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FAILURE RESISTANCE OF ADDITIVELY MANUFACTURED MARAGING STEEL M350 UNDER DYNAMIC IMPACT LOADING

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ABSTRACT

Maraging steel is used in military applications as protective armour owing to its ultra-high strength and hardness. Many studies have been conducted on the dynamic impact response of maraging steels produced by casting and mechanical forming. However, information on the behaviour of additively manufactured maraging steels under dynamic shock loading is limited. The failure resistance and microstructural evolution in M350 maraging steel fabricated by laser-based directed energy deposition (DED) process under dynamic loading are investigated in this study. The influence of additive manufacturing (AM) processing parameters, including laser power, powder feed rate, and energy area density (EAD), are discussed. The mechanical testing of the additively manufactured alloy was done using the Split Hopkinson Pressure Bar (SHPB) system. This dynamic impact test was conducted using strain rates ranging from 10^2 to 4×10^3 s^{-1}. In addition, dynamic impact testing was performed on the cylindrical test specimens with axis parallel and perpendicular to the build direction to evaluate the effects of impact direction relative to the build direction on the deformation and failure resistance of the steel. The test results analysis shows that the critical strain at which the flow stress collapses during the impact loading was influenced by the strain rate, which depends on the striker bar's impact momentum. Test results indicate that deformation and failure resistance is greatest for materials processed using the highest EAD parameters for all investigated impact directions. This finding also implies that the samples possessing a high density produced by the highest EAD parameters possess better impact failure resistance. In these materials, the specimens impacted along with the directions perpendicular to the built direction exhibit greater resistance to impact failure than those that were impacted along the built direction. Strain localization leading to the formation of adiabatic shear bands (ASB) was observed in some impacted specimens. The shear bands propagate close to the edge of test specimens. These ASBs form due to thermomechanical instabilities caused by localized adiabatic heating in the specimens. Cracks were observed along the ASBs, while some AM-process-related defects, such as the lack-of-fusion, interacted with adiabatic shear bands, promoting more cracking tendency inside the shear bands.