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EFFECTS OF PROCESSING PARAMETERS ON THE SURFACE TEXTURE OF ADDITIVE MANUFACTURED 316L STAINLESS STEEL IN THE CONTEXT OF THE SUPER HIGH TEMPERATURE ADDITIVE MANUFACTURED RESISTOJET (STAR)

Abstract

The Super High Temperature Additive Manufactured Resistojet (STAR) is an ongoing project at the University of Southampton (UoS) to develop a resistojet thruster that will deliver a step increase in performance over current designs by operating at significantly higher temperatures. Due to the complicated geometry of the resistojet, additive manufacturing, particularly Selective Laser Melting (SLM) has been chosen as the most suitable method to manufacture a complex yet monolithic heat exchanger. Early versions of the resistojet have been manufactured from 316L stainless steel as low temperature prototypes due to ease of manufacture at UoS and in order to verify and optimise the design.

Despite the advantages SLM offers in terms of build flexibility, it is still limited in terms of surface quality. Factors unique to SLM including half-melted agglomerations or particle "balling" result in significantly rougher surfaces compared to traditionally made parts. Although this can normally be remedied using post processing techniques, the complicated design of the resistojet requires it to be used in the as-manufactured state. This increased surface roughness influences the overall performance of the thruster. To both reduce the amount of heat lost through radiation and maximise the structural temperature it is desired to have as low an emissivity as possible. As emissivity increases with surface roughness it is necessary to achieve as low a surface roughness as possible. This can be achieved through SLM process parameter variation.

In this study using Design of Experiments (DoE), SLM process parameters (laser power, scanning speed, layer thickness, hatch spacing and build angle) of 316L stainless steel were varied to produce a set of 17 parameter combinations that give a comprehensive overview into how these affect various materials characteristics. Test coupons were manufactured using these settings and the surface quality characterised using focal variation microscopy, high-resolution micro-computed tomography and Scanning Electron Microscopy (SEM). These results were then used to generate a model to predict a set of parameter combinations that would result in the lowest possible surface roughness.

This paper presents a novel approach to understanding how process parameters influence the surface quality of SLM parts and represents a necessary step forward in the overall development of the resistojet in order to optimise the design.