Investigating Changes In The Corrosion Mechanism Induced By Laser Welding Galvanised Steel Samples Using SVET

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A novel three-dimensional scanning vibrating electrode (3D-SVET) apparatus is described which allows the quantitative determination of current distributions as they occur immediately above the surface of non-planar metal samples freely corroding in electrolyte. The 3D-SVET apparatus incorporates a bi-functional probe, which acts as both a sensitive displacement detector and an SVET electrode. In displacement mode the probe is used to scan the topographical profile of the test sample in air, before corrosion is initiated. Topographical data is stored as an array of coordinates, which are subsequently used to control probe position when the probe is used in SVET mode to measure localised current densities immediately proximal to the corroding sample surface after immersion in electrolyte. Using stored topographical data means that no time penalty is incurred during SVET scans. Furthermore, the use of a bi-functional probe means that no probe realignment is necessary in switching from topographical to SVET mode.

This apparatus is used to investigate the localised corrosion occurring on 2cm^2 exposed areas of flat samples of electroplated zinc and galvannealed (Zn-Fe alloy coated) 1.2 mm sheet steel and samples of the same substrates laser welded together, freely corroding in near neutral, aerated, aqueous chloride electrolyte. Such laser welding procedures are becoming more commonplace as tailor welded blanks are used to improve crash performance by mixing metallic coating types in laser welded joints.

On flat galvannealed (IZ) samples anodic events are highly localised and occur at random over the exposed sample surface during a 24-hour immersion period. This reflects the progressive de-zincification of zinc rich areas of the iron zinc intermetallic coating. By contrast on flat electroplated zinc (EZ) samples anodic activity is localised but corrosion initiates at a single anodic centre, which eventually spreads out to form a scar on the metallic surface. This concentration of anodic activity on the sample leads to greater dezincification than for the IZ coating. The integrated SVET data was used to provide an estimate of the total zinc loss from the exposed area on the coupons of 277μg cm^{-2} for EZ and 118μg cm^{-2} for IZ respectively.

Laser welded samples were prepared by joining IZ to IZ and IZ to EZ coated 1.2 mm steel panels. A 2 cm^2 exposed area was investigated using SVET with *ca* 1cm^2 exposed either side of the weld. The joining of IZ samples together using a laser weld changes the localisation of anodic activity in neutral aerated sodium chloride solution dramatically. In this instance focal anodes initially concentrate proximal to the weld area in a zone enriched in zinc (and depleted in iron) as a result of the welding process. This localisation of anodic and cathodic activity proximal to the weld reduces the anodic damage on the IZ remote to the heat-affected zone over the 24 hours exposure period but overall zinc loss was 95 μg cm^{-2}, similar to the non-welded case. When samples of EZ and IZ are laser welded together, galvanic coupling leads to all anodic activity becoming focussed on the EZ samples with a total zinc loss over 24 hours from the exposed area measured as 245 μg cm^{-2} very close to that of the zinc loss from the EZ sample alone. By contrast there is no measurable zinc loss from the IZ portion sample under these conditions. The focal activity on the EZ results from it containing no iron whatsoever. This work illustrates the potential for inducing corrosion failure by mixing metallic coating types in tailor welded blank assemblies.

Keywords : 3-D SVET, laser weld, corrosion

Figure 1. Iso-current contour plots of the normal component of current density derived from SVET scans above (i) flat galvanneal (IZ) (ii) flat electro-zinc (EZ) (iii) Laser welded galvanneal (IZ:IZ) and (iv) Laser welded galvanneal: electro-zinc (IZ:EZ) samples freely corroding in 0.86 mol dm^{-3} neutral aerated aqueous NaCl at 20°C. Data presented is after 1-hours exposure.