ELECTRIC FIELD DISTRIBUTION IN NANOCOMPOSITES CONTAINING ONE-DIMENSIONAL NANOFILLER

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This project report is dedicated to,

my beloved wife, Dyg Norkhairunnisa binti Abg Zaidel ,

my beloved son, Muhammad Qaiser Harraz bin Mohd Ridhuan

my beloved parent, Mohd Sharip bin Abd Talib and Norma Ab Rahman

my beloved parent-in-law, Abg Zaidel bin Abg Pauzi and Siti Aishah Abdullah @Alice Bong Mun Jin,

and

all my siblings and in-laws

for their patience, love, cares, encouragements and endless full support over the entire period of my master study.

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ABSTRACT

The need of having novel insulation systems that are capable to operate in the long term is arising due to their promising features that can significantly improve the electrical, mechanical, thermal and chemical properties in high voltage equipment. In this, polymers show signs of improvement in dielectric properties with the addition of nano-filled materials. The unique dielectric properties of nanocomposites as insulators are closely related to the presence of the interphase, i.e., an interaction zone between the nanoparticle and the polymer matrix. In this study, one-dimensional (1D) nanofillers and their interphases were modeled and analyzed using the Finite Element Method Magnetics (FEMM) 4.2 software. Two possible models of the interphase structure surrounding a nanoparticle were analyzed, i.e., one with rectangular-shaped interphase and the other with circularly-shaped interphase. While the polymer and the nanoparticle were assumed to have fixed permittivity values, different values of the thickness and the permittivity of the nanofiller interphase were assigned to determine their effects on the electric field distribution within nanocomposites. The results showed that the presence of the interphase affected the electric field intensity of the nanocomposites. As adjacent nanoparticles displaced further away from each other, the electric field intensity between the nanoparticles reduced. An attempt was made to relate the presence of the interphase with the breakdown behavior of nanocomposites.

ABSTRAK

Keperluan untuk sistem penebatan baru yang mampu beroperasi dalam jangka masa yang panjang semakin meningkat disebabkan ciri-ciri mereka yang menjanjikan dalam aspek elektrikal, mekanikal, haba dan kimia untuk digunakan dalam peralatan voltan tinggi. Dalam hal ini, polimer menunjukkan tanda-tanda peningkatan dalam sifat penebatan elektrik dengan penambahan bahan nano. Sifat unik penebat elektrik komposit nano berkait rapat dengan kehadiran interfasa, iaitu lapisan interaksi antara partikel nano dan matriks polimer. Dalam kajian ini, partikel nano satu dimensi (1D) dan interfasanya telah dimodelkan dan dianalisa dengan menggunakan perisian Finite Element Method Magnetics (FEMM) 4.2. Dua model struktur interfasa sekitar partikel nano telah dianalisis, iaitu, yang pertama dengan interfasa berbentuk segi empat tepat dan yang kedua dengan interfasa berbentuk bulatan. Nilai-nilai permittiviti polimer dan partikel nano ditetapkan, manakala nilai-nilai ketebalan dan permittiviti interfasa partikel nano dipelbagaikan untuk menentukan kesannya terhadap pengagihan medan elektrik dalam komposit nano. Hasil kajian menunjukkan bahawa kehadiran interfasa menjejaskan keamatan medan elektrik komposit nano. Jika partikel nano bersebelahan berada lebih jauh antara satu sama lain, keamatan medan elektrik antara partikel nano berkurang. Percubaan telah dibuat untuk mengaitkan kehadiran interfasa dengan sifat kekuatan medan elektrik komposit nano.