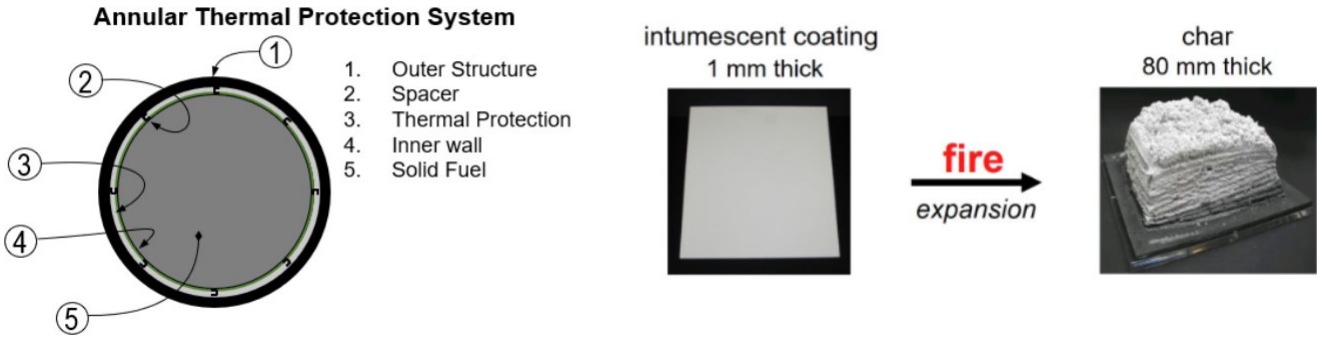
PROJECT SUMMARY 5542.003

High Temperature Applications Using Additive Manufacturing, Phase 2
Task 3 - Thermal Coating Material Advancement for Rocket Motors



Massive insulation of intumescent coatings may reduce the temperatures that structural materials are exposed to and allow less exotic composites in solid rocket motor designs and high-temperature applications.

PROBLEM

The processes for using ceramic matrix composites (CMCs) in air-breathing propulsion systems to form a matrix in solid rocket motors are lengthy and iterative. There is a need to reduce the time and cost of manufacturing CMCs and expand the supply chain beyond a smaller number of domestic CMC manufacturers. Research must be performed to develop composite laminate architectures that can withstand extreme temperatures. Intumescent coatings have the potential to reduce the manufacturing cost and schedule of high temperature composites by using additively manufactured materials, thermosetting bismaleimides (BMIs), and cyanate ester laminates. However, the mechanical bonding properties between intumescent coatings and composite layers, as well as the temperature performance in these applications, are unknown.

OBJECTIVE

The objective of this project is to identify and test intumescent coatings that will allow the use of bismaleimide (BMI) and cyanate esters in composite casings used in solid-propellant rocket motors. Testing includes:

- Bonding performance of intumescent coatings from several manufacturers that employ a variety of chemical makeups with composite materials to determine which layer combinations have acceptable bond strength that merit further study in temperature performance.
- Insulative properties of the intumescent coatings and composite materials with acceptable bond strength for near-future defense programs.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to: MATERIAL

ASTM PROCESS CATEGORY
Material Extrusion, Sheet Lamination

EQUIPMENT
Tensile Test Machine

MATERIAL
15+ Intumescent Coatings

TECHNICAL APPROACH

This project explores the use of an intumescent coating system to create a thermal protection system between solid rocket fuel and the casing structure. The reason for the use of an intumescent coating is that it swells when exposed to heat, which impedes heat transfer, and will not fully expand when sandwiched between casing and propellant.

Intumescent coatings that are not subjected to supply chain issues will be identified and screened. Screening will consist of lap shear testing per ASTM D3163 and climbing drum peel testing per ASTM D1781. Measures will be taken to keep the intumescent layer in place when measuring the physical properties through shear and peel strength testing. Intumescent coatings that demonstrate sufficient bonding performance will be further tested to determine the steady state thermal conductivity reduction and deformation of intumescent expansion in the annular space between coaxial cylinders. Results and recommendations will be summarized in the final report.

PROJECT START DATE

March 2023

EXPECTED END DATE

January 2025

EXPECTED DELIVERABLES

- Test Results, Lap Shear
- Test Results, Climbing Drum Peel
- Expansion Flat Panels
- Expansion Cylindrical Specimens
- Final Project Report

FUNDING

$10,582,407 total project budget
($9,150,000 in public funding/$1,432,407 in private funding)

PROJECT PARTICIPANTS

Project Principal:
Blue Force Technologies (BFT)

Other Project Participants:
America Makes/NCDMM

Public Participants:
U.S. Department of Defense