Dimensional Stability in Binder-Jet 3D Direct Metal Printing

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ABSTRACT

Binder-Jet printing (BJP) can be a viable tool for fabricating metal parts with material mechanical properties that meet or exceed those of metal injection molding. However, the use of this technique today is limited due to dimensional instabilities during post-process sintering that affect the final accuracy of part shape. The causes of these instabilities include: variations in powder packing density in the un-sintered or "green" state, and gravity-induced "slumping" of unsupported material. The latter is typically controlled using sintering aids and setters and is not addressed in this study. Instead, we examine density instabilities caused by print bed-induced variations in green parts. Variations caused by changes in binder saturation relative to printing direction and sample location in the bed are examined with respect to the cured green state, demonstrating that statistical process control of green density is viable. Finally, we show that increasing the binder saturation improves green part strength but leads to greater variations in green density which drive dimensional instability, suggesting an optimal tradeoff is required.

INTRODUCTION

BJP technology produces components by printing binder to fabricate green shapes that are then sintered, and in some cases, Hot Isostatic Pressed (HIP'd) to achieve final shape. Properly controlled the BJP process can produce material that meet standards developed by the Metal Injection Molding (MIM) industry. This has already been reported elsewhere for several alloys including 316L, 420, 17-4PH, 625 and 718 [1-5]. The significant advantage of the binder-jet technology is the freedom from tooling, dies and molds as used in metal injection molding, press and sinter and metal castings. The printed shapes require a consistent "green" density to produce resultant parts with minimal dimensional variations. There have been various studies that have evaluated dimensional control for BJP [6,7]. In Yang's paper on binder saturation, a model is presented for understanding the determining factors in establishing saturation levels, but no guidance is provided as to how saturation affects the dimensional stability of final products.