Energetic Materials Additive Manufacturing
Probing an Unbound Trade Space

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Abstract:

Digital design and automated production remains largely absent from energetic materials processing. Driven by safety considerations and conservative by nature, improvements tend to be evolutionary – rather than revolutionary – and processing methods remain labor intensive. The ability to print an energetic material represents a paradigm change in processing methodology while the unique, unbound trade space characteristic of additive technologies provides a novel means to control energy release. This analogue-to-digital transition presents a unique set of challenges as it occurs at the intersection of process safety, part performance and economics of ordnance production.

As advancements in military-grade materials are inherently a warfare center-centric activity, a fundamental investigation into print processes as well as new materials suitable for the additive environment is warranted to evaluate this trade space. For example, commercially available materials typically suffer from at least one deficiency: chemical incompatibilities with common ingredients such as ammonium perchlorate or cyclotetramethylenetetranitramine, elevated processing temperatures, glassy or brittle behavior at low temperatures, or the inability to be filled up to and beyond 75 vol% with solid particles. By understanding the key processing cause-effect relationships (e.g. heat transfer during extrusion, mass loss of a mobile phase), it is possible to inform formulation requirements (e.g. melt flow, electrophoretic mobility) to design materials (including synthesis of new polymers) which meet functional requirements (e.g. low glass transition).

Biography:

Andrew Ihnen is a research scientist and has worked for the U.S. Navy since 2012 at the Naval Air Warfare Center Weapons Division prior to moving to the Naval Surface Warfare Center Indian Head EOD Technology Division, at Indian Head, Maryland in 2018. He received a Bachelor of Science in civil engineering from Virginia Military Institute in 2006 and a Master of Engineering and Doctorate in Materials Engineering from Stevens Institute of Technology in 2008 and 2012, respectively. Dr. Ihnen is currently investigating the formulation of energetic materials for printing using a wide range of additive manufacturing technologies, as well as high-performance explosives. His work is detailed in multiple publications and he has received both the Dr. William B. McLean Award and the Michelson Laboratory Award in recognition of his work from the Naval Air Systems Command.