The Third Sandia Fracture Challenge: A Deep Dive into the Experimental Results

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ABSTRACT

Experimental validation results are critical in the development of computational solid mechanics models used to predict ever increasingly complex deformation and failure of structures in extreme environments. The Sandia Fracture Challenge (SFC) provides the solid mechanics community a forum for assessing the ability to predict ductile fracture and failure, which has led to three separate challenges consisting of unique "toy problem" specimen geometries, standard calibration data and evolving experimental techniques [1-3].

The third challenge SFC3, as the third installment, featured the use of advanced diagnostics such as Digital Image Correlation (DIC) to capture full-field strains for an additively manufactured (AM) 316L Stainless Steel with internal features, asking critical questions regarding comparisons of full-field simulation and experimental results. Two independent laboratories tested nineteen specimens that all cracked beginning at the edge of the central through-hole, emanating out along angled channels that intersected the through-hole. These specimens had relatively modest bounds in load-displacement behavior with more variability in the surface strain response of the AM structure.

Based on the identified successes and shortcomings of the comparisons between predictions and experimental data, additional experiments were conducted to probe underlying mechanisms of the observed failure mode and crack path trajectory [4]. One surprising observation from the SFC3 was that the Challenge-geometry specimens had low variability in global load versus displacement behavior, attributed to the large stress-concentrating geometric features dominating the global behavior, rather than the AM voids that tend to dominate geometries with uniform cross-sections. This study reinvestigates the damage and failure evolution of the Challenge-geometry specimens, utilizing interrupted testing with micro-computed tomography (micro-CT) scans to monitor the AM void and crack growth from a virgin state through complete failure.

The accomplishments listed above are made possible by giving both experimentalists and computationalists alike a place to evaluate and improve techniques, towards more accurate ductile failure predictions.

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