C. Laser Hybrid Welding of Coated High-strength Steels

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Introduction

Automotive fuel economy requires lower vehicle weights, so the future of steel use in auto bodies may lie in thinner sections of higher strength materials such as dual-phase or TRIP steels, with strengths above 500 MPa (70 ksi). Corrosion protection demands remain, however, and zinc coatings remain a requirement for ordinary steels in body applications. The challenge is to achieve the same level of joint quality (appearance, fabricability, and performance) with these higher strength steels that has been consistently achieved with conventional coated steels over the years.

The present work involves laser/GMAW hybrid welding of a number of high-strength steels from different manufacturers, both uncoated and zinc-coated, via galvanizing, hot dip, and galvannealing processes. Base metal tensile strength ranged from 500 to 1500 MPa (70- 225 ksi), sheet thickness ranged from 0.83 to 2.03 mm (0.032-0.080 in.), and coating thicknesses from zero to 27 µm. Welds were made in a lap joint configuration, aiming for either full or partial penetration.

The laser used was a 4 KW Nd-YAG (1060 nm), with a net power of approximately 3.5 KW as delivered through a 600 µm diameter fiber. A fixture was built to accommodate a GMAW torch and the fiber-terminating lens assembly, which allowed varying geometries between electrode and beam axes. The laser beam led the projected electrode contact point by distances up to 12 mm, and the focal point was varied with respect to plate surfaces to optimize performance. GMA-only and laser-only welds were also made for comparison.

Results confirmed previous experience with coated steels in that a gap was required between the workpieces to allow adequate venting of the vaporized Zn. In the experimental work this gap was provided by shims or wires, while in production it would likely be provided by projections formed by dimpling or other metal forming techniques. Regardless of workpiece gap, if the beam was well within the weld pool, spatter was typically produced, emerging from the keyhole. Cathode spot stabilization effects were observed at beam locations up to several mm in front of the weld pool, and the best surface finishes were obtained at these distances. Preliminary tensile and fatigue test results on lap joints indicate joint efficiencies between 50 and 100%, with failures usually in the weld, sometimes in the HAZ; this is unacceptable, but process optimization work is continuing with the goals of consistently achieving high quality aswelded surface finishes, and base metal strength levels in the weldments.

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