Effect of corrosion exposure on the tensile mechanical properties of aluminum alloy 2024 electron beam welds

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Introduction: Aluminum alloy 2024 welds are rare; welds can be produced but on dramatic cost in terms of mechanical performance. Nevertheless, there is always ground for improvement, by exploiting new techniques or non-conventional processes. Electron beam welding is widely used to weld high performance aircraft alloys such as super alloys (Ti or Ni). In the present work, an effort has been made to weld 2024-T3 sheets with this high-performance welding process. In addition, corrosion damage of the material is also very essential to the structural integrity of the aircraft. Since the material of a component is subjected to corrosion, it is expected that its critical mechanical properties might vary with increasing service time and thus, must be taken into account for the structural integrity calculation of the component.

Experimental procedure: Aluminum 2024-T3 sheets were electron beam butt-welded; the welds were explicitly examined via metallographic investigation and hardness measurements. Tensile and fatigue specimens were machined out of the welded sheets, according to ASTM E8 and E466, respectively. A number of the machined tensile specimens were tensile tested to assess the effect of the welding process on the mechanical performance of the alloy. Reference and butt-welded specimens were exposed for various exposure times up to 48 hours exposure to exfoliation corrosion solution according to ASTM G46. After the exposure, tensile and fatigue tests were performed on welded specimens to assess the effect of corrosion on the mechanical properties.

Results and conclusions: A very narrow fusion and heat affected zone was noticed on electron beam welds; performed hardness measurements of the weld's cross-section showed that hardness was decreased in the fusion zone (FZ) and not essentially increased in the heat-affected zone (HAZ). Decrease of the FZ's hardness was attributed to the solution of the wrought microstructure, while HAZ's small increase in hardness to the precipitation of the θ' (Al_2Cu) metastable phase. An essential decrease was noticed in the tensile ductility of the welds while tensile strength remained almost unaffected, when compared to the reference specimens. Performed fatigue tests on both reference and welded specimens showed that the fatigue endurance limit and Woehler curve was essentially decreased.

Tensile tests on the pre-corroded specimens revealed the deleterious effect of corrosion exposure on the mechanical properties, especially in ductility. Corrosion exposure on the reference specimens showed that after 48 hours exposure, an approximate 45% decrease in ductility was noticed. Corrosion products were noticed to be uniform across the corroded area of the specimen, and had an average depth of attack of 300 μm for 24 hours exposure on the 3.2 mm thickness specimen. However, this was not the case for the welded specimens; localized corrosion was noticed and more than 50% decrease was calculated for 48 hours exposure to the corrosion exposure solution.