High Performance 3D Printed Stainless Steel:
A Metallurgical Perspective on 3DEO's Intelligent Layering

Mahmood Shirooyeh, Payman Torabi, Matthew Petros

3DEO, Inc.
14000 Van Ness Ave.
Gardena, CA 90249
U.S.A.

ABSTRACT

Additive manufacturing (AM), as an emerging technology, is introducing new opportunities by moving from prototyping to production. This study presents an overview on metallurgical properties of as-sintered and heat-treated 17-4 PH stainless steel parts produced by a novel binder-assisted, bulk sintering-based AM technology called Intelligent Layering (IL). The process is a hybrid mix of additive and subtractive technologies that is best suited for serial fabrication of metal parts in large-scale production. Microstructural examinations were conducted to investigate the porosity and densification behavior in the 17-4 PH stainless steel parts produced by Intelligent Layering. In addition, quantitative investigations including measurements of hardness, surface roughness, tensile strength and impact energy reveal that printed parts meet or exceed requirements sets for parts manufacturing through powder metallurgy (PM) processes.

INTRODUCTION

Additive manufacturing is defined as a process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies [1]. AM techniques should be considered complimentary to subtractive processes in that they provide additional capabilities to various manufacturing industries. Traditionally, this has particularly been true when it is not practical to manufacture parts with complex geometries or internal features. Inherent limitations of traditional manufacturing methods such as tool path restrictions, high tooling costs, complex assembly/labor, or lower quantity orders are typically strong indicators for pursuing AM [2].

Although AM technologies have their advantages when compared to conventional manufacturing processes, there are still concerns to be addressed in order to fully accelerate the adoption of this capability for large-scale production. For instance, there is not yet enough data on dimensional stability and mechanical properties of parts produced via AM processes. Ultimately, this is due to the lack of understanding of the processing-structure-properties relationships for various AM technologies [3]. In addition, it has been perceived that microstructure, density, and surface finish of AM parts are not consistently on par with the ones produced by conventional processes such as metal injection molding (MIM) [4].

Among AM processes, binder-assisted processes are likely to be the most viable solution for medium to large production volumes. This bulk sintering technology has several advantages over other AM processes including powder bed fusion (PBF) methods. For example, there is no sign of significant residual stress in the printed parts due to the lack of rapid heating and cooling cycles in the melt pool. Also, there is no need for support structures during the printing process, which can significantly reduce the overall process time. Furthermore, there is no need for an environmentally controlled chamber during green part fabrication [5]. In the past, there have been major concerns with the consistency, density and mechanical properties of parts produced via conventional Binder Jetting processes [4, 6]. This paper will focus upon the improved, consistent performance of parts produced via the IL process.