Effect of Glass Particles Size and Shape on the Behavior of Polyamide Matrix Composite

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ABSTRACT

Keywords:
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Particle reinforcement allows the composite material to be processed using the same techniques used for the material not reinforced. The loads are not directly applied to the reinforcements, but they are applied to the matrix and some of the loads applied are transferred to the particles. The particle composite model was analyzed under tensile load. The aim of this work is to analyze the influence of particles size and shape on the evolution of Von Mises stresses of the composite using finite element analysis. The results show that the variation of the Von Mises stresses changes depending on the size and shape of the reinforcements.

1. Introduction

The addition of rigid reinforcement in thermoplastics is an established practice in the polymer industry. By introducing a stiff second phase, substantial improvements in stiffness, strength, creep performance, fracture toughness, etc. can be obtained. Reinforcement often comes in the form of spheres, plates or fibers. Fibers are often used as reinforcement, although this often results in anisotropic properties. This can cause problems and variations in component dimensions. Particulate fillers in the form of spheres or plates can therefore sometimes be a better choice when tight tolerances or isotropic properties are required [1]. In fact, thermoplastics can be repeatedly softened by increasing temperature and hardened by cooling. This is the opposite of thermosetting plastics. Once cured, they cannot be altered or reshaped at elevated temperatures [2].

Combining the desired properties of thermoplastics and glass particles (high strength and high modulus) is the objective of composite production [3]. Particle-reinforced materials are more attractive due to their cost-effectiveness, isotropic properties, and ability to be processed using technology similar to that used for unreinforced thermoplastics [4]. The particles are used to increase the modulus of the matrix, decrease the permeability and also decrease the ductility. A particle can be long or dimensionless.

Composites consist of particles dispersed in a matrix. Generally, the particles are spherical, ellipsoidal, polyhedral or irregular in shape (Figure 1). Particles are added to the liquid matrix which solidifies later in a certain process. The particles may or may not be treated during reinforcement. Particles are used to increase the strength or other properties of materials [5].

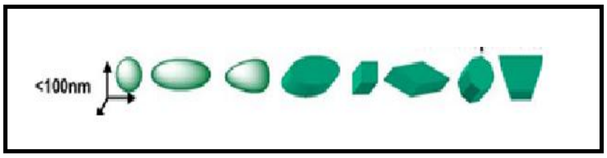


Figure 1 Different shape of particles [6]

The aim of this work is to analyze the influence of the size, shape and arrangement of the particles on the behavior of a composite with a polyamide 66 (PA) matrix reinforced with E-glass particles. The composite is subjected to a longitudinal tensile load.

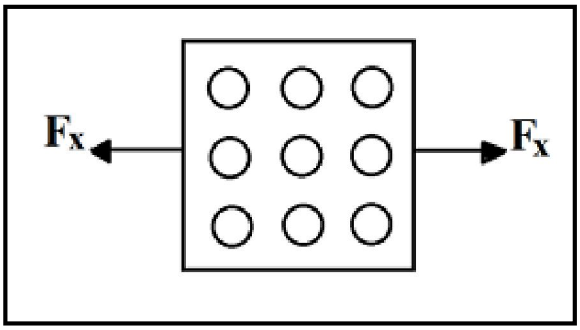
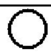


Figure 2 Boundary conditions for a composite reinforced with 9 circular particles.

Table 1 Shape of particles used.

N°	Particles	Shape
1	Circular	
2	Vertical Rectangular V	
3	Horizontal Rectangular H	
4	Shape 1	
5	Shape 2	

2. Results et discussion

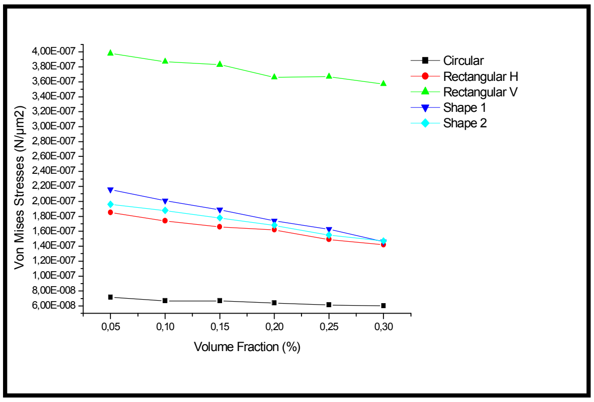


Figure 3 Evolution of Von Mises stresses as a function of volume fraction (square arrangement).

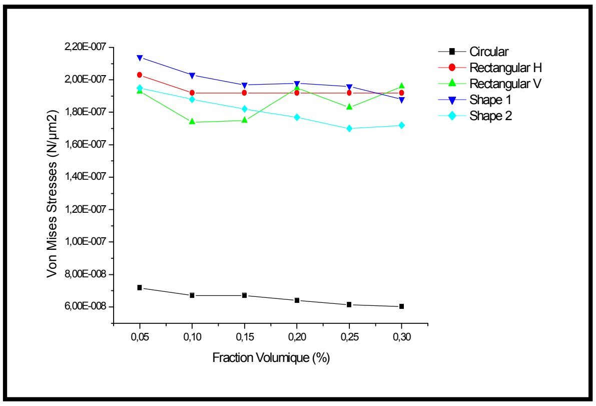


Figure 4 Evolution of Von Mises stresses as a function of the volume fraction (random).

Figure 3 represents the evolution of the Von Mises stresses as a function of the volume fraction of the particles for different shapes and for a square arrangement. Note that the stress values in the particles of Shape2 are much higher compared to the other shapes, followed by Shape1, Rectangular H, Rectangular V and finally the circular shape. It can be seen that as the shape of the particles changes, the strength of the composite also increases. Note that as the volume fraction of the particles increases, the Von Mises stresses decrease.

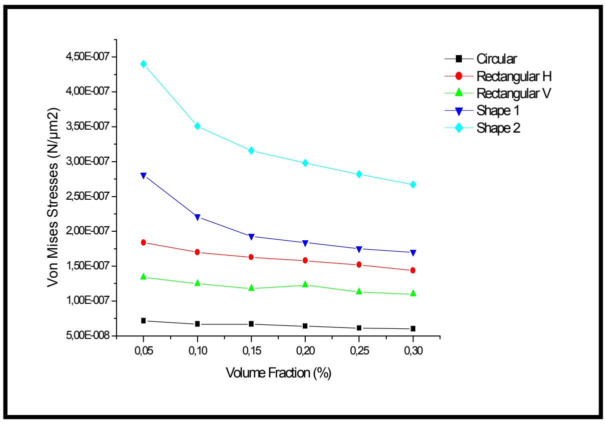


Figure 5 Evolution of Von Mises stresses as a function of the volume fraction (hexagonal).

Figure 4 and Figure 5 represent the evolution of the stresses for the other arrangements (random and hexagonal successively). Same remark as for the square arrangement, the circular shape is the most resistant than the other shapes.

3. Conclusion

This study concerns the evolution of Von Mises stresses in a composite with a thermoplastic polyamide matrix reinforced with glass particles. The shape of the particles is an important factor in increasing the strength of composite materials. It is also interesting to note that the variation of the rigidity increases in a constant way when the shape of the reinforcement passes from the shapes used to the circular shape. However, the polyamide 66 matrix reinforced with the circular shaped glass particles showed the best resistance than all the other shapes. The shape and dispersion of the particles affect the behavior of the thermoplastic matrix composite.

4. References

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