Effect of Cu Interlayer Design on the Global and local Mechanical Properties of Friction Stir Spot Welded Aluminum Joints

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Abstract:

Friction Stir Spot Welding (FSSW) has gained significant attention in aerospace and lightweight structural applications due to its ability to produce high-strength, defect-free joints. This study investigates the influence of a copper (Cu) interlayer on the mechanical properties of the joints in Al7075 alloy. Three joint configurations were examined: (1) a direct Al7075-to-Al7075 joint without an interlayer, (2) a joint with a continuous (solid) Cu interlayer, and (3) a joint with a pre-pierced Cu interlayer. The effect of these configurations on tensile strength and fracture behavior was analyzed. Tensile test results revealed that the joint with a solid Cu interlayer exhibited the highest strength, indicating improved mechanical integrity. The Cu layer facilitated heat distribution and softened metal flow, leading to a larger welded area, better stress distribution. The pre-pierced Cu interlayer, however, introduced stress concentrations around the hole leading to premature fracture. The joint without a Cu interlayer was the weakest, with lower strength, limited plastic deformation, making it less suitable for high-performance applications. Digital Image Correlation (DIC) analysis further supported these findings by revealing localized strain distribution and stress evolution, showing that the solid Cu interlayer resulted in more uniform stress dissipation. These results demonstrate the critical role of interlayer design in optimizing the performance of FSSW joints. The solid Cu interlayer is recommended for applications requiring superior strength, and enhanced safety under tension-shear loading. This study provides valuable insights for designing FSSW joints in aerospace and automotive applications, where lightweight materials with high structural integrity are essential.

Keywords:

Mechanical properties, Cu-Al, welding, Digital Image Correlation (DIC), macrostructure.