An Overview of Laser Powder Bed Fusion as a Method of Manufacturing AISI H13 Parts

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Additive manufacturing (AM) of metals is growing ever more commonplace. Industries such as Aeronautics and medicine have already embraced it as a method of producing parts with difficult geometries. Now, the technology is spreading to other applications such as tools and die-making. The benefits of AM to these industries are twofold: it opens the door for more complex tool design with integrated cooling channels that conform to the shape of the die while also reducing the waste material produced in the manufacturing process, as the unspent powder can easily be reused. Of the various AM methods, laser powder bed fusion (LPBF) is the best suited for this application, as it has some of the highest productivity among all the AM methods, along with high printing accuracy.

One of the most frequently used materials in tool and die manufacturing is AISI H13. It's a chromium, vanadium, and molybdenum-based hot work tool steel with good hardness at elevated temperatures, softening, and wear resistance. Its excellent properties at elevated temperatures, along with good price performance, make H13 a prime candidate for LPBF. However, AM production of H13 is relatively difficult, as the high cooling rate and martensitic transformation induce a lot of retained stress in the printed parts. These stresses have a negative impact on the produced parts, as they can deform them or induce cracking. An effective way of managing such stresses is to produce the parts with base plate preheating. With the fusion process occurring on a surface that is already at an elevated temperature, the cooling rate and, subsequently, the solidification rate are reduced. This causes less solidification stress to be retained. The elevated temperature also has a mild stress-relieving effect, as the build parts tend to be exposed to it for longer periods of time.

The parts produced using LPBF must meet or surpass the specific properties of conventionally produced tools. While the enhanced control over geometry and reduction of waste material are significant advantages of the LPBF production method, the hardness, toughness, thermal conductivity, and tool lifespan must exceed those of traditionally produced parts to justify the higher initial cost and lower production rate.

In this study, our goal is to demonstrate that Laser Powder Bed Fusion (LPBF) is a feasible method for creating tools that can match or exceed tools manufactured using traditional methods. We produced H13 samples with and without preheating, analyzed their microstructure, and tested their mechanical and physical properties. We also compared these samples with reference samples produced using conventional methods to assess their performance.