

Development of Laser Straightening (LS) Strategies to Remove Distortion in Welded Aeronautical Structures

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Abstract. Manufacturing of stiffened aeronautical structures requires the joining of stringers to thin skin. Structures targeted in this work are composed by Ti-6Al-4V (Grade 5) stringers and commercially pure Ti (cp-Ti, Grade 2) skin. The stringers are laser beam welded (LBW) to the skin in T-joint configuration. Despite the highly concentrated and relatively low heat input of the laser source, the reduced thickness of the skin (0.8 mm) leads to significant angular distortion and so-called “Zeppelin effect”. Moreover, buckling distortion is observed in medium size panels (500 x 500 mm) including several stringers. Within this study, laser straightening (LS) process has been developed to mitigate as-welded distortion. The process is applied on the reverse of the skin and is based on the temperature gradient mechanism (TGM). The same welding source (disk laser) and optic head were employed for both LBW and LS. Consequently, the complete manufacturing of the structure can be done in just one working station. Moreover, the same laser triangulation sensor is used both for seam tracking during LBW and distortion measurement before and after LS.

Different LS strategies were applied with the aim of removing welding induced distortion. They included both constant and variable laser power runs. In the first case a constant heat input is introduced along the straightening path, whereas in the latter the laser power is modified according to the local distortion angle. Single and multiple runs were also applied for the definition of best suited LS. After optimization of LS process, medium size panels with maximum distortion of less than 2.6 mm were obtained. Initial distortion was higher than 11 mm, meaning that approximately 80% of welding induced distortion was effectively removed.

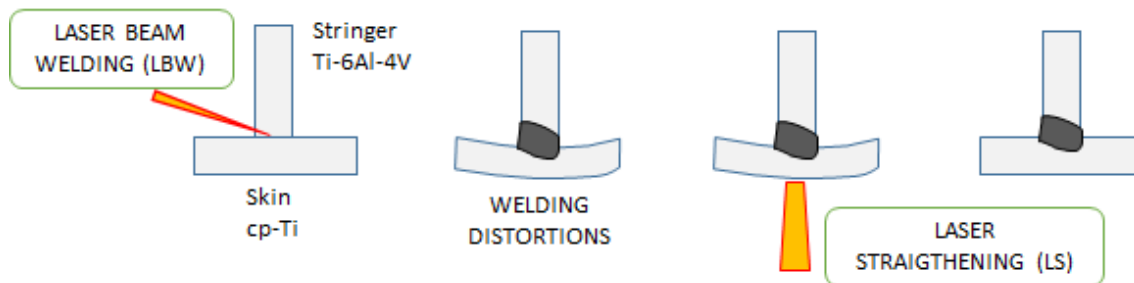


Figure 1 . LBW and LS of stiffened Ti panels.



Figure 2 . Comparison between as-welded and straightened distortion

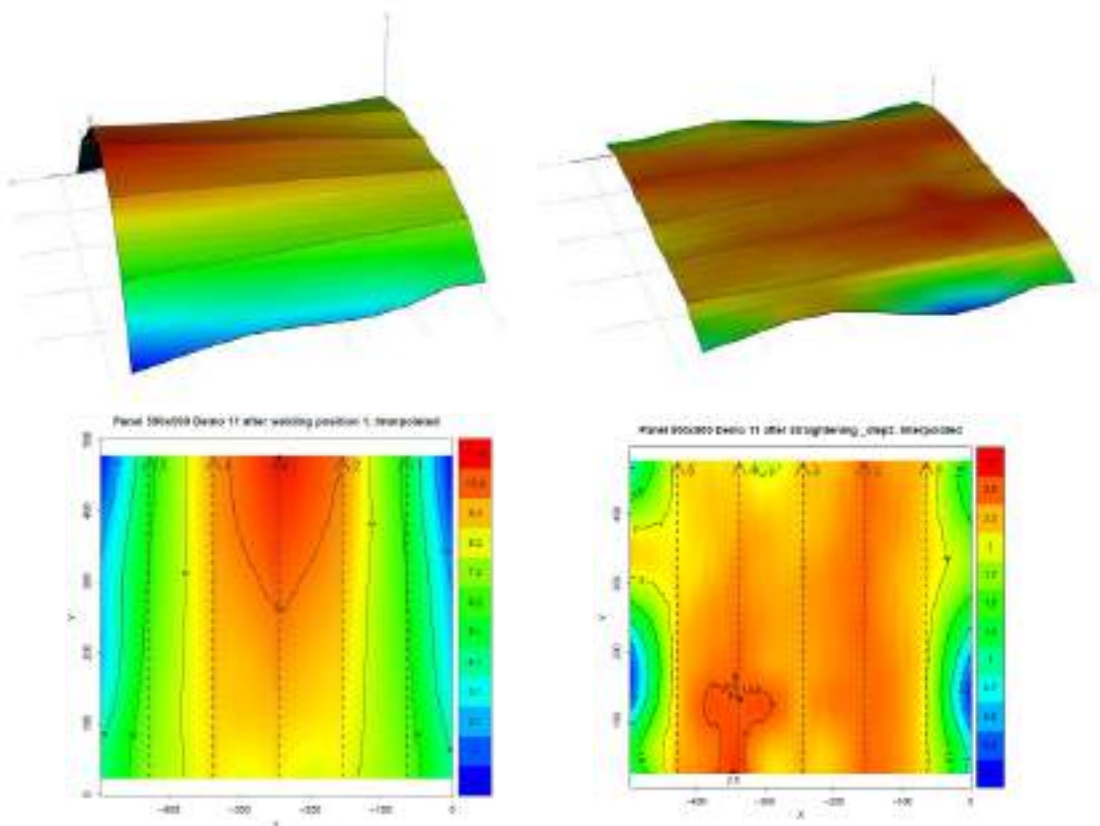


Figure 3 . Distortion plots of as-welded and straightened panel