

## **Developing Sintering Parameters for Binder-Jet Printed H-13**

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### **ABSTRACT**

H13, also referred to as DIN 1.2344 or X40CrMoV5-1 steel, is a hot work steel containing up to 0.4 wt% C and is strengthened by martensite and carbides. It has excellent hot toughness, wear resistance and hardenability thereby warranting its use in both hot and cold work applications such as die casting, injection molding, extrusion, and forging. H13 steel dies are currently fabricated via a combination of CNC milling and EDM that have limited capability to produce certain die geometries and internal features such as conformal cooling channels. Additive manufacturing offers a solution to circumvent this limitation. However, H-13 poses a challenge for LPBF technologies due cracking cause by to the solid-state martensitic transformation. Binder-jet printing (BJP) avoids this issue since the sintering is performed at uniform temperatures and much slower cooling rates. Sintering parameters considered were furnace atmospheres, hold times and temperatures to produce near full density. Carbon chemistry control provided critical for this process.

### **INTRODUCTION**

Permanent molds for metal die casting have been a target for additive manufacturing since the early days of Additive Manufacturing.[1] In this case though, Direct Energy Deposition (DED, was used. While DED is suitable for the repair of existing molds, it might not be the best technology for fabrication of components with internal channels since DED is limited from producing overhanging structures. Owing to LPBF's ability to produce internal channels there has been more interest in this modality for fabrication using H-13. However, it has been found that the rapid solidification inherent LPBF produces the excessive residual stress in H13 that leads to micro-cracking. This cracking event in LPBF H-13 is only