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The effect of travel speed and laser power in the porosity and cracking of AISI H13 tool steel produced by adittive manufacturing.

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Abstract

This paper demonstrates the obtainment of the optimal parameters of production of a H13 tool steel by additive manufacturing in regard of porosity and cracking. The experimental analysis of 28 samples allowed the plotting of 2 charts that contain regions of the most efficient parameters of VED and travel speed that resulted in lower porosity and smaller crack length.

Key words:

Laser powder bed fusion, crack length, parameter optimization

Introduction

Additive manufacturing (AM) technology is drawing interest from the manufacturing industry at a great pace[1]. Among the several perks that this technology provides include the possibility of producing parts with a great range of geometrical complexity that is hardly achieved via subtractive manufacturing.

Laser powder bed fusion (LPBF) is an AM technology that consists in a high-powered laser beam melting consecutive layers of metal powder to form a tridimensional structure. Therefore, the LPBF requires a series of parameter adjustments to be effective in the making of a useful structure. These parameters include travel speed, layer thickness, laser power and hatching space. The variation of these parameters results in different properties, such as density and porosity, which are critical to the deployment of the processed material.

The AISI H13 tool steel is mostly used in hot and cold work applications such as hot extrusion and injection due to its hot strength that allows it to resist to thermal fatigue without cracking or losing its properties [2]. It also has a high toughness and great wear resistance; therefore, it is the most commonly used tool steel in tooling applications.

The present research is focused on obtaining the parameters that result in the best combination of porosity and cracks size in an H13 tool steel produced by LPBF when samples are analyzed with a variation in laser power and travel speed.

Results and Discussion

28 cubic samples of AISI H13 tool steel with dimensions of 10x10x10 mm³ where produced in two separate batches and varied conditions of laser power and travel speed. After that, they were sanded and polished to obtain microscopic images and register the number of cracks and their size. Then, they were assigned three different values in millimeters to the cracks depending on its qualitative size, whether it was a small (0.1~0.5 mm), medium (0.5~1 mm) or large crack (1~2 mm). Then, the number of each type of crack in each sample was accounted separately and added to form a value of total crack length (TCL) that could be used for comparison.

In parallel, the images obtained via optical microscopy were used to determine the porosity of the material under each set of parameters. The results obtained are shown in Fig. 1.

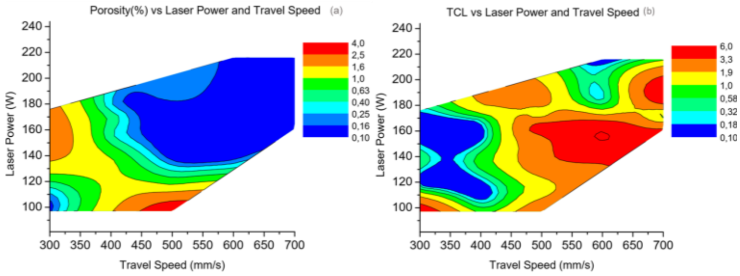

Fig 1. Porosity (a) and TCL (b) vs Travel Speed and Laser Power.

One important information that can be drawn out of both charts is that the TCL and the travel speed are nearly complementary. The parameters that favors TCL positively also influence the porosity, but in a negative way and vice-versa.

On the other hand, there is a small region that intercepts both charts that showed optimistic results. When high travel speed (from 550 to 650 mm/s) and high laser power are combined (from 180 to 215 W) it results in a nearly crack-free and extremely low porosity (99.9%) region.

Conclusions

The experimental approach has shown that even though the TCL and the porosity seem complementary attributes, there are certain combinations of VED and travel speed that bring the best out of those two characteristics. It was also shown that there is a zone where high travel speed (from 500 to 600 mm/s) and average laser power (from 140 to 160 W) generate a significant high value of TCL that makes this combination rather undesirable even though it also has extremely low porosity.

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