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NASA TECH BRIEF

Lewis Research Center

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
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Category 04