ISOTHERMAL FORGING OF A SPARK PLASMA SINTERED AL-0.3SC-0.2ZR POWDER METALLURGY ALLOY

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ABSTRACT

Aluminum alloys containing scandium as the primary alloying element continue to gain significant importance in the aeronautical and automotive industries due to their low intrinsic density and mechanical stability at elevated temperatures. The majority of work completed on these materials have emphasized wrought and cast product forms. However, powder metallurgy technologies represent an attractive alternative as the high cost of scandium can be offset by efficiencies in material consumption via net shape processing. In this work, a prealloyed powder of Al-0.3Sc-0.2Zr was spark plasma sintered and then isothermally forged. Core processing variables emphasized the net strain and the applied strain rate utilized in forging. Both factors influenced the microstructure and tensile properties of the forged products. Forging to strains ≤ 0.8 under a relatively fast rate of 1 s^{-1} yielded forged products with the most desirable combination yield strength, UTS, and tensile ductility. All of these properties experienced some level of decline when large strains 1.6 and slow strain rates (0.01 s^{-1}) were applied.

1.0 INTRODUCTION

Aluminum powder metallurgy (PM) is a commercialized manufacturing technology currently utilized to fabricate a growing number of automotive components. Common examples include cam shaft bearing caps [1], transmission components, and heat sinks [2]. In all instances, these products are fabricated in high annual volumes by means of press-and-sinter PM. Here, the sequence of events typically includes blending of the starting raw powders, followed by die compaction, sintering, and then sizing to refine dimensional tolerances. This process is capable of producing geometrically complex parts in a manner that is both effective and efficient. However, it does have some inherent constraints. For instance, the raw powder blends cannot be fully prealloyed as this deteriorates die compressibility. Secondly, liquid phase sintering coupled with the presence of magnesium additions are mandatory when a dense, well sintered product is sought. Such factors impose clear limitations on the range of alloy chemistries that can be successfully processed and can lead to microstructural coarsening and/or problematic distortion in the sintered product.

In an effort to circumvent the aforementioned issues, numerous researchers are now investigating spark plasma sintering (SPS) [3] as an alternate means of consolidating aluminum powders. In this process, powder is loaded in a conductive tool set (typically graphite) that is then rapidly heated through the flow of high, pulsed DC current, while being uni-axially compacted at the same time. The entire process is conducted under vacuum or a protective gas atmosphere and essentially combines compaction and