Mechanical Testing of Hot Isostatic Press (HIP) and Heat-treating cycles for 3D-printed Aerospace Titanium

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ABSTRACT

Hot Isostatic Pressing process applies high pressure to the exterior of a part via an inert gas. The elevated temperature and pressure cause sub-surface voids to be eliminated and this significantly improves fatigue life, impact toughness, creep rupture strength and tensile ductility in Additive Manufactured metal parts. In this investigation, Ti-6Al-2Sn-4Zr-2Mo samples from Arcam's Q20 and A2X systems will be tested as per ASTM E8 Standard Test Methods for Tension Testing of Metallic Materials. Different variants of HIP + Heat Treatment will be analyzed and compared. Tensile testing will be performed on samples, they will be cross-sectioned to check for porosity and cracking as well as analyze density and microstructure before and after Hot Isostatic Pressing (HIPing). The results will be compared to those found in the literature. Hardness measurements will be made from the prepared mounted optical samples after they have been analyzed. Finally, chemical analysis will be conducted to observe element changes and oxygen or nitrogen pickup.

INTRODUCTION

Additive Manufacturing presents big challenges and while research on improving metal AM processes is still growing, it also presents limitations that make companies to still have manufacturing restrictions in design. Challenges towards metal additive manufacturing include: reducing porosity and residual stress, prevent cracking and warping, and improving the density of the parts. 3D printed metal parts are often plagued with high porosity, which occurs during the printing process as small holes and cavities are formed within the part. There are several causes on why these defects are produced, such as: Powder quality, variances on the atmosphere and settings.

Electron Beam Melting (EBM) is a type of additive manufacturing that is classified as a power bed fusion Additive Manufacturing process that was originally patented and developed by Arcam AB. EBM uses an electron beam as the power source instead of a laser to 3D print metal. An electron beam melts metal powder layer by layer in a high vacuum, which makes this process perfect for manufacturing reactive materials with a high affinity for oxygen and can achieve full melting of the metal powder. This method can produce fully