Laser Polishing of Additively Manufactured Aluminium Surfaces

B. Mason, D. Bhaduri, M. Ryan, R. Setchi, A. Kundu
Cardiff School of Engineering, The Parade, Cardiff, CF24 3AA, UK.

The benefits of Additive Manufacturing (AM) are well documented, with significant interest from aerospace, motorsport, and other weight-critical industries. There are, however, some significant limitations with current methods. One example is the excessive surface roughnesses of AM components. In the case of powder-bed systems, this arises due to the complex thermal conditions present during manufacture, excessive melting (or sintering) of the powder feedstock, surface contamination, and so on. Considerable effort has been devoted to optimizing the manufacturing conditions, however these still lag behind the expectations of traditional engineering processes. It is therefore common to post-process AM components to improve their surface finish.

There are a multitude of options available to smooth the surfaces, these either compromise the geometric freedom available (for example machining, or manual polishing) or can come with environmental concerns (chemical, or electro-chemical polishing). Laser Polishing (LP) is an attractive solution as it is non-contact and produces nearly zero waste. LP is of interest for applications such as electronic enclosures, aerospace, and automotive due to the improved aesthetics and mechanical properties afforded.

Work has been undertaken to develop a strategy to smooth the surface of AM Aluminium parts through laser exposure. Experiments were conducted on the vertical walls of AM AlSi10Mg samples manufactured using a Renishaw AM250 machine, followed by polishing using a DMG Lasertec 40 laser milling centre. The proposed strategy combines ablation and smoothing steps to successively reduce the surface roughness. The number of passes was varied (4 to 36 in steps of 4), while the spot energy density kept constant at either 13.7 or 11.9 J/cm^2 for the ablation or smoothing steps respectively. The overlap factor along the scanning direction was around 95%, and 95% or 90% in the step over direction (ablation or smoothing steps respectively).

Surfaces were measured optically before and after processing from which a range of surface roughness parameters were calculated. The lowest roughness achieved was 3.22 µm Sa, while the greatest reduction was 77.6% (from 29.1 µm to 6.5 µm Sa). There were significant reductions in all other surface amplitude parameters evaluated, most notably S10z (70% from 409 µm to 86 µm) and Sp (82% from 176 µm to 32 µm). Visually, the surfaces had a high lustre, with no traces of adhered particles or soot. No significant differences in smoothing were observed when changing the hatch angles. While the process was found to be stable, returning similar percentage reductions in roughness across multiple repetitions, there was reduced effectiveness on surfaces with lower initial roughnesses. This implies there is a lower limit for how smooth this process is able to achieve.

Furthermore, as LP is a thermal process, there is a certain degree of microstructural evolution during the process. Representative areas were processed to represent the state at various stages of the strategy. These samples will be used to evaluate the microhardness through the heat affected zone and the microstructural changes caused by the laser irradiation. Further samples have been prepared for tensile testing at a later date.