ADVANCED ANALYSIS OF SHORT-FIBER POLYMER COMPOSITE MATERIAL BEHAVIOR

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ABSTRACT

Short-fiber polymer composites experience widespread use in many industrial applications, where the orientation state of the short-fibers within the polymer matrix define the material properties of the composite structure. Due to the extensive use of these short fiber products, it is necessary to develop an accurate understanding of the fiber orientation kinematics and the resultant material characteristics of the processed part.

This dissertation presents techniques to accurately represent the orientation state of fibers during the part molding process, and from the orientation state within the processed part predict, statistically, the resulting elastic material characteristics. Higher-order representations of the fiber orientation distribution are presented through the sixth-order orientation tensor fitted closure, and results yield a material stiffness tensor with fewer planes of material symmetry than current fourth-order closures while retaining a more accurate representation of fiber orientation. Analytic expressions for material stiffness expectation and variance are developed and validated through the Monte-Carlo method, and provide a more thorough understanding into the statistical nature of the material stiffness tensor. This work concludes with the presentation of the directional diffusion model for fiber collisions, and results demonstrate a significant delay in fiber alignment beyond existing models while retaining an identical steady state orientation.