Considerations in the Adaptation of Cold Spray to High-Performance Polymers

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The capabilities of the relatively nascent field of polymer cold spray currently lag behind those of more well-established metallic and ceramic systems. One reason for this disparity is the prevalence of more complex intermolecular and intramolecular interactions unique to polymers not yet understood in the context of cold spray. Thermal phenomena absent in metals and ceramics may arise, including chain relaxation, glass transition, cross-linking, and partial crystallinity. Furthermore, the thermal properties of a polymer particle are conducive to non-uniform temperature profiles, whereas metallic particles are assumed to be uniform in temperature. Because the mechanical behavior of polymers is highly dependent on both temperature and thermal history, the transfer of heat through and across the domain of a sprayed particle cannot be ignored.

This work presents multiple instances of these thermomechanical phenomena occurring across thermoset, thermoplastic, and thermosetting polymer systems and their effects on cold spray processing parameters and deposition characteristics. Our research is divided into four sectors: simulations of impact velocity and temperature, preheat of feedstock, polymer crystallinity, and feedstock preconditioning. First and foremost, simulations of poly(etheretherketone) (PEEK) show that particles can have internal thermal gradients of 70-100 K, which significantly affect surface material properties and deposition characteristics. While impact temperatures can generally be manipulated by particle pre-heating or cooling, surface physics and chemistry must also be considered. Fluoropolymer flow and deposit properties have been shown to be sensitive to preconditioning and storage conditions, and sprays of semicrystalline poly(etherketoneketone) (PEKK) demonstrate that rigid, brittle crystalline domains inhibit plastic deformation-driven deposition.