D. Effects of Ti-C Coating on Electrode Degradation: Tip Life Improvement for RSW With HDG Steel

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Resistance spot welding (RSW) of zinc coated sheet steel in the automotive industry presents the problem of reduced welding electrode tip life. The tip life of the electrode is determined by the number of welds before the weld nugget falls below the minimum allowable size. The use of electrode coatings such as TiC to prevent the interaction between the Zn-coating and the electrode was investigated. Cu-Cr-Zr (Cu-0.84wt%Cr-0.05wt%Zr) domed electrodes (FB-25) from Huys Industries Ltd were used as the uncoated electrodes and coated versions of the same electrode (TFB-25) were used for the coated electrodes. The TiC composite coating was applied to the electrodes using methods proprietary to Huys Industries. Hot dip galvanized (HDG 60G) 0.7mm mild steel was used as the work sheets. Each electrode type was then subjected to life tests on a stationary, air operated, single phase AC resistance spot welding machine. In the following, a minimum weld size of $4(t^{1/2})$ is used where t is the single sheet thickness.

The average tip life of an uncoated electrode was found to be in the range of 400 to 500 welds. After coating the electrode with the TiC composite, the welding current was reduced (to achieve the same initial nugget size) and the tip life increased to approximately 1000-1200 welds. Without electrode coating, alloying between the electrode and the zinc sheet coating can result in electrode material loss and enlargement of the tip face leading to reduced current densities and weld failure. The TiC coating acted as a barrier between the Cu and Zn hindering their interaction and prolonging the life of the electrode. Failure however was unavoidable as the welding process eventually damaged the TiC layer to the point where Zn was able to penetrate and further damage the TiC coating integrity. Alloy pickup at the periphery and plastic deformation played a lesser role in the failure of the electrodes. For this electrode geometry, the coating is believed to have acted as a hard hemispherical shell resisting and arresting the flow of plastic deformation. The presence of the coating beyond the weld face also hindered the amount of alloy pickup on the periphery of the face.

The addition of the TiC composite coating to the face of the domed FB-25 electrode showed improved tip life on the order of two. Pitting and erosion of the electrode face due to alloy formation and alloy loss proved to be the main mechanism for the degradation of this geometry of electrode. The alloy layer was formed due to the zinc-copper interaction. With the coating in place, the alloying was restricted and the degradation of the electrode was delayed until the coating was damaged by physical and thermal stresses.