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Mechanical Behavior of Particle Reinforced Thermoplastic Matrix Composites Using Finite Element Modeling

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Particles are becoming increasingly popular reinforcing elements in products made by injection molding. Particles reinforcement allows the thermoplastic to be processed employing the same methods as those used for unreinforced thermoplastic. Ultrafine particles, whose diameters are comparable to the crystalline regions in the polymer, have a prominent reinforcing effect on the elastic properties of the polymer. Small particles adhere strongly to the polymer, which leads to a strong reinforcing effect. In particle reinforced thermoplastic matrix composites, loads are not directly applied to the particles but are applied to the matrix, and some of the applied loads are transferred to the particles. The process of transfer of load between particles and matrix depends on the strength of the interface. In this work, multiparticle composite model was analyzed under tensile load. The purpose of this work is to analyze the influence of particle diameter (the diameters of 19.61, 26.15, 39.22 and 78.45 μm were used) on the Von Mises stress of glass particle reinforced thermoplastic nylon 66 matrix composite using finite element analysis (FEA). The second objective is to analyze the effect of particle packing (square, hexagonal and random arrangement) on nanocomposite behavior.

Keywords: Nanomaterials, Composite materials, Glass particles, Thermoplastic matrix, Finite element.

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1. INTRODUCTION

Addition of rigid reinforcement into polymeric materials is an established practice in the polymer industry. By introduction of a stiff second phase, substantial improvements in stiffness, strength, creep performance, fracture toughness etc. can be obtained. The reinforcement is often in the form of spheres, plates or fibers. Fibers are often used as reinforcement, although this often results in anisotropic properties. This may lead to problems and variation in component dimensions. Particulate fillers in the form of spheres or plates can therefore sometimes be a better choice when close tolerances or isotropic properties are required [1].

In fact, thermoplastics can be repeatedly softened by increasing temperatures and hardened by cooling, contrary to thermosets which, once cured, cannot be reshaped or remold at elevated temperatures [2]. Thermoplastics have many advantages over metal parts including weight, ease of fabrication and economy. Although the advantages have allowed them to proliferate in various industries, the lack of structural load carrying capacity has hindered their use in automotive and aerospace industries [3]. Some of the material demands in the advanced industries cannot be fulfilled by monolithic materials. Therefore, composite materials have been developed. The combination of desired properties of thermoplastics and glass particles (high strength and high modulus) is the aim of composites production [4]. The high costs and technical difficulties involved in the fabrication of fiber-reinforced composites sometimes limit their use in many applications [5]. Particle reinforced materials are more attractive due to their cost-effectiveness, isotropic properties, and their ability to be processed using similar technology used for monolithic materials [6].

Particles are used to increase the modulus of the matrix, decrease the permeability and also decrease the ductility. A particle may have either a dimension or no long dimension. Composites consist of particles of one material dispersed in the matrix of the second material. Generally, particles are spherical, ellipsoidal, polyhedral, or irregular in shape. Particles are added to the liquid matrix that later solidifies in some process. The particles may be treated or untreated during reinforcement. Particles are used to increase the strength or other properties of inexpensive materials during reinforcement with other matrix materials [7] (Fig. 1).

The purpose of this work is to analyze the particle diameter and packing effect of glass particle reinforced nylon 66 (PA) matrix composites considering the interaction between the matrix and particles interface. Particle reinforced composite is subjected to the longitudinal tensile loading.

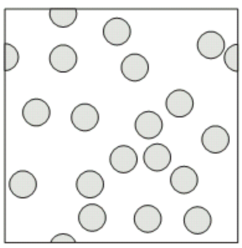

Fig. 1 – Example of the composite reinforced with particles

2. ANALYTICAL ANALYSIS

In fact, the stress is higher in the material with the higher elastic modulus (usually the fiber) [8]. The bond-

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