Thermo-mechanical responses of fibre-reinforced composites subjected to multi-axial loading conditions: Experimental characterization and numerical life-time prediction

Applications such as pressure vessel, shafts and pipes are generally subjected to multi-axial /biaxial loading. The current practice of designing the FRP components which are inhomogeneous and anisotropic materials based on the uniaxial test data when they are under multi-axial stress state has witnessed to be inadequate and piloted the way to understand the behaviour of these complex materials under biaxial loads. A considerable amount of work has been focused on the biaxial and/or tri-axial loading of isotropic materials where different set of experimental techniques and test procedures were adopted for isotropic materials and similar investigations were carried out on composite materials. The study on composite material, compared to isotropic materials, is more complicated due to the anisotropic and inhomogeneous nature of these materials. Restricting the evaluation of materials mechanical behaviour using uniaxial coupon test may lead to discrepancy in the materials behaviour when used in an engineering structure. Many attempts have been made to understand the behaviour of these materials under multi-axial/ biaxial but were limited, as there is a limited potential to assess the full multi-axial/biaxial response of composite materials. The effects of multiaxial stressing on the fatigue and fracture properties of fibre-reinforced composites are recognized as being even more complex than for metals because (1) biaxial stresses may enhance the damage during loading as a result of the anistropy of strength and stiffness, and (2) several additional problems are encountered during multiaxial testing of composites, such as premature failure of a specimen near the end attachments as a result of poor load transfer. In-plane loading of cruciform specimens along two perpendicular arms is the most pragmatic technique to create biaxial stress states.

The main objective of this project is to introduce a thermo-mechanical testing strategy and conduct a series of uniaxial, cruciform quasi-static biaxial as well as proportional/non-proportional cruciform biaxial cyclic tests on fibre-reinforced composites. This is served to experimentally and numerically study the failure modes of the material such as delamination failure under multi-axial loading and develop a failure envelope (T/T, T/C, C/C) for a better understanding of mechanical properties and life time prediction.

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