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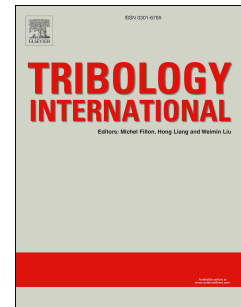
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Finite element modelling of sliding wear in three-dimensional woven textiles

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Abstract: Wear properties of 3D preforms have not been explored in depth, while it plays an important role in their assessment for load-bearing applications. Wear simulation was performed in this paper by employing Archard's wear law. Wear in a unit cell of 3D woven fabric was simulated using user-defined subroutine UMESHMOTION linked with ABAQUS. Wear profile evolution was extracted from displaced contact surface nodes, due to geometry update by adaptive meshing. A parametric study is conducted with the developed wear model to investigate the effect of key parameters on wear rate. The results showed that wear rate in 3D woven textiles increases at higher normal loads and sliding speeds, but the effect of variation in friction coefficient is not significant.

Keywords: Finite Element Simulation, Sliding Wear, Three-dimensional Woven Textile, UMESHMOTION

1. Introduction

Three-dimensional (3D) woven preforms have been developed by adding yarns that pass through the thickness of fabric, in order to stack up several layers of warp (0°) and weft (90°) yarns. They are used as the reinforcement component of 3D textile composites to overcome delamination and poor through-thickness properties that conventional two dimensional (2D) woven composites have [1, 2]. Furthermore, near-net-shape manufacturing method is feasible with 3D weaving, leading to a higher efficiency and lower cost of the final product. Comparing to 2D weaves, 3D woven preforms were found to offer better mechanical performance such as higher through-thickness strength, improved damage tolerance, more than two times higher absorption of impact energy with minimal fiber damage, higher interlaminar toughness and higher strain to failure [3-7]. These features make 3D woven constructs a suitable choice in engine parts, aircraft fairing, military armors, sport equipment, boat hulls, medical and many other applications [5, 7-9]. Due to flexibility in weaving parameters such as pore size, fiber diameter, and type of architecture, desired mechanical properties can be adjusted to achieve strength and resilience required for specific purposes.

Most of previous studies have focused on mechanical characterization of 3D woven composites. There exist numerous experimental studies to investigate their structural behavior under tensile [10-12], compressive [13-15], shear [5, 16, 17], and bending [18, 19] scenarios. Rudov-Clark and Mouritz [12] conducted a set of experiments to study tensile fatigue properties of 3D orthogonal woven composites and found that fatigue life is inversely proportional to binder yarns content, due to fiber cracks in binder direction and debonding during manufacturing. Sun et al. [20] experimentally investigated the bending behavior of 3D non-crimp orthogonal composites and concluded the failure strength was higher for those samples with high binder volume fractions. Pan et al. [21] developed a finite element (FE) model of 3D woven composite under compressive load at high strain rates. Woven preform was assumed to undergo elastic deformation, while elasto-plastic properties were assigned to the ductile matrix and shear damage was identified as the main mode of failure.

On the other hand, wear and friction characteristics of 3D textile composites, especially woven reinforcement, have not been studied thoroughly. Wear is considered as a crucial failure mode that affects the life span of any load-bearing component. Experimental friction and wear studies were

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