Proceedings of the Canadian Society for Mechanical Engineering International Congress 2021
CSME Congress 2021
June 27-30, 2021, Charlottetown, PE, Canada

MICROSTRUCTURE AND MECHANICAL PROPERTIES OF ULTRASONIC SPOT WELDED ALUMINUM SHEETS WITH AND WITHOUT CLAD LAYER

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ABSTRACT

According to recent Green House Gas (GHG) report issued by Environment and Climate Change Canada, the transportation sector accounts for the second largest source with ~25% (~185 MT CO_2 equivalent) of total national emissions. The challenge of climate change is propelling the transportation industry towards more fuel-efficient products and manufacturing processes with lower energy consumption. The demand for reducing fuel consumption and GHG emissions led to increased applications of lightweight aluminum and magnesium alloys to diminish the effect of global warming. This inevitably entails the fabrication and/or joining of lightweight body structures. The road map for the transportation industry has highlighted the need for more efficient joining methods. Ultrasonic spot welding (USW) is one of the emerging solid-state welding processes, producing robust joints with low energy consumption. Short weld cycle time (~0.5-1 s) results in strong welded joints owing to a small heat-affected zone (HAZ). Aluminum alloys like Al5182 have been commonly used for manufacturing vehicle body, brackets, steering wheels, etc., and thus became a prominent candidate for joining, while some aluminum alloys like Al7075 which are mostly used in the aerospace applications are difficult to be welded by fusion welding. Via USW a defect-free and robust bonding of Al7075-Al7075 was achieved due to the presence of Alclad (Al-1Zn) coating, which is also referred to as corrosion resistant alloy. A strong welded joint could be obtained at a welding energy as low as 1 kJ in the studied alloys, compared with the required high welding energy of 50-100 kJ by resistance spot welding. The microstructure of the weld interface appeared to be necklace-like with ultrafine grains manifesting a higher weld strength. The obtained tensile lap shear strength increased with increasing welding energy and exceeded the AWS D17.2 standards which confirmed a robust interfacial bond. A high tensile shear load of ~6 kN was attained in both Al5182 and Alclad Al7075 alloys. Interestingly, even the so-called “unweldable” Al7075 alloy reached a tensile lap shear load of >6 kN at a higher welding energy via USW. Furthermore, the welded joints of both alloys exhibited superior fatigue resistance with similar failure mechanisms under stress control. A bi-linear fatigue life characteristic was observed depending on the applied cyclic loading level, regardless of the presence of Alclad layer. More information on the promising USW for joining automotive and aerospace grade body structures with superior mechanical properties for the lightweight applications will be presented.