A Creep Model for Distortion Control during Sintering and Infiltration

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ABSTRACT

Production of parts by three-dimensional printing (3DP) enables much more complex shapes than can be produced by conventional compaction processes. Furthermore, parts produced by 3DP generally have a density of 50 to 60% of theoretical, so extensive densification is required. For these reasons, control of distortion and dimensional change during thermal processing is critical for successful production of parts by this new shapemaking process. A creep model within finite element analysis, combined with unique experiments to determine the creep constants, has led to a method for prediction of the distortion due to gravitational forces during sintering and infiltration. The results from a verification test are very promising.

INTRODUCTION

Rapid prototyping (RP) refers to a class of technologies that automatically constructs physical models from Computer-Aided Design (CAD) data. Such objects can be used as functional prototypes or for tooling. Because RP technologies are being increasingly used in non-prototyping applications, the techniques are often collectively referred to as solid free-form fabrication. ProMetal Three-Dimensional Printing (3DP) is one of the free form fabrication systems incorporating powder metallurgy processes. A major advantage of 3DP is that it can produce parts containing internal channels that are neither round nor straight. This capability provides great design freedom for conformal cooling of injection molding tools and for other complex fluid transport devices in engines, pumps, and valves.

3DP is very similar to ink-jet printing on paper. Instead of ink, a binder is printed into a metal powder layer. The printed pattern is determined by applying a slicing algorithm to the computer solid model of the article to be produced. The resulting assembly of slices produces a three-dimensional “green” part consisting of about 60 volume percent metal powder, 10 volume percent binder, and the remainder is porous space. The green part is somewhat fragile and must undergo a thermal process to achieve full, or nearly full, density and desirable mechanical properties.