Thermite additive manufacturing feedstocks

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Abstract

Thermites are mixtures of metals and metal oxides that are traditionally valued for their high reaction temperature, low gas production, molten solid reaction products and low explosive sensitiveness. This makes these formulations ideal for cutting, welding, and incendiary devices that require controllable burn rates and optimum heat production. Traditional thermites are used in powdered or block form. This requirement limits the geometry of thermite charges and can restrict their application. The pressing of thermite blocks is a process that has inherent hazards, and the final products can have mechanical or ignition failures, especially when multiple blocks are required to produce the desired effect (e.g. variable burn rates). A potential means of overcoming the geometric limitations and hazards associated with the production and handling of traditional thermite formulations is to employ additive manufacturing (AM). AM represents a means of producing energetic materials with bespoke, multi-material charge geometries that offer tailored energy release, improved safety and handling as well as on-demand production. Complex three-dimensional architectures can be obtained by the sequential layering of energetic material via extrusion-based AM technologies, but the successful use of such AM techniques requires the development of thermite feedstocks that are compatible with the printer technology in question. This paper provides outcomes of initial AM-compatible thermite feedstock development research centred on satisfying ingredient compatibility and safe handling and processing whilst meeting nominal performance requirements. Results will be presented for traditional copper(II) oxide (CuO)/aluminium and bismuth(III) oxide (Bi_2O_3)/aluminium powder-based thermites and these will be compared with solvent-based, binder-containing feedstocks that employ the same fuel-oxidiser constituents, with identical stoichiometry and that are suitable for extrusion-based AM.