NASA SBIR 2019 Phase I Solicitation

A1.10 Hypersonic Technology - Innovative Manufacturing for High Temperature Structures

Lead Center: LaRC

Participating Center(s): LaRC

Technology Area: TA15 Aeronautics

Hypersonic aircraft have structural challenges that require significant advances in materials and in their manufacturing processes. Because a hypersonic aircraft must be streamlined for low drag, it is volume limited with sharp leading edges and thin wings, and it has tight integration of the propulsion system and the airframe.

Aerodynamic friction produces external structure temperatures above 1,000° C, and heating of the internal surfaces of propulsion structures necessitates their cooling. Therefore, the low mass/high structural efficiency requirement for subsonic aircraft is made more complex by these thermal requirements.

The focus of this subtopic is advanced manufacturing (e.g., additive) that enables cost-effective fabrication of structurally efficient components such as wing, control surfaces, and fuselage structures that operate as hot structures for multiple flights. Also, of interest are innovative manufacturing approaches for engine panels with integral cooling passages that are lightweight and can accommodate thermal growth mismatches with their manifolds and adjacent panels. Manufacturing approaches that can fabricate complex thermal management devices, such as heat-pipe-cooled leading edges—that serve as “heat spreaders” to eliminate hot spots from aerodynamic heating—are also within scope of this subtopic.

Further, the current state-of-the-art for hypersonic hot structures is either nickel-based superalloys or high temperature ceramic-matrix composites. Nickel-based superalloys are heavy and are also limited in their maximum use temperatures. Ceramic-matrix composites have higher use temperatures, but are brittle, are difficult to manufacture, and have limited useful life in service. Hence, an additional goal of this subtopic is to discover new materials that are lighter in weight but capable of repeatedly reaching service temperatures up to 1,000° C through use of advanced manufacturing techniques like additive manufacturing.

Specifically, this subtopic is seeking advanced metallic materials that:

- Can replace current state-of-the-art nickel-based alloys with new alloys that are lower in weight (e.g., gamma titanium aluminides, beryllium-containing alloys, refractory alloys, high temperature metal matrix composites, and oxide dispersion-strengthened alloys).
- Are capable of surviving multiple excursions to temperatures >1,000° C.
- Are resistant to high temperature oxidation.
- Are tough enough to handle thermal shock from sudden changes in temperatures under load.

In combination with these advanced materials and advanced manufacturing methods (including additive manufacturing approaches), this subtopic is seeking capabilities that can: Fabricate complex geometries, such as incorporating cooling passages or integral heat pipes for thermal management; or, providing novel shape controls that enable resiliency and flexibility for seals or connecting hot structures:

- Provide transition from a high-temperature low coefficient of thermal expansion material to a higher coefficient of thermal expansion material, such as connectors between dissimilar materials.
- Provide multi-functionality, incorporating thermal management and structural load capabilities into an integrated component.
- Enable novel materials through novel manufacturing approaches, such as in-situ reactions to form reinforcing phases within the metallic materials during processing; or, functionally graded structures with different materials in different parts of the same component.

The expected Technology Readiness Level (TRL) range at completion of the project is between 2-4.

High temperature materials and manufacturing of relevant shapes with these materials is a challenge that has not been fully exploited. Materials development is a long lead-time research area, and engaging innovation across a wider community through SBIR provides time to develop technologies that can be enabling for future hypersonic vehicles. Accordingly, during Phase I, it is expected that feasibility will be demonstrated to fabricate novel materials using advanced manufacturing methods that meet the environmental, thermal, and structural requirements for high temperature hypersonic vehicles. These would involve simple geometries and material characterizations that show the potential of the material and manufacturing approach selected. During Phase II, the process and materials should scale up to larger, more complex, and realistic components relevant to hypersonic hot structures applications.

Deliverables include understanding of the process and materials used, as well as realistic prototype components relevant to hypersonic hot structures applications.

References:

https://www.nasa.gov/aeroresearch/programs/aavp/ht