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Process Development Toward Full-Density Stainless Steel Parts with Binder Jetting Printing

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Abstract

In the Additive Manufacturing (AM) community, the binder jet printing (BJP) process is known to produce parts not suitable for most structural applications due to the insufficient consolidation of the powder in the finished part. A new processing protocol for the BJP is presented to reach near full density and better surface finish for stainless steel (SS) parts. Two main modifications from the standard BJP processing are (1) the use of the mixtures of various powders and (2) the adaptation of a full sintering cycle in a vacuum furnace. Two distinct average particle sizes of SS powder were used to improve the packing density in the printing stage. Improving the packing density of the printed powder helps to consolidate the powder better and to reduce the shape distortion in the final parts. More importantly, an extremely small amount of the sintering additive was added to enhance the densification, which reduces the sintering time and temperature. In particular, up to 0.5 weight % of boron compounds as sintering additives were used to achieve a near full density in the final part. Thus, the starting powder, consisting of two distinct SS powders and sintering additive, is mixed before building a part in a layer-by-layer fashion. After completing the printing process with a binder phase, the printed powders are cured and the binder phase is burned out at 460°C before sintering at 1250°C for 6 hours in a vacuum furnace to reach near-full densities (up to 99.6%). A subtle difference between SS 420 and SS 316 was evident because the enhanced oxidation during the binder burnout cycle on SS 316 due to a higher surface area of the SS 316 powder used in the experiment. The main contribution of this work is to provide the BJP process an important ability to fully consolidate the powders under an isothermal condition, which enable us to produce the final parts without residual stresses.

Keywords

binder Jet Printing, Sintering additives, Densification, Vacuum Sintering, Powder packing

1. Introduction

Additive manufacturing (AM) has received tremendous attention recently because of its many unique advantages over traditional manufacturing. AM enables us to fabricate physical parts directly from computer aided design (CAD) files in a single machine without prior knowledge of the manufacturing processes. This new technology brings about many innovations: (1) the product development cycle can be substantially shortened; (2) the complex parts impossible to fabricate with any conventional method can be fabricated; and (3) material, energy, and human resources can be significantly reduced [1]. Since its inception in the 1970s, many new