Automotive Lightweighting Materials

Prediction of Resistance Welding Electrode Wear

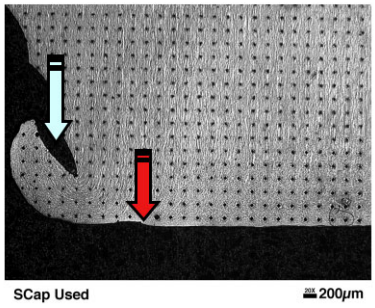
Background

The introduction of galvanized high-strength steels has led to increased demands on the performance of copper electrodes used in resistance spot welding of these alloys. Until now, this problem has been addressed by trial-and-error experiments with different electrode geometries and compositions, different compositions and thicknesses of zinc coating, and modification of resistance spot welding parameters. A more systematic framework is needed to evaluate candidate electrode materials and accelerate the selection of improved electrodes for the various needs of the automotive industry.

The Technology

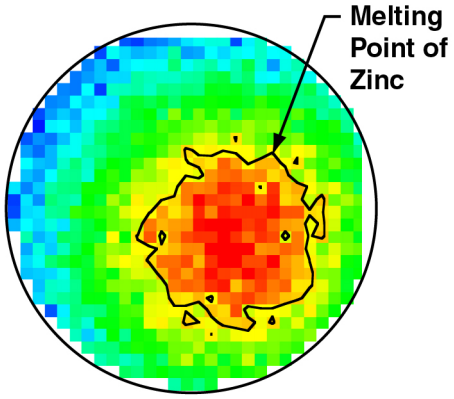
A primary mode of electrode deterioration is by deformation. Various finite-element-based models can simulate electrode deterioration for individual welds. Estimating electrode life, however, would require repeating the analysis 1,000 to 2,000 times. One problem with doing this is that each spot weld simulation takes up to 10 hours of computing time. Consequently, simulating 2,000 spot welds would take 833 days! Another problem is that the electrode shape will change with each successive weld. The new electrode shape will require a new mesh. This is another time-consuming activity.

ORNL researchers overcame these obstacles by developing a phenomenological model that captures the essential physical processes through an analytical model. First, the deformation at the electrode-steel interface is assumed to be confined to a small disc. Then, the strains in this disc during one spot weld are estimated using an analytical deformation



Cross-sectional view of a copper resistance spot welding electrode illustrating deterioration by mechanical deformation (blue arrow) and chemical attack (red arrow).

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle



Schematic illustration of temperature distribution on the face of a copper resistance welding electrode. Regions that are hotter than the melting point of zinc will experience accelerated degradation.

accumulates the strains associated with subsequent spot welds. The amount of strain in each spot weld is related to the stress-strain characteristics of a copper electrode measured as a function of temperature and a relation between peak temperature and electrode diameter. The model was applied to experimental measurements made as part of a U.S. Council for Automotive Research project. The model results were in good agreement with the measurements.

The model captures the effect of the degradation (through tempering) of electrode properties on the overall performance of the electrode. The model is being updated to also consider chemical effects on electrode degradation.

Most importantly, the model is capable of evaluating "what-if" scenarios that allow engineers and scientists to optimize the resistance spot welding electrode alloys to better suit various industrial conditions.

Commercialization

A user-friendly computer model has been developed that allows users to change parameters and rapidly evaluate how properties of electrode alloys influence degradation as judged by the growth of the electrode's face diameter. This copyrighted software will be available to the public.

Benefits

The model provides a rational framework for developing improved resistance welding electrodes.

Where Can I Find More Information?

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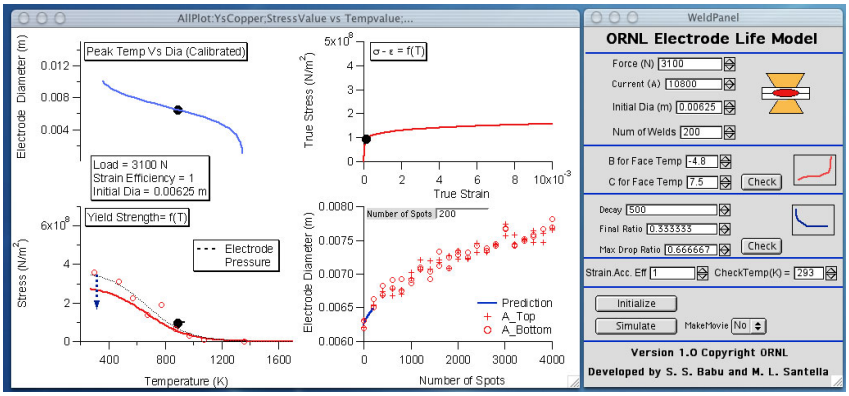

User interface of the computer software for predicting electrode degradation.

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Energy Efficiency and Renewable Energy

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