NASA TECH BRIEF

Polyimide Polymers Provide Improved Ablative Materials

Continuing research has been directed towards improving the capability of ablative materials to withstand more severe engine combustion environments. Results from this research indicate that these materials have application in supersonic aircraft structures, circuit boards, and adhesive formulations.

Silica-reinforced plastic ablative materials have been studied recently, and it has been shown that the principal heat absorption occurs from the in-depth reaction of silica with carbon to form silicon monoxide and carbon monoxide, e.g., $SiO_2 + C \rightarrow SiO + CO$ (heat absorbed is 2.06 Kcal/gm of reactants). Thus, the higher the degree of completion of this highly endothermic chemical reaction per unit weight, the higher the capacity of the ablative material to absorb heat.

Current silica-reinforced plastic ablative materials are formulated from phenolic resins. The resultant ablative composite contains approximately 30% resin, which, during ablative pyrolysis, yields about 50% conversion to char (15% char absolute). By substituting a higher-charring resin for the conventional phenolic resin, the ablative capacity of the resultant composite material can be enhanced.

Polyimide polymers are such high-char resin systems. During pyrolysis, these polymers convert to about 80 weight percent char. By preparing a composite material composed of 20% polyimide resin, the product obtained after pyrolysis consists of 16% char. The 16% char (carbon) and 80% silica represent equal molar quantities and result in more reactants being available for the SiO_2-C endothermic reaction. Consequently, this polyimide ablative composite has a significantly higher capacity to absorb heat.

Theoretical ablative reaction capacity for any resin-silica system is not totally achieved because of kinetic limitations. A solid state reaction is involved and the carbon and silica must diffuse together to provide contact of unreacted materials as the reaction proceeds. Silica is present in glass fiber form and probably never comes in total contact with the available carbon in the system. Therefore, by using finer diameter silica filaments, which provide considerably more surface area per unit volume, the silica-carbon reaction is significantly improved. It is not advised that powdered silica be used because it would be blown from the ablator combustion gas interface. Thus, the finer diameter silica fiber is recommended.

Notes:

1. The new polyimide polymers, their properties and other applications, are described in NASA Tech Brief 69-10118.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B70-10300

Patent status:

No patent action is contemplated by NASA.

Source: E. Burns, J. Jones and H. Lubowitz of TRW Systems Group under contract to Lewis Research Center (LEW-10861)

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