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SIMULATION OF CRACK PROPAGATION/DEFLECTION IN CERAMIC MATRIX CONTINUOUS FIBER REINFORCED COMPOSITES WITH WEAK INTERPHASE VIA THE EXTENDED FINITE ELEMENT METHOD

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Abstract

Toughness in continuous ceramic fiber reinforced ceramic matrix composites (CMCs) with dense matrices depends on the properties of the fiber coating or interphase. Multiple criteria have been proposed to describe the mechanism of crack propagation/deflection at the filament scale in brittle matrix continuous fiber reinforced composites; however, most of these criteria fail to account for the presence of an interphase of finite thickness and/or employ unrealistic boundary conditions. Recent simulations employing the extended finite element method (XFEM) have shown that variations in interphase thickness and strength relative to the fibers and/or matrix can have a significant influence on the crack propagation/deflection mechanism. It is shown that primary crack deflection most often occurs when conditions favor secondary cracking in the interphase in front of an approaching matrix crack. Although this mechanism is similar to that argued by Cook and Gordon (Cook J, Gordon JE, Proc. Roy. Soc. A 1964; 28; 508-520), the simulations here indicate that the conditions for secondary crack initiation and deflection of the primary crack can be much different than that which was originally presented in their analytical model. Variations in the properties of the interphase are simulated to produce large deviations in the local crack growth behavior as a matrix crack grows into interphase. Results are discussed relative to what has been observed experimentally.

1. Introduction

Toughness in continuous ceramic fiber reinforced ceramic matrix composites (CMCs) is enabled through one of two mechanisms. In CMCs with a porous matrix, cracks in the matrix lack a stress singularity, and propagate by the means of the sequential failure of the cell walls surrounding the pores when the load is of sufficient magnitude. In this manner, fibers are not subject to a stress singularity from an approaching matrix crack and resist failure due to their superior strength relative to the weaker matrix. The second mechanism is observed in the presence of a fairly dense