Effect of Atomization Method and Post-Processing Treatments on the Microstructure and Mechanical Properties of Ti-6Al-4V Alloys Manufactured via Laser Powder Bed Fusion

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ABSTRACT

Due to the rapid development of AM technologies, a special attention is necessary towards reducing processing defects and achieving fully dense and homogenous materials. In this work, the assessment of Ti-6Al-4V powders fabricated via two of the most developed atomization processes, advanced plasma atomization (APA) process, which uses plasma torches to melt and atomize the metal wire feedstock, and electrode induction melting gas atomization (EIGA) is thoroughly carried out. Following production of parts by laser powder bed fusion (LPB-F) and post-processing treatments, which includes stress relief and hot isostatic pressing (HIP) treatments, the resultant mechanical properties at room temperature are reviewed. Microscopy study aimed to detect and discuss the level of microstructural changes and texture and their influence on the performance of pre and post heat-treated parts in order to obtain optimal parameters to achieve superior properties. A comparison is made between the effect of these processing stages and traditionally cast and HIPed Ti-6Al-4V alloys for various applications.

1. INTRODUCTION

The Ti-6Al-4V (Ti64) alloy accounts for more than 50% of global usage of Ti alloys, which is due to its high specific strength, corrosion resistance and biocompatibility. Most applications for Ti64 encompass the medical, aerospace and automotive industries. Processing of these alloys include the use of ingot casting, forging, and most recently, powder metallurgy and additive manufacturing, where the ability of complex shapes with lower weight and cost is explored [1, 2].

Ti-6Al-4V is an $\alpha + \beta$ alloy where both a and b phases coexist at room temperature. This is interesting due to a combination of the strength of α alloys with the ductility of β alloys, with a wide variation of appropriate heat treatments and thermomechanical processes [3, 4], since dual-phase alloys such as Ti64 rely on this to promote a microstructure that can provide durability and structural performance. The use of different cooling rates from temperature above the melting point can lead to the formation of cellular or equiaxed microstructures, which occurs due to a liquid-solid transformation, while fast cooling (intrinsic to additive manufacturing (AM) processes) forms needle-like structures and metastable phases that takes place due to solid-solid transformation.

The transition from α (HCP) to β (BCC) for Ti64 alloys occur at approximately 995°C, referred to as β-transus temperature, and can be controlled by the addition of either α or β stabilizing elements. Therefore additions of Al and V play a significant role into stabilizing both phases at room temperature and providing a solution strengthening effect, but also the kinetics of transformation from