Laser keyhole termination regimes on varying composition of low carbon alloy steels

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Laser keyhole initiation and termination related defects, such as keyhole cavities due to keyhole collapse, is a well-known issue in deep penetration laser and hybrid laser welding of thick section steels. Run in and out plates are used in longitudinal butt welds to avoid this problem, however, this is not applicable for girth weld applications where start/stop defects at the weld overlap occurs. These issues can hinder industry from applying laser keyhole welding for girth welding of thick section steels.

Mitigation of these termination defects can be achieved using various termination regimes, such as laser power ramp-down or laser defocusing, where both methods lead to a reduction in laser power density. This reduction in laser power density leads to the progressive reduction of material vaporisation and thus switching the laser operation mode from keyhole to conduction, which is necessary for controlled closure of the keyhole. The control of the material vapourisation and melt pool dynamics is key for successful laser keyhole closure and laser termination. However, material vapourisation is heavily dependent on the chemical composition of the workpiece being processed and variations in plate composition can lead to different behaviour occurring.

Experiments were carried out to investigate the behaviour of the laser melt pool during laser termination when applying laser power ramp-down and laser defocusing on varying composition of low alloy carbon steel plates. Results show that variations in the chemical composition of low alloy carbon steels can affect both laser penetration and the occurrence of defects occurring during the laser termination regime.