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Thermomechanical Deformation Response in Cold Sprayed SiCp/Al Composites: Strengthening, Microstructure Characterization, and Thermomechanical Properties

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Abstract : SiC_p/ pure Al composites with different SiC fractions (20 wt %, 30 wt %, and 40 wt %) were precisely cold sprayed, followed by hot axial-compression tests at deformation temperatures of 473 K to 673 K, leading to failure of specimens through routine crack propagation in their multiphase. The plastic deformation behaviour with respect to the SiC_p contents and the deformation temperatures were studied at strain rate 1s-1.As-sprayed and post-failure specimens were analyzed by X-ray computed tomography (XCT), transmission electron microscopy (TEM), and scanning electron microscopy (SEM). Quasi-static thermomechanical testing results revealed that compressive strength (UTS = 228 MPa and 30.4 %) was the highest in the composites that was thermomechanically compressed at 473 K compared to those of the as-sprayed, while the as-sprayed exhibited a compressive strength of 182.8 MPa related to the increment in SiC fraction. Strength—plasticity synergy was promoted by dynamic recrystallization (DRX) through strengthening and refinement of the grains. The DRX degree depends relevantly on retainment of the uniformly ultrafine SiC_p particulates, the pinning effects of the interfaces promoted by the ultrafine grain structures (UFG), and the higher deformation temperature. Reconstructed X-ray computed tomography data revealed different crack propagation mechanisms. A single-plane shear crack with multi-laminates fracture morphology yields relatively through the as-sprayed and as-deformed at 473 K deposits, while a multiphase plane shear cracks preeminently existed in high temperature deformed deposits resulting in multiphase-interface delaminations. Three pertinent strengthening mechanisms, videlicet, SiCp dispersed strengthening, refined grain strengthening, and dislocation strengthening, existed in the gradient microstructure, and their detailed contributions to the thermomechanical properties were discussed.

Keywords : cold spraying, hot deformation, deformation temperature, thermomechancal properties, SiC/Al composite
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