Zero-gap alloy based laser welding of zinc-coated steel:
Process development, Monitoring and Visualization

Problem Definition

Laser welding of zinc-coated steel has always been a challenge due to low boiling point (907 deg. C) of zinc, which evaporates violently at the weld interface resulting in undesirable high porosity joints. This problem is more prominent in lap welds. While there are number of methods reported in the literature for such type of welding, as of today there is no production friendly solution available. So a strong need for better laser welding process and its monitoring mechanism still exists.

Background

A popular approach for solving this problem was reported by [Akhter, A., Steen, W. M. and Cruciani, D., 1988], in which a constant gap was proposed between steel plates placed in lap configuration. However his approach is not practical. Recently a dual beam approach [Xie, J., 2002] was reported for laser welding to maintain the melt pool for a longer period so that all zinc got vaporized. This approach needs additional circuitry and is expensive. Researchers have also tried approaches like plasma suppression, selective removal of zinc etc., but none of them were robust.

Approach

We have introduced a novel technique for welding zinc-coated steel in lap configuration [Dasgupta, A., Mazumder, J. and Bembenek, M., 2000]. Our method depends on a new element, copper that alloys with zinc and traps it inside the weld without letting it create porosity. This way anti-corrosion property of the weld is also maintained. We intend to develop our technique further by identifying production friendly ways of putting copper at the weld zone and making process control sensors for shopfloor use.

Deliverables

a) Spectroscopic sensor for monitoring quality of laser welds

We have observed that copper noticeably improves weld quality. Our primary studies have shown that plasma emission signal of zinc has a correlation with weld quality. We have been able to identify a remarkable difference in zinc spectral intensity of welds made with and without copper. This can be seen in Figure 1. Our goal here is to develop a cheap spectroscopic process control sensor that will provide in-process weld quality information and eliminate the need for destructive testing.

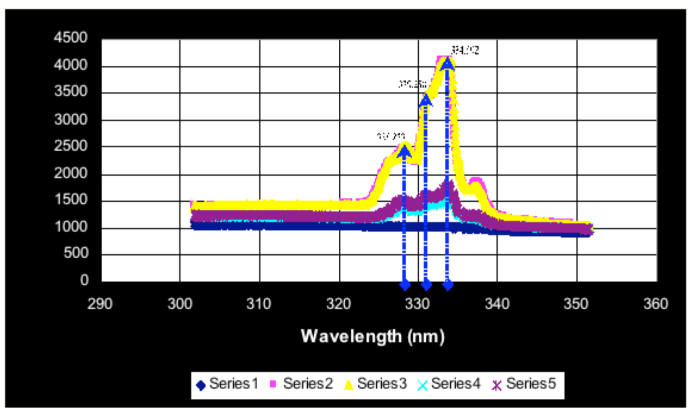

Figure 1: Comparison of zinc spectral intensity (Series 2 and 3: Without copper welds, Series 4 and 5: With copper welds)

b) Visualization of melt-pool using Reflective Topography

We also intend to supplement our spectroscopic findings with reflective topography data. By using a high speed camera and suitable optical filters we have been able to observe the weld pool and plasma plume profiles. Results indicate that addition of copper makes the weld pool more uniform and stable. Such information will be vital in developing a model of the welding process.

References

[1] Akhter, A. et al., "Laser welding of zinc coated steel", 5th International Conference on Lasers in Manf, 1988, pp 195-206.
[2] Xie, J., "Dual beam laser welding", Welding Journal, Oct 2002, pp 223s-230s.
[3] Dasgupta, A. et al., "Alloying based laser Welding of galvanized Steel", Proceedings of ICALEO, LIA, Oct 2000.