Additive manufacturing and neutron diffraction: Residual stress assessment and control

Additive manufacturing (AM) of components made out of metals using powder and laser has been in increasing demand especially in the sector of aerospace, medical sectors, etc. With AM, parts with complex geometries can be manufactured easily in comparison to the traditional ones. However, with the ease of manufacturing complex parts, several issues must be tackled to get a good quality party without losing its mechanical integrity. One of such issues is the control of residual stresses (RS). These RS are generated mainly due to the temperature difference between the consecutive layers while printing. For a comprehensive and systematic study of different process parameters such as print orientations and scan strategies two separate studies on L-shaped geometry printed out of IN718 superalloy were done. The first study was on print orientation where parts were printed in different orientations namely: horizontal (HB), vertical (VB), and 45° angle (45B), and for the second study parts were printed in the vertical orientation with different scan strategies. With the help of neutron diffraction, RS distribution in the bulk of the sample and the influence of these printing parameters on the RS magnitude and distribution were studied. For the print orientation study, it was found that part built in a Vertical orientation has the highest magnitude of RS and for the scan strategies' influence, it was found that different scan strategies can lead to the reduction of RS in the same part printed in the vertical orientation. From the data available from the experiment, a simplified FEM model to predict the RS due to print orientation was also established. The model can predict the RS distribution trend similar to that measured ones but with a higher magnitude of stresses. Further data from the neutron diffraction results can be used to calibrate the existing models for the prediction of RS in AM or to verify new models as well.