Proceedings of the 9th World Congress on Mechanical, Chemical, and Material Engineering (MCM'23)
Brunel University, London, United Kingdom - August 06-08, 2023
Paper No. ICMIE 126
DOI: 10.11159/icmie23.126

Mechanical Behavior and Fatigue Responses of Hybrid Nanocomposite Laminates with Kinked Edge Cracks

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Extended Abstract

The aims of this research work were first to fabricate hybrid Ti/APC-2 neat and nanocomposite laminates. Then, the samples were cut with kinked single- and double-edged cracks by electrically discharged wire machine. The second part was to perform the static tensile tests to obtain their load-displacement diagrams, mechanical properties and failure mechanisms. According to the base-line data of mechanical properties the cyclic tests were conducted to receive the fatigue responses such as the load vs. cycles curves, fatigue life and the process of failure mechanisms.

The work was mainly focused on experiments. The carbon fiber/polyetheretherketon (CF/PEEK) prepregs of 25.4 mm wide were cut and stacked into $[0/90]_s$ cross-ply layups. The cover sheets of Titanium were of 0.5 mm thick and treated optimally by chromic acid method of electroplating. As for nanoparticles of SiO_2 were spread uniformly at the interfaces between 0° and 90° plies with the amount of 1% by weight of original sample [1-2]. The modified diaphragm curing process was adopted [3-4]. The cured panels were cut into samples of L×W×t: 240 mm×25 mm×1.55 mm. The single-and double-edged cracks were of 0.3 mm wide, and the kink angles were of 30°, 45° and 60° at the tips of horizontal main cracks. In conducting both the tension and fatigue tests an MTS-810 servohydraulic computer-controlled dynamic material testing machine was used. To do constant stress amplitude tension-tension cyclic tests the conditions such as stress ratio of 0.1, at frequency 5 Hz, and a sinusoidal wave form under load-controlled mode at room temperature. There were at least 3 specimens for tension tests in each set and listed in the average value with standard deviation; whilst , more than 6 specimens for fatigue tests by using staircase method, and tests stopped at one million cycles with the denotation of run-outs as small arrows to the right.

Until now, the received results were summarized as follows. The length of cracks increasing and kink angles decreasing, their mechanical properties were decreasing. The longer the crack lengths were, the more reduced the properties and life. With the adding of nanoparticles SiO_2 in the interfaces of samples their mechanical properties and fatigue life were enhanced. Thus, the mechanical properties and fatigue life of nanocomposite laminates were improved slightly over those of neat laminates. It was attributed to uniformly spreading the nanoparticle, not concentrated at the tips of cracks and along the path of crack growth. The stress intensity factors (SIFs) at the tips of kinks were obtained for further applications [5]. The complicated mechanisms of crack growth and path delayed the crack tips merged that were observed in double-edged cracks with kink angles. Although the interactive attraction did force both tips to move forwards, they did not head on together, i.e., they circled around to form a very small piece of ellipse. Simply, the two crack tips run around until they merge together with a small broken ellipse. Due to this phenomenon the life of symmetrically double-edge crack with kink angles was longer than a half of life of the counterparts of single-edged cracks with kink angles.

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