Influence of the welding sequence on residual stresses in laser welded T-joints of aluminium alloys

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Replacing riveted by laser beam welded (LBW) joints of aluminium alloys is a current topic in the aircraft industry due to weight and cost savings. Such LBW joints have already been realized for skin-stringer joints in several aircraft types. However, extension of this technique to short-distance T-joints of so-called clips to the skin is still needed. The start (run-in) and end (run-out) locations of short skin-clip welds are critical locations with respect to crack initiation and growth due to high stress concentration. Recent measurements indicated that longitudinal tensile stresses are lower at the run-in locations than at the run-out locations. Therefore, in the present study, the LBW joint of 2 mm thick AA6013-T6 clips to 4.5 mm thick AA6156-T6 base plates – resembling a skin-clip joint of an airframe – using a 3.3 kW Nd:YAG Laser source are investigated. Particularly, the effect of different welding sequences on the residual stress state was studied. One welding sequence was made straight from one end of the clip to the other, a second with two starting points in the centre, and a third with starting points at the clip ends. Experimental determination of residual stresses was done using neutron and high-energy X-ray diffraction. In addition, welding temperature field measurements were made to verify the predictions of a finite element simulation of the welding process, which is used for predictions of the residual stress distribution. The results show that the stress distribution around the weld depends strongly on the welding sequence. Two run-ins in the middle produce low tensile longitudinal stresses and compressive transverse stresses in the middle of the clip. On the other hand, two run-ins at both ends of the clip produce low tensile longitudinal stresses and compressive transverse stresses at the clip ends.