Analytical Methods for Reducing Binder Saturation Variation in a Sinter-Based Additive Manufacturing Technology

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ABSTRACT

Research shows that binder saturation directly affects a variety of properties of sinter-based AM parts in both green and sintered states. Properties such as sintering shrinkage, green part strength, debinding and sintering densification are among the most important ones that define the quality of the final product. Therefore, it is beneficial to increase the uniformity of binder saturation across every printed layer. In this paper, a proprietary test method was developed and was used to measure binder mass per unit area at various independent X-Y locations on the print bed. The scope of this study is to explain the statistical techniques and analysis of the test data performed in order to reliably choose the most suitable binder delivery design, minimizing binder saturation variation. The analysis led to a design that produced a more repeatable and uniform binder distribution within the build area that follows a more natural variation than special cause variation.

INTRODUCTION

Intelligent layering™ is a hybrid mix of additive and subtractive strategies that are derived from machining, metal injection molding and binder jetting. This has enabled the rapid production of small parts in serial production. The process starts with spreading a thin layer of metal powder over the build tank. A binder delivery system is used to delicately deposit a proprietary liquid binding agent onto the entire layer, indiscriminately of where the parts are located or how they are arranged. Overhead Infrared lamps heat the bound layer and cure it. Once the layer is cured, precision CNC micro-end mills are used to cut the perimeters and internal geometries of parts. From then on, these steps are repeated on a layer-by-layer basis until the green part is completely built. The green parts are then carefully broken out and cleaned via an automated process, sometimes they undergo a de-binding depending on the material and finally sintered in a high temperature furnace [1].

The binder delivery system is a pivotal component of the Intelligent Layering™ additive manufacturing process. After a uniform layer of metal powder is deposited by the recoater, the gantry precisely positions the binder delivery system over the build area. The system deposits a predetermined mass of binder on the powder bed, which then seeps through the interstitial spaces of the powder bed, creating an adhesive bond that firmly secures the powder particles to each other and the layer below. This phenomenon is facilitated by capillary forces in the powder bed [2]. Upon curing, the solvent in the binder evaporates, lending strength to the layer and rendering it stable for milling. This system offers several advantages over traditional binder jet print heads, including simplicity of execution, cost-effectiveness, and extended mean time between failures. For this study, a proprietary binder formulation was used.