

Determination of RSW Electrode Degradation through Image Processing

*J. Peng, S Fukumoto and Y. Zhou, University of Waterloo
L. Brown, University of Western Ontario*

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Introduction

It is known that the electrode design and quality plays an important role in determining the weld properties of resistance spot welding (RSW) [Matsumoto 1994, Rivett 1980, Glagola 1976, Ikeda 1995, Patrick 1996]. The electrode degradation in RSW of aluminium was found much more severe and faster than that in steel welding [Williams 1984]. It resulted in a much shorter electrode life, which has restricted the application of aluminium in automobile industry. Past researches on RSW of aluminium showed that the influence of electrode tip surface condition on weld quality is not as simple as that in steel welding [Fukumoto 2003, Lum 2002]. More tip surface features were observed and no simple relationship existed between the weld strength and the tip surface diameter. This paper investigated an imaging approach for relating the weld shear strength with the tip surface features.

Procedure

The electrode degradation in RSW of aluminium was investigated through electrode life tests from which the weld shear strength and the electrode tip imprints were obtained. The life tests were performed on both DC and AC welders. The tip surface features were defined based on an observation of the imprints. Relevant formulas were designed for obtaining those feature values through image processing. The influence of tip surface features on weld strength was analysed with reference to the electrode life test results. Simulation test was conducted to validate the findings.

Results

Three tip surface features were identified:

- Relative radius (R_r), which relates to the nominal contact area at tip surface.
- Edge concentration (EC), which describes the scattering of the contact points towards the tip surface edge.
- Eccentricity (ECC), a sudden drop or climbing of which indicates the occurrence of a heavy pitting at electrode surface.

The latter two determine the current distribution at contact surfaces.

An analysis was made by comparing the shear test results with the tip surface features from image processing of the electrode imprints. The following results were obtained:

- The electrode failures were associated with high R_r values. R_r determines the contact area of the faying interface between the two sheets. The higher the R_r value, the less the average current density at the faying interface. However, in DC electrode life test, high shear strength was also found from time to time when R_r stayed high.
- AC electrode life test results showed that an increase in EC led to a decrease in weld shear strength. Simulation test confirmed the phenomenon. A further comparison between the AC life test and the simulation test revealed that the contact at the electrode tip center was important for maintaining a good weld quality.
- DC electrode life test results showed that the shear strength started to drop after an obvious climbing up of EC and ECC. An analysis of typical DC life test samples proved the influence of ECC on weld quality.
- Compared to the result of AC welding, the shorter electrode life in DC RSW of aluminium was due to its concentration of electrode degradation at the positive electrode side and the quick loss of central contact at the tip surface.

Conclusion

Based on the carbon imprints of electrode life tests three aspects of electrode tip surface features were defined: relative radius (R_r), edge concentration (EC) and eccentricity (ECC). Image processing programmes were developed to extract these features.

The analysis of the results of the electrode life tests and the simulation test proves that R_r , EC, ECC and tip surface central contact all contribute to the weld quality. The growth of R_r and EC led to a decrease in weld shear strength. The existence of central contact on tip surface helped maintaining a good weld quality.

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