National Aeronautics and Space Administration

Photon Doppler Velocimeter to Measure Entrained Additive Manufactured Bulk Metal Powders in Hot Subsonic and Supersonic Oxygen Gas

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HAT: 1.2b-E TA: 1.2 Liquid Rocket Propulsion Systems TRL: start 3/ current 4

INNOVATION CHARGE ACCOUNT (ICA) PROJECT OVERVIEW

Parts produced by additive manufacturing, particularly selective laser melting (SLM), have been shown to silt metal particulate even after undergoing stringent precision aerospace cleaning processes (Lowrey 2016).

As printed parts are used in oxygen systems with increased pressures, temperatures, and gas velocity, the risk of ignition by particle impact, the most common direct ignition source of metals in oxygen, substantially increases. The White Sands Test Facility (WSTF), in collaboration with Marshall Space Flight Center (MSFC), desires to test the ignitability of SLM metals by particle impact in heated oxygen.

The existing test systems rely on gas velocity calculations to infer particle velocity in both subsonic and supersonic particle impact systems. Until now, it was not possible to directly measure particle velocity. To increase the fidelity of planned SLM ignition studies, it is necessary to validate that the Photon Doppler Velocimetry (PDV) test system can accurately measure particle velocity.

INNOVATION

The innovation of this ICA is the creation of hardware to integrate modern instrumentation into existing state-of-the-art ignition test systems. The opportunity to directly measure metal particle velocity in flowing oxygen will allow for a validated entrained particle velocity model and increased confidence in test condition fidelity to meet modern testing demands.

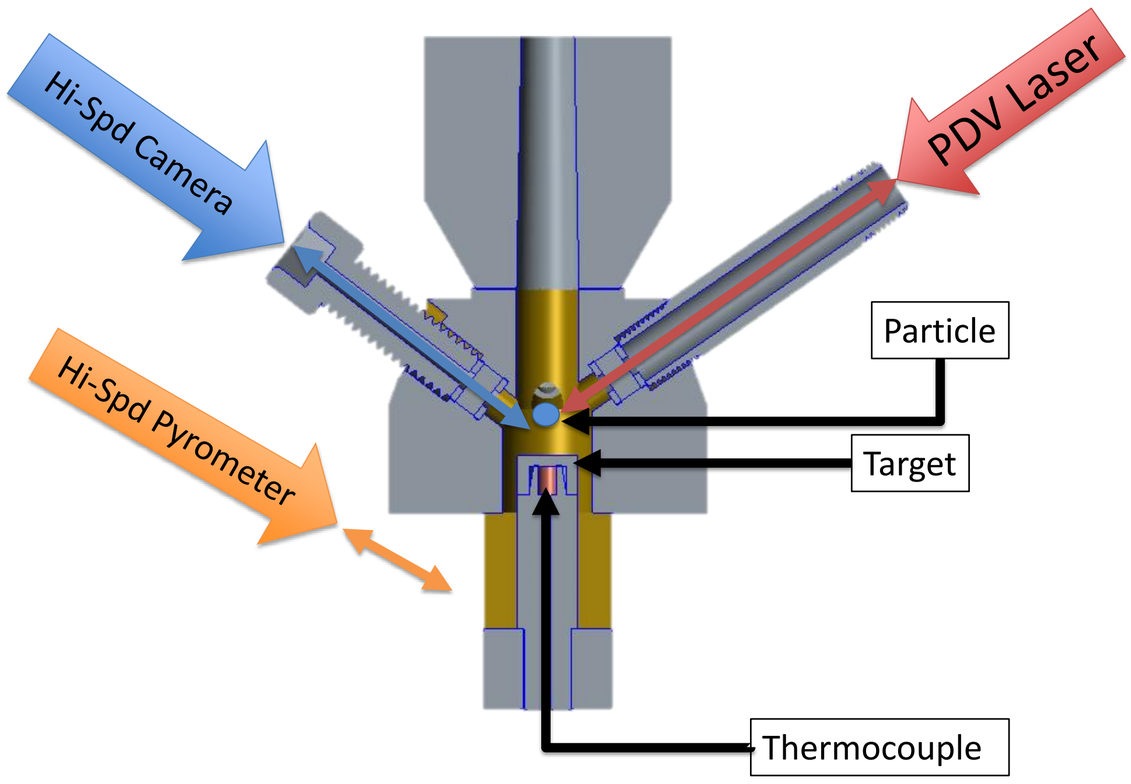
OUTCOME / RESULTS

- MSFC conducted particle size and morphology study from an SLM print at various positions relative to the part. In addition, they provided characterized samples with documentation to WSTF.
- Validation and integration of high-speed pyrometer to PDV data acquisition systems as pre-trigger for particle impact.
- Completion of supersonic chamber modifications to allow direct PDV measurements immediately before impact and high-speed video during impact.
- Completion of hardware to integrate PDV laser into current subsonic chamber port.

INFUSION FOR SPACE / EARTH

- This technology may be used to increase the fidelity of particle impact ignition testing to aid in the development of high performance liquid rocket propulsion and life support systems.

PICTURE OF ICA-DEVELOPED PROTOTYPE



PARTNERSHIPS / COLLABORATIONS

Studies performed by MSFC were instrumental in ensuring the particles WSTF entrains are representative of particles that could be found inside additively manufactured parts.

FUTURE WORK

- Acquire PDV data using system modifications.
- Apply data collected to models of particle impact.
- Perform ignition studies using SLM material.