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Wear Behavior of AA4015/Graphite Nanoparticle-Reinforced Metal Matrix Composites

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ABSTRACT

In recent years the aerospace, military and automotive industries have been promoting the technological development of composite materials to achieve good mechanical strength/density and stiffness/density ratios. Graphite is well known as a solid lubricant and its presence in aluminum alloy matrices makes the alloy, self-lubricating. Aluminum alloys reinforced with graphite fibers are emerging as potential structural materials for aerospace needs and their outstanding mechanical properties have drawn considerable scientific attention to the exploration of their possible applicability to high-technology naval applications. The reason for the excellent tribological properties of graphitic aluminum is that aluminum alloy matrix yields at low stresses and deforms extensively, which enhances the deformation and fragmentation of the surface and sub-surface graphite particles even after short running-in period. This provides a continuous film of graphite on the mating surfaces which, essentially, prevents metal to metal contact and hence prevents seizure. Several processes involving incorporating graphite particles in aluminum-base alloy to produce particulate composites have been developed. The most economical production of such composites is by stir casting; nevertheless, this is associated with some problems arising mainly from the apparent nonwettability of graphite by liquid aluminum alloys and density differences between the two materials. As a result, the introduction and retention of graphite particles in molten aluminum is extremely difficult.

In view of the above-mentioned problems, this study was undertaken to produce AA4015/graphite composites by bottom-up pouring technique to get good mechanical properties of the final product. In this connection, the effects of particle clustering and porosity on micromechanical behavior were analyzed using experimental procedure and finite element method (FEM). Two models were used in the computational framework. The first one is uniform distribution of nanoparticles without clustering and porosity. The second one is with clustering and porosity.

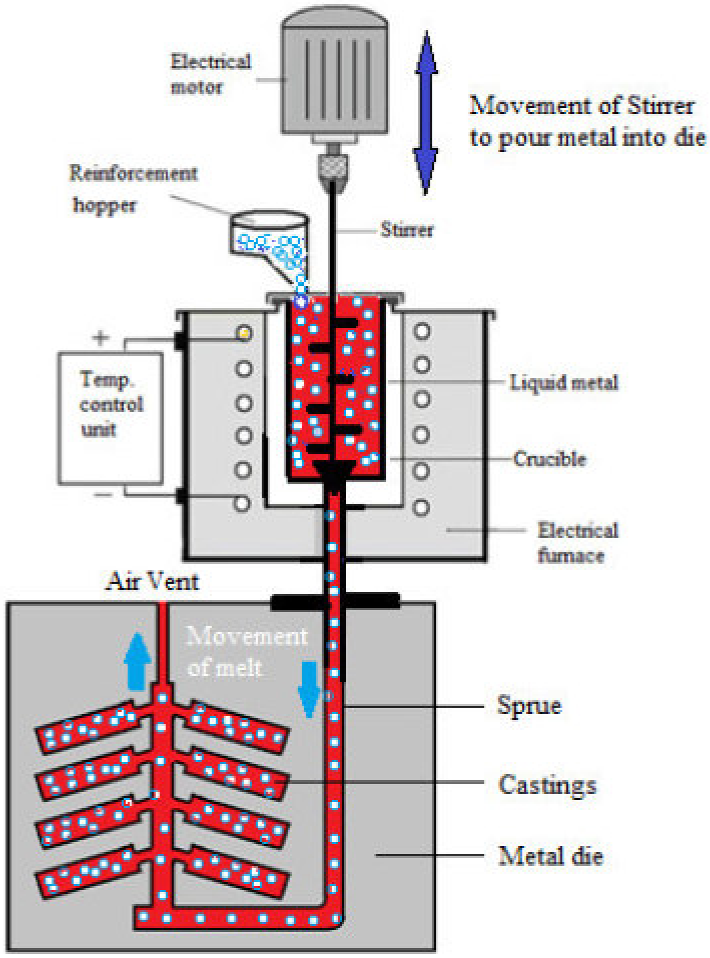

Figure 1: Concept of bottom-up pouring of composite metal.

