Influence of Dual-Beam Laser Welding Parameters on the Geometry of a Duplex Stainless Steel Butt Welds: A Numerical Approach

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Laser beam welding (LBW) has become a widely adopted method for joining duplex stainless steels (DSS) due to its high energy density, precise heat input control, and ability to produce welds with minimal thermal distortion and narrow heat-affected zones (HAZ). In recent developments, dual laser beam welding (DLBW), particularly in twin-spot configurations, has gained increased attention for its enhanced control over the thermal profile during welding. By varying the power ratio and spatial offset between the two laser beams, it is possible to manipulate temperature gradients and tailor solidification dynamics. This level of control is essential for maintaining the optimal austenite-to-ferrite phase balance in the weld metal, thereby ensuring the mechanical integrity and corrosion resistance of the welded joint [1-3].

This study examines the effect of process parameters on weld size and geometry during DLBW of DSS 2304 (EN 1.4362) using finite element modeling (FEM). Simulations were performed in ANSYS 2022 R2 with beam power ratios of 50:50, 20:80, and 80:20. A 3D model of 5 mm thick welded sheets was created, incorporating refined meshing along the weld path. Thermophysical properties were obtained from JMatPro v6.1.

A conical volumetric heat source represented the twin beams in a tandem setup, with third-kind boundary conditions applied to simulate convective and radiative cooling. Temperature field predictions were validated against weld macrostructures. Mechanical properties were assessed through tensile testing and microhardness measurements.

The results demonstrate that DLBW process parameters significantly influence weld geometry and thermal behavior. The FEM approach proved effective for optimizing welding conditions to achieve defect-free joints with desirable mechanical properties.

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