Engineering Microstructural Evolution during Arc Wire Directed Energy Deposition of Magnesium Alloy (AZ31)

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Abstract : Magnesium and its alloys are widely used for various lightweight engineering and biomedical applications as they render high strength to low weight ratio and excellent corrosion resistance. These alloys possess good bio-compatibility and similar mechanical properties to natural bone. However, manufacturing magnesium alloy components by conventional formative and subtractive methods is challenging due to their poor castability, oxidation potential, and machinability. Therefore, efforts are made to produce complex-design containing magnesium alloy components by additive manufacturing (AM). Arc-wire directed energy deposition (AW-DED), also known as wire arc additive manufacturing (WAAM), is more attractive to produce large volume components with increased productivity than any other AM technique. In this research work, efforts were made to optimise the deposition parameters to build thick-walled (about 10 mm) AZ31 magnesium alloy components by a gas metal arc (GMA) based AW-DED process. By using controlled dip short-circuiting metal transfer in a GMA process, depositions were carried out without defects and spatter formation. Current and voltage waveforms were suitably modified to achieve stable metal transfer. Moreover, the droplet transfer behaviour was analysed using high-speed image analysis and correlated with arc energy. Optical and scanning electron microscopy analyses were carried out to correlate the influence of deposition parameters with the microstructural evolution during deposition. The investigation reveals that by carefully controlling the current-voltage waveform and droplet transfer behaviour, it is possible to stabilise equiaxed grain microstructures in the deposited AZ31 components. The printed component exhibited an improved mechanical property as equiaxed grains improve the ductility and enhance the toughness. The equiaxed grains in the component improved the corrosion-resistant behaviour of other conventionally manufactured components.

Keywords : arc wire directed energy deposition, AZ31 magnesium alloy, equiaxed grain, corrosion
Conference Title : ICWAM 2022 : International Conference on Welding and Additive Manufacturing
Conference Location : Athens, Greece
Conference Dates : October 13-14, 2022