Effect of the particle shape in the Young modulus of SiC particle reinforced Al matrix composite

L.C. Villacorta-Hernández[1*], L. Rosales-Marines[1], J.E. Rivera-Salinas[2], K.M. Gregorio-Jáuregui[3], A. Cruz-Ramírez[3].

[1]*Autonomous University of Coahuila, 25280, Saltillo, Coahuila, Mexico.*

[2]*Centro de Investigación en Química Aplicada—CIQA, 25294 Saltillo, Coahuila, Mexico.*

[3] *Instituto Politécnico Nacional, ESIQIE, UPALM, 07738 México D.F., Mexico*

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Introduction: Particulate reinfoced metal matrix composites (PRMMC) show good combination of strength-to-weight ratio, as a result they are used commonly in fields such as the automotive, aerospace. Particle reinforments exhibit angular and circular shapes. Young moduli of PRMMC depend strongly on factors such as the volume fraction reinforcement, particle shape, particle size as well as particle orientation and cohesive forces at the particle-matrix.

Aim: Effects of **particle shape**, **particle volume fraction** and **particle size** on the Young modulus for Al-SiC system

1. Theory

Mechanic's equilibrium

$$\nabla \cdot \sigma + f = 0$$

Average stress and strain

$$\bar{\sigma}_{ij} = \frac{1}{A}\int_A \sigma_{ij}(x,y)dA = \frac{1}{A}\int_\Gamma \left(Eu_i n_j + Eu_j n_i\right)d\Gamma$$

$$\bar{\varepsilon}_{ij} = \frac{1}{A}\int_A \varepsilon_{ij}(x,y)dA = \frac{1}{A}\int_\Gamma \left(u_i n_j + u_j n_i\right)d\Gamma$$

Numerical model

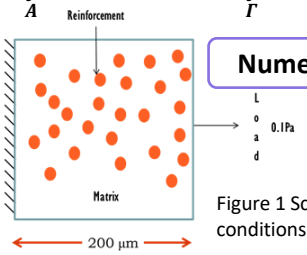


Figure 1 Scheme of model and boundary conditions used on numerical simulation

2. Results and discussion

Particle size

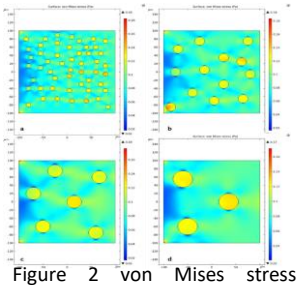
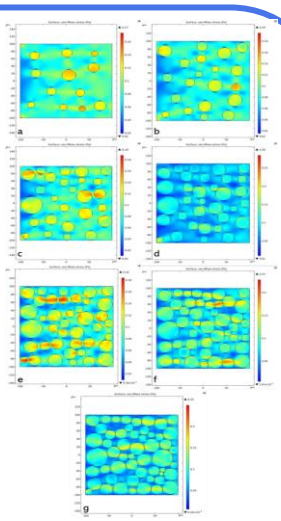


Figure 2 von Mises stress distribution with particle size of a)10µm, b)20µm, c)30µm and d)40µm at volume fraction 10%.

- **The stresses are concentrated mainly on the reinforcing particles**
- **Stress concentration decreases as particle size increases.**
- **The distance causes that the stresses were distributed in a different way inside the particle.**

2. Results and discussion

Circular shape

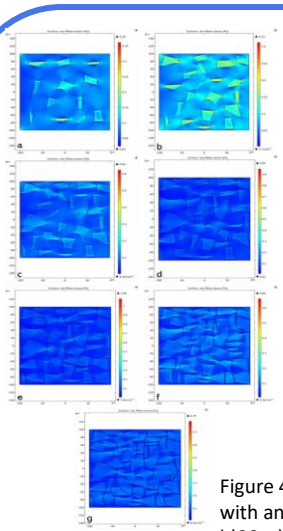


- **The stress distribution within the particles is not uniform, because the behavior is influenced by the distance.**
- **There is a higher stress concentration in the short distances among particles**
- **Smaller particles supported a greater loads, especially those who are near to the load constraint**

Figure 3 von Mises stress distribution for reinforcement with circular shape particles at volume fraction of a)10, b)20, c)30, d)40, e)50, f)60, g)70

2. Results and discussion

Angular shape



- **Stress is concentrated in sharped corners of angular particles, due to the area of the particles is not constant**
- **The stress concentration is greater where the distance between the particles is smaller.**
- **The angular particles support a higher stress than the circular ones**

Figure 4 von Mises stress distribution for reinforcement with angular shape particles at volume fraction of a)10, b)20, c)30, d)40, e)50, f)60, g)70

2. Results and discussion

Young's Modulus

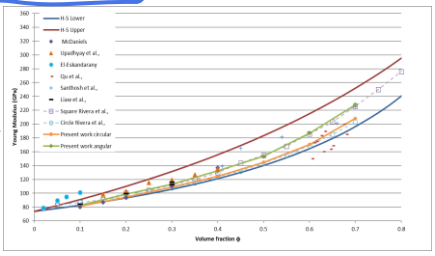


Figure 5 Effect of reinfocement content on the Young modulus of Al-SiC composite

The experimental data and the numerical predictions, are close to the lower limit of Hashin-Shtrikman at low volume fractions (10 to 40%)

There is a small particle shape effect in the calculation of Young's modulus

As the reinforcement volume fraction increases, the degree of reinforcement for the material increases

3. Concluisons

1. The smaller circular particles considered in the study act as stress concentrators.

2. In angular particles, the stress is concentrated in the sharp corners.

3. The Young´s modulus increases as the reinforcement volume fraction increases.

4. The particle shape has an evident effect at high reinforcement volume fractions, resulting in a higher modulus of elasticity for irregularly shaped particles.

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