World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:15, No:03, 2021

Analysis of Correlation Between Manufacturing Parameters and Mechanical Strength Followed by Uncertainty Propagation of Geometric Defects in Lattice Structures

Authors : Chetra Mang, Ahmadali Tahmasebimoradi, Xavier Lorang

Abstract : Lattice structures are widely used in various applications, especially in aeronautic, aerospace, and medical applications because of their high performance properties. Thanks to advancement of the additive manufacturing technology, the lattice structures can be manufactured by different methods such as laser beam melting technology. However, the presence of geometric defects in the lattice structures is inevitable due to the manufacturing process. The geometric defects may have high impact on the mechanical strength of the structures. This work analyzes the correlation between the manufacturing parameters and the mechanical strengths of the lattice structures. To do that, two types of the lattice structures; body-centered cubic with z-struts (BCCZ) structures made of Inconel718, and body-centered cubic (BCC) structures made of Scalmalloy, are manufactured by laser melting beam machine using Taguchi design of experiment. Each structure is placed on the substrate with a specific position and orientation regarding the roller direction of deposed metal powder. The position and orientation are considered as the manufacturing parameters. The geometric defects of each beam in the lattice are characterized and used to build the geometric model in order to perform simulations. Then, the mechanical strengths are defined by the homogeneous response as Young's modulus and yield strength. The distribution of mechanical strengths is observed as a function of manufacturing parameters. The mechanical response of the BCCZ structure is stretch-dominated, i.e., the mechanical strengths are directly dependent on the strengths of the vertical beams. As the geometric defects of vertical beams are slightly changed based on their position/orientation on the manufacturing substrate, the mechanical strengths are less dispersed. The manufacturing parameters are less influenced on the mechanical strengths of the structure BCCZ. The mechanical response of the BCC structure is bending-dominated. The geometric defects of inclined beam are highly dispersed within a structure and also based on their position/orientation on the manufacturing substrate. For different position/orientation on the substrate, the mechanical responses are highly dispersed as well. This shows that the mechanical strengths are directly impacted by manufacturing parameters. In addition, this work is carried out to study the uncertainty propagation of the geometric defects on the mechanical strength of the BCC lattice structure made of Scalmalloy. To do that, we observe the distribution of mechanical strengths of the lattice according to the distribution of the geometric defects. A probability density law is determined based on a statistical hypothesis corresponding to the geometric defects of the inclined beams. The samples of inclined beams are then randomly drawn from the density law to build the lattice structure samples. The lattice samples are then used for simulation to characterize the mechanical strengths. The results reveal that the distribution of mechanical strengths of the structures with the same manufacturing parameters is less dispersed than one of the structures with different manufacturing parameters. Nevertheless, the dispersion of mechanical strengths due to the structures with the same manufacturing parameters are unneglectable.

Keywords : geometric defects, lattice structure, mechanical strength, uncertainty propagation
Conference Title : ICAMTFDMA 2021 : International Conference on Additive Manufacturing Technologies, Fused Deposition Modelling and Applications
Conference Location : Paris, France
Conference Dates : March 29-30, 2021