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Quantitative Laser Thermographic Method for Mechanical Characterization of P-FSSW Joints in Aluminium Alloys

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This study introduces a novel non-destructive methodology based on step-heating laser thermography technique to evaluate the mechanical strength of dissimilar aluminium joints produced through probeless friction stir spot welding (P-FSSW). The proposed approach enables the quantitative analysis of the thermo-mechanically stirred region, distinguishing two different morphologies (ductile and mixed) correlated with the joint's ultimate mechanical strength. Eleven welded joints were analysed by using two of them used for calibration through thermographic tests, Chisel and scanning electron microscopy (SEM) analyses. At the same time, nine underwent tensile-shear tests were carried out to correlate thermographic parameters (A1, A2) with maximum force (Fmax).
Statistical analysis revealed that the ductile area (A2) is the most significant parameter, exhibiting a robust correlation with Fmax ($r = 0.81$). A simplified regression model based on A2 demonstrated high reliability (adjusted $R^2 = 0.60$). This methodology provides a significant advancement in non-destructive quality control for P-FSSW joints, paving the way for its integration into industrial applications.

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