Effect of Tempering on Additively Manufactured AISI H13 Hot Work Tool Steel

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Additive manufacturing (AM) is a new and exciting process in any metallurgist's arsenal, especially Laser Powder Bed Fusion (LPBF). While it has been a boon to many high-tech applications, like the aerospace and medical sectors, its die-making potential has been somewhat overlooked. AM offers the ability to manufacture complex geometries, which would be unobtainable with regular means of production, like machining. Furthermore, it produces very little waste, as upon completion of a print, the leftover steel powder is fed back into the machine, reusing the unspent powder.

We manufactured our samples, 10x10x10 mm cubes, using an Aconity 3D mini (Aconity Gmbh, Herzogenrath, Germany), which utilizes the LPBF process. First, we created a 3D model of the parts using modelling software. Next, the model was sliced into thin 30 µm layers, and a scanning path for each layer was assigned. The sliced models were uploaded to the printer, and the first step of the LPBF process began: A brush deposited a thin layer of powder onto the work surface. The powder layer thickness depends on the size of the powder particles. In our case, the mean particle size was 30 µm. With the powder bed applied to the work surface, a laser scanned the geometry of a single slice, selectively melting the powder, to produce the desired shape. The last step was lowering the work surface and applying another layer of powder. These steps were repeated by the machine until the full model was built. We used a laser spot size of 60 µm, so the melt pools it created were relatively small resulting in very rapid solidification.

However, for all its benefits, there are also some drawbacks associated with the LPBF process. One problem is the somewhat poor mechanical performance of the as-built parts. Due to the high solidification rate, most of the carbide-forming elements remain in the solid solution. Because H13 derives a significant amount of its strength from small carbides located at grain boundaries, this leaves the as-built parts lacking in key properties such as hardness [1,2].

In this work, we studied the effect of tempering at 4 different temperatures (450 °C, 500 °C, 550 °C, 600 °C) on the hardness of LPBF-produced parts, manufactured on a preheated baseplate (200 °C, 350 °C) as well as without preheating. The microstructure of all the samples was analysed, and our results were compared to conventionally manufactured H13 tool steel.

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