Effects of HIP on Fatigue Life of Binder Jet 3D Printed 316L Stainless Steel

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ABSTRACT

The improvement of additive manufactured (AM) metal parts has been of great interest in recent years. As a result, various post-processing methods for additive processes have been investigated. The combination of binder jet 3D printing (BJ3DP) with hot isostatic pressing (HIP) allows for the optimization of microstructure and porosity. This is ideal for structural materials, such as 316L stainless steel. In this study, 316L stainless steel samples were BJ3DP, sintered, and exposed to various HIP cycles. To understand the effects of these processes on part strength, fatigue testing was performed. The aim of this study was to compare various heat treatments on as-printed samples. It was found that the high roughness of the samples and presence of inclusions in all samples negated the benefits of HIP on the microstructure. As a result, there was no difference in the fatigue life of the Sintered versus HIP samples. There was however improvement in the consistency of failure at a given stress level for the HIP samples as opposed to the non-HIP samples. Lastly, the BJ3DP parts performed better than metal injection molded parts and as good as traditionally manufactured parts despite the high roughness.

Key Words: binder jet printing; hot isostatic pressing; 316L stainless steel; fatigue

INTRODUCTION

Binder jet 3D printing (BJ3DP) is a powder based additive manufacturing (AM) process. Powders are spread into a thin layer, typically 50-100 µm ($2x10^{-3}$-$4x10^{-3}$ in) thick, then a printhead is used to selectively deposit binder into the bed. Binder is jetted only where the part is on a given layer. The unbound powder surrounds the printed part, so no support structures are needed. After printing is complete, the entire build box goes into a curing oven set to 200 °C (392 °F). After curing, the green parts are harvested from the build box while the remaining powder is recycled and reused for subsequent prints. The green part is then sintered to achieve high density [1-4].

As a result of recent developments with printer technology, binder jet 3D printers are able to print with powders that are commonly used in the metal injection molding (MIM) process. The furnaces used for sintering binder jet parts are often the same furnaces that are used for MIM as well. By using the same