Understanding on microstructure and cracks of permanent magnetic material Nd-Fe-B using Laser Powder Bed Fusion

Julan Wu[1], Nesma T. Aboukhair[1], Richard J.M. Hague[1], Ian Ashcroft[1]

1- Centre for Additive Manufacturing, Faculty of Engineering, University of Nottingham, Nottingham, NG8 1BB, UK

We present a parametric study on the laser powder bed fusion (L-PBF) of isotropic Nd-Fe-B magnet powders[1]. The microstructure and the magnetism of the L-PBF'd Nd-Fe-B were also studied. Consequently, the issues encountered with utilising L-PBF for the production of relatively high-density Nd-Fe-B magnetics are elucidated and discussed. Furthermore, new insights on the geometrical constraints on the shape complexity and design freedom during L-PBF of this material are presented, proposing a guideline for the possible capabilities in this aspect.

High-density samples with remanence of 0.65T and maximum energy product of 62 kJ/m^3 were successfully produced, whilst demonstrating the integrity of the parts was affected by the scan speed and hatch distance; in addition, the sample's size and geometry were also found to influence the success of building within the LPBF system. The microstructure of the L-PBF'd Nd-Fe-B was found to be different from the conventional sintered Nd-Fe-B, but similarities to laser spot welded nuggets of the sintered magnets were observed. The L-PBF'd Nd-Fe-B magnet mainly consisted of the $Nd_2Fe_{14}B$ phase with random orientation and small amounts of the precipitated phases. The relative density and integrity of the produced samples were mainly constrained by the intrinsic brittle mechanical property of intermetallic $Nd_2Fe_{14}B$ phase and the residual stresses induced during the rapid heating and cooling of the materials during laser processing, alongside phase precipitation. Cracks formed in the produced material due to the excessive residual stresses in the heat-affected zones (HAZ) and between the interfaces of the different phases.

[1] Magnequench. MQP-S-11-9-20001 powder data sheet. 2020.