JOULE HEAT EFFECTS IN ELECTRIFIED ORGANIC MATRIX COMPOSITES

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Future technological advancements depend to a great extent on the ability to optimize the existing materials and to utilize special properties of new materials in their multifunctional capacities. In this regard, there is an immediate need in the materials that are capable of providing at least one additional function or adapting their performance in accordance to changes in the operating environment. In particular, advanced composite materials present reach possibilities for enhancing their performance by coupling structural capabilities with electrical, magnetic, or thermal functions.

The existing experimental evidence suggests that organic matrix composites sustain less impact damage when an electric field is applied. The intricate interaction of an electrical field and mechanical load is governed by coupling of the mechanical and electromagnetic fields via the Lorentz force as well as by the processes undergoing at the microscopic level: Joule heat, fiber-matrix interface changes, etc.

The current work aims to investigate the effects of Joule heating in composites due to an externally applied electrical field in connection to the composite strength. Joule heating is especially important in the mechanical response of electrified carbon fiber polymer matrix composites that possess relatively low electrical conductivity of fibers and thermal conductivity of the matrix. Both experimental and computational studies have been conducted for unidirectional carbon fiber epoxy matrix plates. The results indicate that Joule heating leads to significant temperature gradients across the composite plates. The increase in the temperature in the center of the plate is proportional to the square of the electric current density. It has been determined that the time required to reach the steady-state temperature is solely a function of the plate's thickness and is independent of the electric current density. It also has been ascertained that within a meaningful range of the material and field parameters arising in the applications, the thermal and mechanical parts of the problem can be uncoupled, and stresses in the plate can be determined after the thermal field is known.

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