3DPRINTING AND INFILTRATION OF TOOL STEELS

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ABSTRACT

The production of fully dense tool steel alloys by 3DPrinting and infiltration will be shown. The infiltration depends on a technique called Homogeneous Steel Infiltration (HSI), where a low-C skeleton is infiltrated with a high-C infiltrant under conditions that are determined in part by use of computational thermodynamics. The mechanical properties of the steel are sufficient for some tooling applications, particularly in plastic injection molding. The HSI technique for infiltration is applicable to a wide variety of tool steels and stainless steels, and greatly enables building of larger parts by 3DPrinting for production tools or other direct use metal parts.

INTRODUCTION

The production of metal tooling by solid freeform fabrication methods is an ongoing concern. A field of use for metal tooling made by SFF is in the plastic injection molding industry. [1-4] An advantage of making injection molding tools by SFF is the possibility to include conformal cooling channels in the part, which have been shown to decrease cycle times and increase part quality. [5-8] Several SFF methods rely on making a powder metal perform, which is then densified by either sintering or infiltration. One SFF method is 3 Dimensional Printing (3DP). [9-10] Because the green bodies made by 3DP are usually no more than 60% dense, sintering to full or near full density means that large shrinkages occur in the part. If parts have complex geometric features which can not be supported during sintering, slumping may occur. Infiltration with Cu based (typically bronze) alloys provides a way to densify parts with little shrinkage, typically ~ 1% from the as-printed part. Use of support powder during infiltration reduces or even eliminates slumping of bronze infiltrated steel. However, the resultant structures typically do not meet the mechanical properties required of production tooling: hardness greater than 30 HRc, as can be obtained with P20 tool steel. The presence of the bronze infiltrant, which begins to melt at temperatures at or below the austenizing temperatures of steels limits the ability to heat treat the steel powder. Further parts made by bronze infiltration have other drawbacks, such as increased susceptibility to corrosion due to galvanic differences between steel and bronze. Additionally, even if acceptable properties could be obtained with bronze infiltrated steel, market acceptance of dense steel