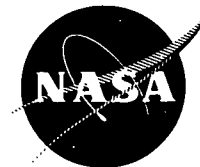


July 1975

NASA TECH BRIEF

Lewis Research Center



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Fabrication of Composite Fan Blades Using PMR A-Type Polyimide Resin and Graphite Fiber Reinforcement

The application of fiber reinforced polymer matrix composites to jet engine hardware for use at temperatures exceeding 449 K (350°F) has been limited because of processing limitations of thermally stable polymers. Polyimides are one class of these thermally stable polymers, and have excellent potential for high temperature, high strength applications. Processing difficulties of the polyimides are caused by the inability to control, in early processing stages, the formation of molecular groups which are inherently insoluble and infusible. The resulting restricted resin flow causes the entrapment of volatile materials produced during further staging. The entrapped volatile materials create undesirable voids which markedly reduce the performance properties of the composite end-product. These serious processing problems have now been overcome by the use of PMR polyimides developed at the NASA Lewis Research Center.

The PMR polyimides are safe, easy to handle, can be processed with relatively wide process controls, and offer excellent mechanical properties, with thermo-oxidative stability.

Reinforced polymeric material utilizing the PMR polyimides has been fabricated into useful hardware. Specifically, procedures, staging and cure schedules have been developed for producing a fully dense, crackfree, dimensionally controlled, complex structure: high tip speed fan blades 1.27 cm (0.5 in) thick.

The processing involves the application of monomeric reactants onto the reinforcing fibers. The low boiling solvent used in preparing the PMR solution is then removed by mild heating. The required ply shapes are cut from this prepreg and placed in preforming tools. During the preforming operation, the monomers react in situ to form prepolymer. Final curing takes place in matched metal dies.

Using the above process, several dense, crackfree, high tip speed fan blades have been fabricated. These blades successfully withstood the loads resulting from spin testing at 670.6 m/sec (2200 ft/sec) up to 422 K (300°F).

Notes:

1. The process can be applied to the fabrication of other blades or airfoils, and other aerospace or commercial structures requiring high quality, high temperature resin matrix composite construction.
2. The PMR A-type polyimide was previously announced in NASA Tech Brief 71-10442, "Thermally Stable Polyimides from Solutions of Monomeric Reactants."
3. Further information is available in the following report:

NASA CR-134727 (N75-14841), Resin/Graphite Fiber Composites

Copies may be obtained at cost from:
Aerospace Research Applications Center
Indiana University
400 East Seventh Street
Bloomington, Indiana 47401
Telephone: 812-337-7833
Reference: B75-10066

4. Specific technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B75-10066

Patent Status:

NASA has decided not to apply for a patent.

Source: W.E. Winters and P.J. Cavano
TRW Equipment
under contract to
Lewis Research Center
(LEW-12366)

Category 04

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Comparison of Composites in the Testing of A-10

The purpose of this report is to provide a comparison of the results of tests conducted on composite and metal specimens under various loading conditions. The tests were conducted in the testing facility at the NASA Langley Research Center, Hampton, Virginia.

The specimens were tested under various loading conditions, including tension, compression, and shear. The results of the tests are presented in the following tables.

The first table shows the results of the tension tests.

The second table shows the results of the compression tests.

The third table shows the results of the shear tests.

The fourth table shows the results of the combined loading tests.

The fifth table shows the results of the impact tests.

The sixth table shows the results of the fatigue tests.

The seventh table shows the results of the creep tests.

The eighth table shows the results of the stress corrosion tests.

The ninth table shows the results of the fracture toughness tests.

The tenth table shows the results of the residual stress tests.

The eleventh table shows the results of the dynamic mechanical analysis tests.

The twelfth table shows the results of the thermogravimetric analysis tests.

The thirteenth table shows the results of the differential scanning calorimetry tests.

The fourteenth table shows the results of the Fourier transform infrared spectroscopy tests.

The fifteenth table shows the results of the X-ray diffraction tests.

The sixteenth table shows the results of the scanning electron microscopy tests.

The seventeenth table shows the results of the transmission electron microscopy tests.

The eighteenth table shows the results of the atomic force microscopy tests.

The nineteenth table shows the results of the scanning tunneling microscopy tests.

The twentieth table shows the results of the electron spin resonance tests.

The twenty-first table shows the results of the nuclear magnetic resonance tests.

The twenty-second table shows the results of the ultraviolet-visible spectroscopy tests.

The twenty-third table shows the results of the Raman spectroscopy tests.

The twenty-fourth table shows the results of the neutron scattering tests.

The twenty-fifth table shows the results of the synchrotron radiation tests.

The results of the tests show that composite materials generally exhibit higher strength and stiffness than metal materials. However, composite materials are more susceptible to damage from impact and fatigue.

The results of the tests also show that composite materials have a higher modulus of elasticity than metal materials. This means that composite materials are stiffer than metal materials.

The results of the tests also show that composite materials have a higher ultimate tensile strength than metal materials. This means that composite materials can withstand higher tensile loads than metal materials.

The results of the tests also show that composite materials have a higher ultimate compressive strength than metal materials. This means that composite materials can withstand higher compressive loads than metal materials.

The results of the tests also show that composite materials have a higher ultimate shear strength than metal materials. This means that composite materials can withstand higher shear loads than metal materials.

The results of the tests also show that composite materials have a higher ultimate combined loading strength than metal materials. This means that composite materials can withstand higher combined loading loads than metal materials.

The results of the tests also show that composite materials have a higher ultimate impact strength than metal materials. This means that composite materials can withstand higher impact loads than metal materials.

The results of the tests also show that composite materials have a higher ultimate fatigue strength than metal materials. This means that composite materials can withstand higher fatigue loads than metal materials.

The results of the tests also show that composite materials have a higher ultimate creep strength than metal materials. This means that composite materials can withstand higher creep loads than metal materials.