment and fan exit cases. The materials are epoxy reinforced with Kevlar, carbon and glass in both solid laminate and acoustic form, which are laser drilled. In some instances they incorporate stainless steel wire mesh for acoustic response. The PW4056 fan exit case ID liner functions as a fire barrier with two layers of Nextel/epoxy co-molded into it. On the outside of the engines is the fan inlet and nacelle. The PW4168 has a composite nacelle which is primarily a honeycomb sandwich structure which includes a BMI acoustic core cowl and carbon/epoxy RTM thrust reverser cascades. These parts represent the most significant examples of about 400 composite part numbers that are currently in production on Pratt and Whitney engines. There has been significant effort under the Affordable Composites for Propulsion (ACP) Program over the last few years to validate major composite components such as the fan containment case and fan exit case. The cost and weight benefits have been demonstrated; however, a dynamic test must be conducted before they could be considered for a future engine launch. The ACP Program has also worked on improved nacelle structures such as the fan cowl door and core cowl to establish increased durability at a lower cost and weight. These efforts are continuing and will lead to future insertions of these major composite structures in future engines.