Carleton UNIVERSITY | DEPARTMENT OF Mechanical and Aerospace Engineering

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The Application of 2D Digital Image Correlation (DIC) System on Strain Measurements and Fatigue Crack Growth Analysis for Polymer Additive Manufacturing (AM) Parts

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Abstract:

This paper introduces the novel application of 2D digital image correlation (DIC) for polymer additive manufacturing (AM) parts. First, the application of DIC method for two-dimensional strain measurement on 3D printed samples is discussed and a comparison between the DIC strain results and the strain measurements obtained from the extensometer was validated. Second, DIC method was found to be a very promising technique for crack growth analysis for AM polymer parts. In this study, two software tools were employed for crack growth analysis. The Ncorr DIC analysis software is used to detect and monitor fatigue cracks, both for initiation and propagation for each set of cycles. Additionally, ImageJ software is utilized to measure the crack lengths within AM specimen. Also, a tensile test was carried out for six coupons that were manufactured based on ASTM D638-10 - Standards for Polymer Tensile Testing. The specimens were printed at different angles of orientations (0°, 45°, and 90°). Three of them were manufactured using a Stratasys BST 1200es fused deposition machine (FDM) and other three printed on a low cost commercial desktop 3D printer – the Creality CR–10. In addition, three fatigue initiation tests were performed on low K_t fatigue coupons that also printed at three orientations (0°, 45°, and 90°) orientations using the Stratasys BST 1200es FDM machine. The full field strain of polymer additive manufacturing parts was successfully measured by using the 2D DIC technique. The results demonstrated a great similarity between the strain collected from DIC system and the strain obtained from a conventional extensometer in AM deformed polymer specimen with a neglected error percentage. The sources of errors are discussed, including the influence of test setup parameters on the accuracy of DIC method. The advantages of using DIC as a strain measurement technique over traditional mechanical extensometer are explained. Based on fatigue crack analysis, AM parts manufactured with 45° orientations found to have more fatigue life compared with parts built with 0° and 90° angles of orientations. For full field strain measurements, it was observed that the maximum vertical strain was located at the top of specimens and the minimum at the bottom.

BIOGRAPHY

Hayat El Fazani *received a BSc. and MSc. in Aeronautical Engineering from the University of Tripoli in Libya. In her master, she ranked number one at the Facility of Engineering focusing on aircraft structures and materials. In Libya, Hayat worked as an Aircraft Safety and Airworthiness Engineer at the Libyan Civil Aviation Authority, where she performed aircraft inspection and aircraft accident and incident investigations. Hayat is currently pursuing a Doctor of Philosophy in Aerospace Engineering in the Department of Mechanical and Aerospace Engineering at Carleton University working on research of Additive Manufacturing and Related Certification Challenges for Aerospace Applications under Professor Jeremy Laliberté supervision. She is examining current and emerging certification regulations for novel materials, processing and mechanical properties of additive manufactured materials and conduct both experimental and analytical investigations of additive manufactured components. In her experimental work, Hayat studies the performance of AM materials where she conducted mechanical testing for AM parts including tensile and fatigue testing. Also, she applied Digital Image Correlation (DIC) for surface strain measurements and for fatigue crack monitoring and crack measurements. Hayat has experience in cold-mounting, polishing as well as image analysis for AM parts including scanning electron microscope (SEM) and microscopy imaging. She also investigated the design parameters of AM parts such as the build orientations and layer thickness. Furthermore, she investigated the thermal characterization of AM materials using the Differential Scanning Calorimeter (DSC) and Thermogravimetric Analysis (TGA). With her recent work, Hayat has worked on different research projects with companies in Canada.*