Mechanical Engineering Doctoral Defense

Corrosion and Sensitized Microstructure Evolution of 3D Printed Stainless Steel 316 and Inconel 718 Dissolvable Supports

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abstract

Additive manufacturing (AM) describes an array of methods used to create a 3D object layer by layer. The increasing popularity of AM in the past decade has been due to its demonstrated potential to increase design flexibility, produce rapid prototypes, and decrease material waste. Temporary supports are an inconvenient necessity in many metal AM parts. These sacrificial structures are used to fabricate large overhangs, anchor the part to the build substrate, and provide a heat pathway to avoid warping. Polymers AM has addressed this issue by using support material that is soluble in an electrolyte that the base material is not. In contrast, metals AM has traditionally approached support removal using time consuming, costly methods such as electrical discharge machining or a dremel. This work introduces dissolvable supports to single- and multi-material metals AM. The multi-material approach uses material choice to design a functionally graded material where corrosion is the functionality being varied. The single-material approach is the primary focus of this thesis, leveraging already common post-print heat treatments to locally alter the microstructure near the surface. By including a sensitizing agent in the ageing heat treatment, carbon is diffused into the part decreasing the corrosion resistance to a depth equal to at least half the support thickness. In a properly chosen electrolyte, this layer is easily chemically, or electrochemically removed. Stainless steel 316 (SS316) and Inconel 718 are both investigated to study this process using two popular alloys. The microstructure evolution and corrosion properties are investigated for both. For SS316, the effect of applied electrochemical potential is investigated to describe the varying corrosion phenomena induced, and the effect of potential choice on resultant roughness. In summary, a new approach to remove supports from metal AM parts is introduced to decrease costs and further the field of metals AM by expanding the design space.

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