EXPLORATION OF 3D PRINTING A NEW POLYSILOXANE COMPOSITE FOR HIGH TEMPERATURE APPLICATIONS

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Abstract

Thermal protection materials are a necessary component for high-temperature applications because they serve as protection for delicate components, structures and payloads. Advanced composites are the materials of choice for these applications because of their ability to be fine-tuned for specific parameters. Current thermal protection materials are usually manufactured with fiber reinforced polymer composites. Phenolic resins, specifically SC-1008, are the preferred matrix materials for thermal protection material systems because of their low cost and abundant characterization. Techneglas UHTR resin has recently been explored as a better alternative to phenolic resins and it has vastly outperformed phenolic's thermal properties. Current thermal protection material manufacturing and fabrication processes are very labor intensive and design freedom is limited. There is an inherent need to automate the manufacturing process and create more design flexibility. 3D printing presents a solution to current thermal protection material manufacturing limitations. The goal of this research was to develop and characterize a UHTR composite that can be 3D printed (extruded) into thermal protection for high-temperature applications. The resin was mixed with milled carbon fiber (MCF) and phenolic microballoons (PMB) to form the composite. The initial research was focused on understanding the material system and optimizing it for 3D printing. This involved determining the proper curing mechanism, between multiple catalysts and thermal curing as well as determination of the proper loading levels of the two fillers. A final material system of 10wt%

MCF/5wt% PMB was selected because of its performance during DMA, TGA, and flexural testing. The UHTR resin was tested for UV curability and it was found not to be compatible with UV curing. UHTR uses IPA to control its viscosity and rheological studies were conducted to determine the optimal amount needed for extrusion and it was concluded that 15wt% was ideal for this application. Finally, an auger extruder prototype was developed that was adapted to an off the shelf TAZ LulzBot 3D printer. These fundamental studies will be used as a foundation for future work in UHTR characterization and 3D printing of thermoset resins.

Key Words: Thermal Protection, Polysiloxane, Ablation, 3D Printing, Thermoset