Development of BEV Battery Pack and Key Technologies Utilizing Advanced Steel Sheets (Second Report)

- Development of Lower Case Solutions for Eliminating Electrodeposition Coating-

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Achieving carbon neutrality by 2050 requires substantial reductions in lifecycle greenhouse gas emissions in the automotive industry, where battery electric vehicles (BEVs) are rapidly expanding. The battery pack is a key structural component that affects safety, performance, cost, and manufacturability. This study examines resistance spot welding for applying highly corrosion-resistant coated steel sheets to BEV battery boxes without electrodeposition coating. To mitigate liquid metal embrittlement (LME) in zinc-coated steels, an asymmetric electrode configuration using a DR-type upper electrode and an R-type lower electrode is proposed, and the acceptable current range, joint strength, and LME occurrence are evaluated. Under normal conditions, the acceptable current range was 1.5 kA, whereas under asymmetric conditions it was 2.0 kA (Fig. 1). The wider range under asymmetric conditions is attributed to the larger contact area between the R electrode and the steel sheet, which reduces current density (and thus temperature rise) even at higher currents. Joint strength was then evaluated (Fig. 2), and post-test appearances are shown in Fig. 3. CTS and TSS were comparable under both conditions, and plug fracture occurred in all cases, indicating similar joint strength when the nugget diameter is the same. Finally, cross sections were examined to determine whether an applied disturbance increased tensile residual stress and induced LME (Table 1). Under normal conditions, no LME cracks were observed without expulsion; however, at 11.0 kA (severe expulsion), small cracks were found directly beneath the electrode. Because fracture remained plug-type and no crack growth beneath the electrode was observed, these cracks are not expected to affect joint strength. Under asymmetric conditions, no LME cracks occurred at any current, likely due to reduced indentation and lower near-surface stress/strain. Overall, even with disturbance, asymmetric conditions show the potential to suppress LME cracking.

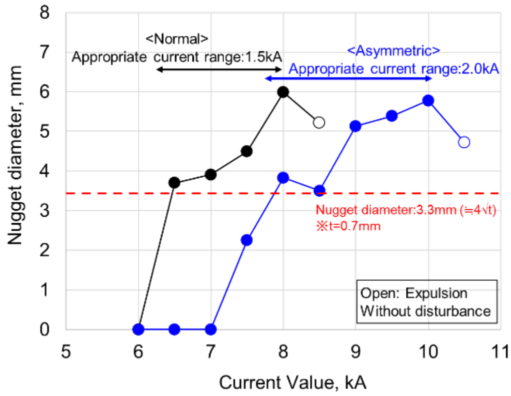


Fig.1 Relationship between current and nugget diameter without disturbance

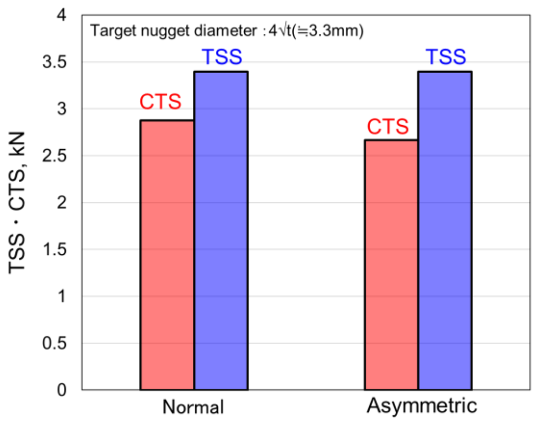
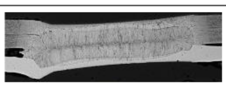
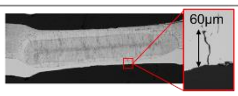
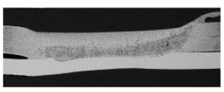


Fig.2 Results of shear tensile and cross tensile tests

Table.1 Cross-sectional observation for LME

2mm	Normal	Asymmetric
Current value: 9.5kA (No expulsion)	 No LME cracks	 No LME cracks
Current value: 11.0kA (Expulsion)	 Micro LME cracks ※No effect on joint strength	 No LME cracks

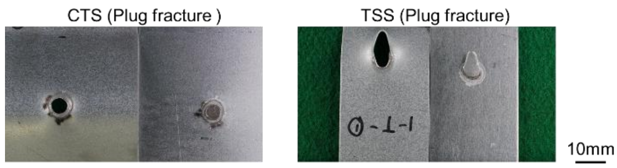


Fig.3 Appearance of joints after tensile