PARTICLE SIZE EFFECT FROM MICRO TO NANO ON THE THERMAL AND MECHANICAL PROPERTIES OF POLYMER COMPOSITES

by:

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Certificate

This is to certify that the thesis entitled ***"Particle Size Effect from Micro to Nano on the Thermal and Mechanical Properties of Polymer Composites****" submitted by Mr.* ***Mohammad Hossein Alaei*** *to the Indian Institute of Technology Delhi, for the fulfillment of award of the degree, Doctor of Philosophy, is a record of bonafide research work carried out by him under our supervision and guidance. This thesis has been prepared in conformity with the rules and regulations of the Indian Institute of Technology Delhi, New Delhi.*

The thesis, in our opinion, is worthy of consideration for award of the degree of Doctor of Philosophy in accordance with the regulations of the Institute. To the best of our knowledge, the results embodied in the thesis have not been submitted to any other University or Institute for the award of any other Degree or Diploma.

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Abstract

The recent emergence of particulate composites such as nano composites has stimulated tremendous research in material sciences and solid mechanics. Specifically, the incorporation of nano sized objects in a traditional matrix material give rise to advanced composites with improved physical properties. This is due to the fact that atoms at the surface/interface of the inhomogeneities experience a different local environment than atoms in the interior of the material and the equilibrium position and energy of these atoms will, in general, be different from those of the atoms in the interior. For a medium in which the number of atoms near the surface/interface is small compared to the total number of atoms (i.e. conventional composites), such effect is insignificant, and may be rightfully ignored. However, for a fine-scaled material and nano-inhomogeneities with a large ratio of the surface/interface region to the bulk, the surface/interface effect can be substantial.

The thesis unfolds the unique experimental study of uniform shape and size spheres of silica (SiO_2) having a size range from 130 μm down to 15 nm in a selected polymer matrix of polypropylene to study first, the effect of particle size as a unique variable on the thermo-mechanical properties of particulate composites and secondly to identify experimentally for the first time the surface elasticity parameters using the experimental results obtained through the mechanical testing of the manufactured composite samples using Digital Image Correlation (DIC) and by inverse use of recent micromechanical models. Unlike initial assumption of surface elasticity parameters being numerical constants, it is observed that these terms are variables and are functions of particle size.

Further Finite Element Method (FEM) is used to model the size-effect in the form of interphase thickness between matrix and the particle to further improve the FEM modeling of polymer composite. Experimental results obtained through uniaxial testing of prepared composite samples are correlated with the FEM results in order to find out the equivalent interface thickness of the particles of different sizes. It is observed that interface thickness is a function of particle size, which slightly increases for samples having particle size above 100 nm and exponentially for particle sizes below 100 nm.

Table of Contents