Crystal Plasticity Modeling Effort to Capture Microstructural Variations in Cold Sprayed Materials

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Microstructures and mechanical properties of cold spray additively manufactured Aluminum 6061 showed non-uniformity with spatial variation in microstructure and mechanical properties affecting the overall response of the additively manufactured parts. The high-velocity impact of powder particles created intersplat boundaries with regions of high dislocation densities and sub-grain structures. Full-field crystal plasticity simulations showed that the distribution of smaller grains along the intersplat regions is responsible for localized stress spots and larger grains away from intersplat boundaries accommodate initial plasticity. The mechanical tests performed on the specimens were done in the in-plane direction with the expectation that it would behave similarly to that of rolled material than of build direction. The build direction was believed to behave minorly due to the tension acting on the intersplat boundaries which would pull apart much more easily than those in the in-plane direction. An expectation of the normal plane, or in-plane, was that it would have a higher number of intersplat boundaries. Due to the higher number of intersplat boundaries, we can expect to see a higher localized stress in these areas versus the build plane diection. In this work, we attempt to implement the effects of grain size and distribution of smaller grains along the intersplat boundaries using the grain size and powder size distribution function to accurately predict the deformation response of cold sprayed material using a mean-field viscoplastic self-consistent model. Then, the model was calibrated, validated, and verified using uniaxial tension and compression data at various strain rates. The authors gratefully acknowledge support from The Office of the Secretary of Defense (OSD), DEVCOM - Army Research Laboratory and LIFT through the "K005-01 PROJECT# 21025" grant, entitled, "Research Utilizing the Chemistry–Process–Structure–Property–Performance (CPSPP) Paradigm".