Resistance-Based Sintering and its Application for the Fabrication of Aluminum Powder Metallurgy Components

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ABSTRACT

Powder-based metallic parts are increasingly integrated across various markets, particularly in the automotive sector. These products address a range of issues from lightweighting to precision creation. However, there are challenges associated with creating powder products. Two major issues include long lead times and energy inefficiency from furnace use. This study introduces a resistance-based sintering process (RBS) that significantly reduces processing times and increases energy efficiency by more than 97%. The process involves passing current through conductive powders under pressure, generating sufficient heat for the powders to soften and sinter together. To comprehend this process, a Zener heat flow model was employed to simulate the heat flow through the sample during sintering. The model was applied to AlSi10Mg aluminum powder; achieving sintering requires generating just enough heat to produce less than 1% liquid to coat the powder and overcome the aluminum oxide layer on the surface of the aluminum powder. The resulting parts exhibit 95% density, with homogeneous microstructures displaying minimal to no liquation. Evaluation of the conductivity of these samples relative to bar stock showed only minimal differences, demonstrating that after sintering, the conductivity of the samples was preserved. This highlights the potential of using this technique to replace conventional copper in electric vehicles.

INTRODUCTION

Aluminum and its alloys are becoming key components for electric vehicles with applications ranging from body-in-white lightweighting to thermal and energy management systems. The low density of aluminum (50% to 70% less than traditional materials such as steel and copper) suggests that substitution across a range of applications can substantially reduce EV vehicle weight [1, 2, 3]. One area of current interest is for use in the electrical power system itself [1]. The low resistivity, density, and cost of aluminum make it a strong candidate for these applications.

Aluminum product forms currently used in vehicles range from sheet, to wrought, to castings, and even sintered products [2, 3]. With respect to complex shaped products, casting is favored. Casting processes in use today range from die casting, where molten aluminum is injected into the mold, to real- and thixo-casting, where slurries of aluminum prepared at temperatures between the liquidus and solidus are