Defense-Wide Manufacturing Science & Technology (DMS&T) Program

Near Net Shape Manufacturing of Ultra High Temperature Components by Field Assisted Sintering Technology (NNSM-FAST)

PROBLEM / OBJECTIVE

Future rocket and missile systems will need non-eroding, dual-pulse-capable nozzles for increased thrust and maneuverability and Mach 8 leading edges for global strike capability.
Current Carbon-Carbon (C-C) composites do not have the required erosion resistance and temperature capabilities to meet these challenges.

- Therefore, ultra high temperature materials (UHTM) such as W and carbides/borides of Ta and Hf are required.
- These UHTMs exhibit high strength and are resistant to creep and erosion under the desired conditions.

Current consolidation processing via Pressure-less Sintering, Hot Pressing, Vacuum Plasma Spraying & Hot Isostatic Pressing are inadequate, cost prohibitive or cannot achieve full densities required for these aero heated components.

APPROACH / BENEFITS

Objective

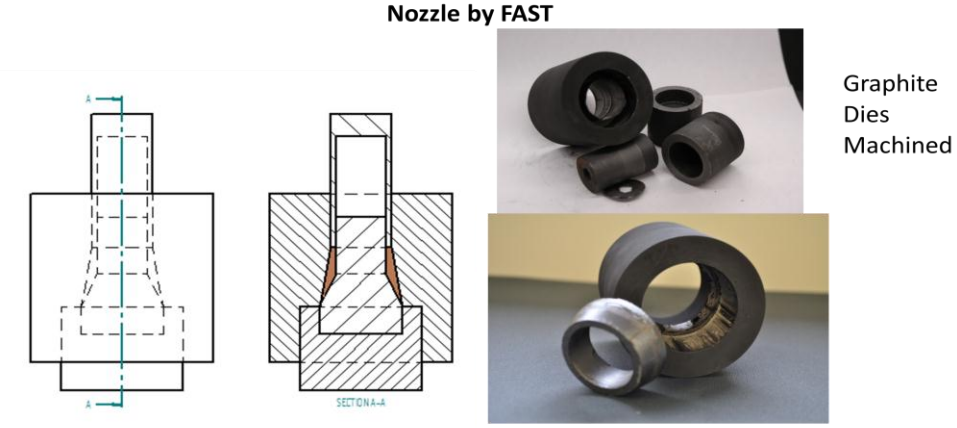
- Produce full scale Bulk and Near Net Shaped - FAST nozzles and leading edges out of advanced refractory/ceramic materials and deliver them for full scale rig testing at MDA and AFRL.

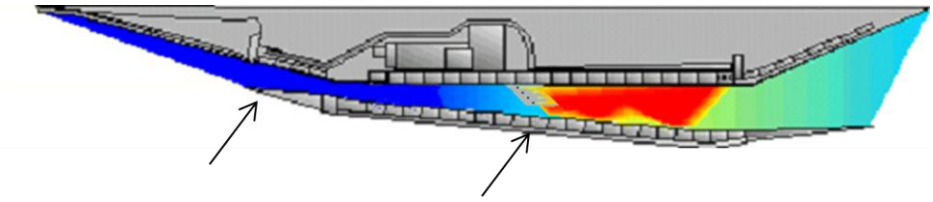
Approach

- Develop Field Assisted Sintering Technology (FAST) coupled with Near Net Shape Manufacturing (NNSM) for reducing material usage and machining cost, time and waste.
- **SRM Nozzles -** Retain the fine lath microstructure found in the FAST bulk processed TaC-C3 alloy; this includes acicular grain structure that contains second phases and a high concentration of aligned precipitates and stacking faults.
- **Leading Edges** - Advance high temperature alloy based on carbides containing Hf and Ta for Mach 7-10 applications. Process in monolithic and functionally graded forms if needed; design new attachment for close packing and alignment; retain fine microstructure needed for strength, toughness and oxidation resistance; produce multiple NNSM-FAST parts out of a single run; validate by scram jet testing.

- Transition to industry in 3 to 5 years with no government sustainment cost through reductions in use of refractory/rare earth materials and waste.

Preliminary Results of Near Net-Shaped Nozzle by FAST





Cowl Leading Edge **Fuel Injection Strut Leading Edge**

Expected Benefits and Warfighter Impact

- **Provide Advanced Rocket and Missile Nozzles** for Standard Missile 3-Block 2B, Enhanced Intercontinental Ballistic Missiles, and Solid Rocket Motor Heavy Lift
- **Provide Advanced Leading Edges** for Mach 6 to 8 reusable launch, X-51A-like and future hypersonic strike
- **Financial ROI** - Reduce material usage, machining time and cost by at least 50% (part dependant). Example: Production time reduced from 1 month to 2 weeks; cost for 1 nozzle liner reduced from $8,880 to $1,385.
- **Cycle time** - Reduce part fabrication cycle time up to 75 %
- Advance the only available technology capable of producing full density, large diameter, tall components capable of Mach 6 +.

POINT OF CONTACT

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