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Enabling Wire Arc Additive Manufacturing in Aircraft Landing Gear Production and Its Benefits

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Abstract : As a crucial component in aircraft, landing gear systems are responsible for supporting the plane during parking, taxiing, takeoff, and landing. Given the need for high load-bearing capacity over extended periods, 300M ultra-high strength steel (UHSS) is often the material of choice for crafting these systems due to its exceptional strength, toughness, and fatigue resistance. In the quest for cost-effective and sustainable manufacturing solutions, Wire Arc Additive Manufacturing (WAAM) emerges as a promising alternative for fabricating 300M UHSS landing gears. This is due to its advantages in near-net-shape forming of large components, cost-efficiency, and reduced lead times. Cranfield University has conducted an extensive preliminary study on WAAM 300M UHSS, covering feature deposition, interface analysis, and post-heat treatment. Both Gas Metal Arc (GMA) and Plasma Transferred Arc (PTA)-based WAAM methods were explored, revealing their feasibility for defect-free manufacturing. However, as-deposited 300M features showed lower strength but higher ductility compared to their forged counterparts. Subsequent post-heat treatments were effective in normalising the microstructure and mechanical properties, meeting qualification standards. A 300M UHSS landing gear demonstrator was successfully created using PTA-based WAAM, showcasing the method's precision and cost-effectiveness. The demonstrator, measuring Φ200mm x 700mm, was completed in 16 hours, using 7 kg of material at a deposition rate of 1.3kg/hr. This resulted in a significant reduction in the Buy-to-Fly (BTF) ratio compared to traditional manufacturing methods, further validating WAAM's potential for this application. A "cradle-to-gate" environmental impact assessment, which considers the cumulative effects from raw material extraction to customer shipment, has revealed promising outcomes. Utilising Wire Arc Additive Manufacturing (WAAM) for landing gear components significantly reduces the need for raw material extraction and refinement compared to traditional subtractive methods. This, in turn, lessens the burden on subsequent manufacturing processes, including heat treatment, machining, and transportation. Our estimates indicate that the carbon footprint of the component could be halved when switching from traditional machining to WAAM. Similar reductions are observed in embodied energy consumption and other environmental impact indicators, such as emissions to air, water, and land. Additionally, WAAM offers the unique advantage of part repair by redepositing only the necessary material, a capability not available through conventional methods. Our research shows that WAAM-based repairs can drastically reduce environmental impact, even when accounting for additional transportation for repairs. Consequently, WAAM emerges as a pivotal technology for reducing environmental impact in manufacturing, aiding the industry in its crucial and ambitious journey towards Net Zero. This study paves the way for transformative benefits across the aerospace industry, as we integrate manufacturing into a hybrid solution that offers substantial savings and access to more sustainable technologies for critical component production.

Keywords : WAAM, aircraft landing gear, microstructure, mechanical performance, life cycle assessment
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