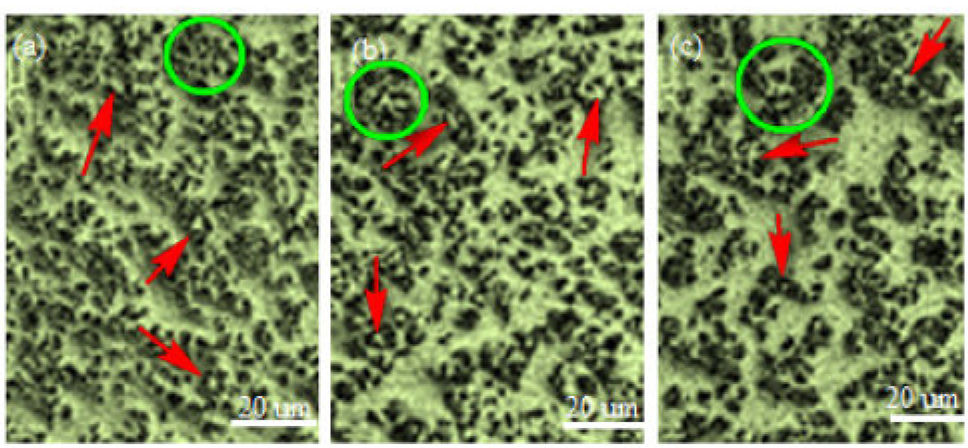

Figure 2: Microstructure showing distribution of graphite nanoparticles, clustering and porosity in AA4015 alloy matrix.

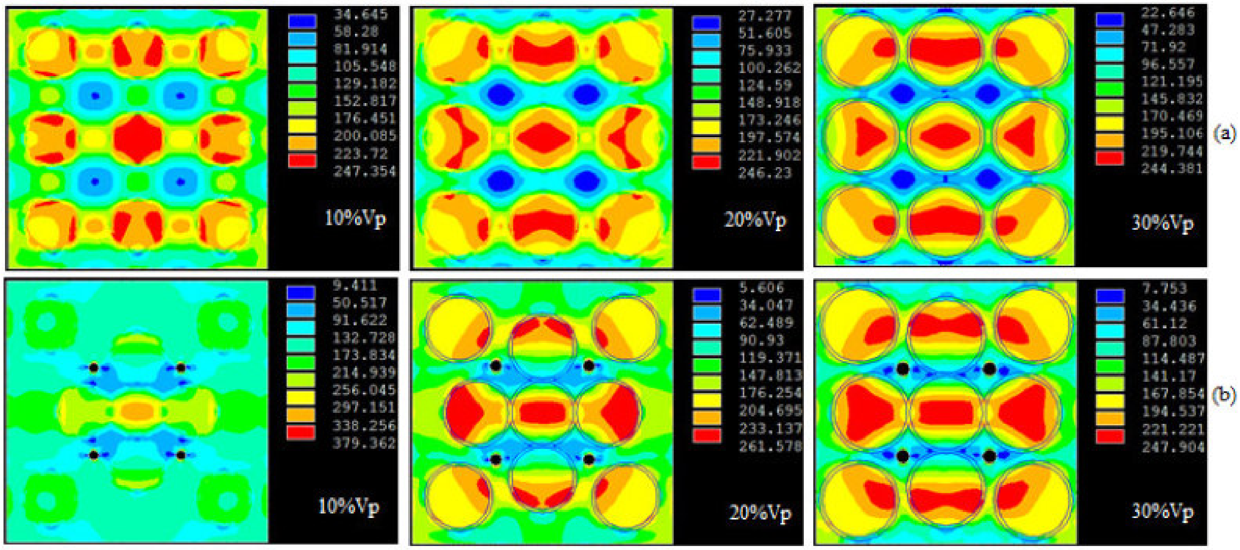

Figure 3: Images of von Mises stresses obtained from FEA: (a) without clustering and porosity and (b) with clustering and porosity.

AA4015/ graphite metal matrix composites had clusters and porosity voids. The voids are typically located at the interface of clustered particles. The stress intensity was increased with porosity and clustering of graphite nanoparticles. The wear loss has decreased with increase of volume fraction of graphite in AA4015 alloy matrix. AA4015/graphite composites can be attractive candidates for automotive applications.

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