

The Effect of Surface Enhancement on the Corrosion Properties, Fatigue Strength, and Degradation of Aircraft Aluminum

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ABSTRACT

Corrosion, Stress Corrosion Cracking (SCC) and corrosion fatigue failures of high strength aircraft aluminums are costly and potentially catastrophic material problems affecting the aircraft fleet today. As the service lives of aircraft are extended, the increasing inspection and repair of corrosion in aging aircraft adversely affects fleet readiness, the cost of operation, and personnel safety.

Shot peening (SP) is a widely used surface enhancement and repair method that produces a shallow layer of compressive residual stress on the surface of components to improve fatigue life and corrosion resistance. The repeated random impact of shot subjects the treated surface to a high level of plastic deformation, or cold working. The high level of cold working reduces the thermal and mechanical stability of the beneficial compressive layer and creates a more chemically active surface that is prone to corrosive attack. Low Plasticity Burnishing (LPB) surface enhancement processing imparts a deep layer of stable compression with minimal cold working and has been shown to greatly improve fatigue and corrosion properties while avoiding the adverse effects of high cold working.

The corrosion fatigue and pitting corrosion performance of 7475-T7351 aluminum alloy is investigated for both SP and LPB treated test specimens. In all cases, LPB provided greater resistance to pitting and SCC damage. Corrosion fatigue life and damage tolerance were improved compared to the SP specimens. The depth of the shot peening compressive layer extends only a few thousandths of an inch into the surface. LPB imparts a much deeper layer of thermo-mechanically stable residual compression.

Corrosion pits, cracks, or other damage that exceed the depth of compression serve as the nucleation point(s) for corrosion induced fatigue cracking. Pit depths asymptotically approached a maximum depth dependent upon the surface treatment. The depth of compression from LPB greatly exceeds the maximum corrosion pit depth, therefore preventing corrosion related fatigue failure and ensuring safe-life operation.