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Fabrication of Al/Al2O3 Functionally Graded Composites via Centrifugal Method by Using a Polymeric Suspension

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Abstract : Functionally graded materials (FGMs) exhibit heterogeneous microstructures in which the composition and properties gently change in specified directions. The common type of FGMs consist of a metal in which ceramic particles are distributed with a graded concentration. There are many processing routes for FGMs. An important group of these methods is casting techniques (gravity or centrifugal). However, the main problem of casting molten metal slurry with dispersed ceramic particles is a destructive chemical reaction between these two phases which deteriorates the properties of the materials. In order to overcome this problem, in the present investigation a suspension of 6061 aluminum and alumina powders in a liquid polymer was used as the starting material and subjected to centrifugal force for making FGMs. The size rang of these powders was 45-63 and 106-125 μm. The volume percent of alumina in the Al/Al2O3 powder mixture was in the range of 5 to 20%. PMMA (Plexiglas) in different concentrations (20-50 g/lit) was dissolved in toluene and used as the suspension liquid. The glass mold contaning the suspension of Al/Al2O3 powders in the mentioned liquid was rotated at 1700 rpm for different times (4-40 min) while the arm length was kept constant (10 cm) for all the experiments. After curing the polymer, burning out the binder, cold pressing and sintering , cylindrical samples (φ=22 mm h=20 mm) were produced. The density of samples before and after sintering was quantified by Archimedes method. The results indicated that by using the same sized alumina and aluminum powders particles, FGM sample can be produced by rotation times exceeding 7 min. However, by using coarse alumina and fine alumina powders the sample exhibits step concentration. On the other hand, using fine alumina and coarse alumina results in a relatively uniform concentration of Al2O3 along the sample height. These results are attributed to the effects of size and density of different powders on the centrifugal force induced on the powders during rotation. The PMMA concentration and the vol.% of alumina in the suspension did not have any considerable effect on the distribution of alumina particles in the samples. The hardness profiles along the height of samples were affected by both the alumina vol.% and porosity content. The presence of alumina particles increased the hardness while increased porosity reduced the hardness. Therefore, the hardness values did not show the expected gradient in same sample. The sintering resulted in decreased porosity for all the samples investigated.

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