Electron Beam Welding (EBW) and Laser Beam Welding (LBW)

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The electron beam welding (EBW) and laser beam welding (LBW) processes are high-energy density welding processes that offer several possible advantages, including low welding heat input, high weld depth-to-width ratio, narrow heat-affected zone (HAZ), and reduced distortion. To impinge on the weld joint and produce coalescence, EBW utilizes a moving concentrated beam of high-velocity electrons, while LBW utilizes the heat from a high-density coherent laser beam.

Most Ni-/Co-base alloys that can be joined with conventional arc welding processes can also be successfully joined via EBW and LBW. These beam welding processes are even considered more suitable for alloys that are difficult to arc weld and can provide better overall weld properties compared to arc welding. The low welding heat input results in a shorter time spent in the solidification temperature range and relatively fast cooling rates, which suppresses precipitation of secondary phases during weld solidification.

Weld joint preparation and fit-up are especially important for the EBW and LBW processes. In most cases, a square butt joint design is utilized. Although filler metal is not normally added to the weld pool, it can be added via bare wire. EBW generally needs to be performed in a vacuum environment without the use of shielding gas, which provides excellent protection against atmospheric contamination. LBW is normally performed with argon or helium shielding gases to prevent oxidation of the molten weld pool. Porosity can be a weldability issue due to the rapid solidification rates and deep weld pools that do not readily allow for dissolved gases to escape; this effect is exacerbated by high weld travel speeds. Oscillation or agitation of the weld pool by weaving the beam may provide the time necessary to help gases escape the weld pool and reduce porosity. Susceptibility to liquation cracking in the ‘nail-head’ region of the HAZ is promoted by the stress/strain state in this region. Slower weld travel speeds produce a shallower temperature gradient in the HAZ and are beneficial towards reducing liquation cracking susceptibility.

For detailed information on EBW, please refer to: *AWS C7.1M/C7.1, Recommended Practices for Electron Beam Welding and Allied Processes.*

For detailed information on LBW, please refer to: *AWS C7.2M, Recommended Practices for Laser Beam Welding, Cutting, and Allied Processes.*