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The effects of surface pits and intermetallics on the competing failure modes in laser shock peened AA7075-T651: Experiments and modelling

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Abstract

The effects of laser shock peening (LSP) on the fatigue life of AA7075-T651 were investigated. The combined influence of surface imperfections (i.e. pits and intermetallics), compressive residual stresses (CRS) and the applied stress on crack initiation sites (surface or subsurface) and the associated fatigue life were investigated. Critical surface imperfections were found to significantly reduce the benefits of LSP in life improvement, by promoting surface crack initiation despite the resisting effects of CRS. To facilitate quantifying the effects of LSP on fatigue life, a finite element (FE) model was developed to simulate residual stress distribution induced by LSP, as well as its redistribution caused by the formation of surface pits. Based on the FE results, a method identifying whether the specified surfaces pits and intermetallics are critical to lead to surface cracking at given stress conditions was proposed, based on the Smith-Watson-Topper method and the Murakami's model respectively. The interaction between surface imperfections, CRS and the applied loads were taken into account in this method. In addition, a fatigue life assessment framework was proposed based on the prediction of crack initiation sites, which was validated to be reliable in efficiently evaluating the efficacy of the applied LSP in improving fatigue life.