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Combined Loading Evaluation of Braided Composites

A. Armanfard[1], G.W. Melenka[1*]
[1]Mechanical Engineering Department, York University, Toronto, Canada
*gmelenka@yorku.ca

ABSTRACT

Industries such as aerospace, automotive, sports and medical have been recently turning to extensive use of composite materials for primary and advanced structures due to the high strength to weight ratio of composite materials. Composite materials are the combination of two or more materials that when combined have improved mechanical properties than the individual constituents. However, conventional composites having several ply structures, laminates, suffer from relatively low toughness due to delamination. Manufacturing laminates is labor-intensive, time-consuming and costly. Braided composites, however, are a modified and improved category of composite materials. They feature an interwoven structure that improves structural stability and damage tolerance. Flexibility in manufacturing to the near-net-shape and high production rate are advantages of braided composites. All together along with improved and tailorable mechanical properties of braided composites has made them a candidate for manufacturing key mechanical elements in structures of great significance. Jet engine vanes, aircraft structures, automobile shafts, and bone casts are some examples of braided composites applications. Presently, braided composites under tension and torsion loading have been studied individually. Mechanical behavior of braided composites under combined tension-torsion loading is common, yet few studies have explored this effect. In this study, mechanical properties of Kevlar, Carbon and Glass 2D tubular braided composites were assessed and compared under tension and coupled tension-torsion loading. Regular strain measurement techniques such as strain gauges and extensometers are not practical for braided composites. These techniques cannot demonstrate exact strain behavior of samples under loading because they perform measurements in limited directions and locations. They also do not capture strain variations on inhomogeneous surfaces. However, failure prevention of structures is feasible when largest stresses are known anywhere in the structure which needs accurate and detailed strain information. Therefore, to acquire accurate strain data in every direction for uneven surfaces of braided composites, a more advanced measurement technique must be implemented. In this research project, a contact-free three-dimensional digital image correlation (3D DIC) technique was used to derive detailed and continuous strain maps of curved inhomogeneous surfaces of braided composite samples under combined loading. Stress-strain curves and high-quality strain field figures are obtained and discussed in this research. Benefitting from this research experiment, combined loading as a common and critical loading condition can be analyzed more realistically and accurately in designing elements out of braided composites to prevent structural failures.