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Corrosion Resistance of 17-4 Precipitation Hardenable Stainless Steel Fabricated by Selective Laser Melting

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Abstract : Additive manufacturing (AM) has gained more interest in the past few years because it allows 3D parts often having a complex geometry to be directly fabricated, layer by layer according to a CAD model. One of the AM techniques is the selective laser melting (SLM) which is based on powder bed fusion. In this work, the corrosion resistance of 17-4 PH steel obtained by SLM is investigated. Wrought 17-4 PH steel is a martensitic precipitation hardenable stainless steel. It is widely used in a variety of applications such as aerospace, medical and food industries, due to its high strength and relatively good corrosion resistance. However, the combined findings of X-Ray diffraction and electron backscatter diffraction (EBSD) proved that SLM-ed 17-4 PH steel has a fully ferritic microstructure, more specifically δ ferrite. The microstructure consists of coarse ferritic grains elongated along the build direction, with a pronounced solidification crystallographic texture. These results were associated with the high cooling and heating rates experienced throughout the SLM process (10^5-10^6 K/s) that suppressed the austenite formation and produced a 'by-passing' phenomenon of this phase during the numerous thermal cycles. Furthermore, EDS measurements revealed a uniform distribution of elements without any dendritic structure. The extremely high cooling kinetics induced a diffusionless solidification, resulting in a homogeneous elemental composition. Consequently, the corrosion properties of this steel are altered from that of conventional ones. By using electrochemical means, it was found that SLM-ed 17-4 PH is more resistant to general corrosion than the wrought steel. However, the SLM-ed material exhibits metastable pitting due to its high porosity density. In addition, the hydrogen embrittlement of SLM-ed 17-4 PH steel is investigated, and a correlation between its behavior and the observed microstructure is made.

Keywords : corrosion resistance, 17-4 PH stainless steel, selective laser melting, hydrogen embrittlement
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