NASA SBIR/STTR Technologies

T12.02-9985 - Integrated Reacting Fluid Dynamics and Predictive Materials Degradation Models for Propulsion System Conditions

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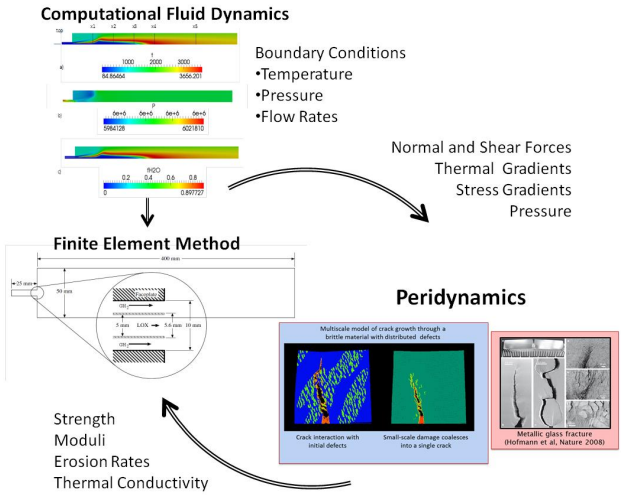
Identification and Significance of Innovation

Computational fluid dynamics (CFD) are routinely used by NASA to optimize the design of propulsion systems. Current CFD methods rely on general materials properties, which introduces uncertainty when conditions where materials degrade and properties may change. CFDRC together with Sandia National Laboratories propose to develop a computational materials model to simulate the degradation ceramic composite materials based on peridynamic (PD) theory, a formulation of continuum mechanics that describes fracture and damage at the microstructure level. CFD modeling will be used to determine thermal mechanical stress states at the boundaries and PD simulations will be used to predict damage as a function of microstructure and boundary conditions. Methods to link materials properties with the CFD system will be evaluated. The objective is to provide NASA a computational tool to assist in the selection and optimization of materials for propulsion system applications.



Estimated TRL at beginning and end of contract: (Begin: 2 End: 3)

Technical Objectives and Work Plan

The overall technical objectives of the Phase I effort are to develop and demonstrate a computational model to dynamically simulate fracture and mechanical erosion of a ceramic matrix composite at the mesoscale and to develop a method to integrate changing materials properties into a CFD simulation.To meet these objectives, the team will:

.Produce a model for damage accumulation in a brittle fiber reinforced composite using peridynamics theory.
.Perform CFD simulations of the propulsion environment to determine boundary conditions for the materials model.
.Develop a coupling scheme to link materials properties as a function of damage from a mesoscale simulation to CFD.Evaluate the current state of materials interaction in CFD methods and assess the improvement gained with better materials integration.

The work plan will focus on executing the following tasks:

Demonstrate peridynamics simulations of degradation in a ceramic matrix composite.
Model erosion of a ceramic matrix composite material using peridynamics simulations.
Perform CFD simulations of the propulsion system environment.

NASA Applications

Integrated computational materials engineering is an enabling technology to accelerate the development and incorporation of advanced materials. The work product falls within the scope of ICME as a means to link material features to product performance. This work can be adapted to assist material selection in any application where mechanical degradation limits performance, such as ablative and high temperature materials for hypersonic environments.

Non-NASA Applications

DoD supported programs such as the development of hypersonic systems face challenges in selecting and incorporating materials for extreme environments. Performance of energy systems for power generation and fossil energy extraction are also limited by material degradation. The work established in this project can be transitioned to support these other applications.

Firm Contacts

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