Failure Characterization and Damage Modeling of Resistance Spot Welds in Hot-Stamped Steel

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A typical body-in-white of a car has something between 2000 to 5000 spot welds for maintaining the structural integrity during normal operation as well as crash incidents. It is known that failure behavior of spot welds plays a vital role in overall performance of safety components. In my research, several grades of commercial boron-bearing hot-stamping steel with anti-intrusion and energy-absorption applications (Usibor1500-AS and Ductibor500/1000-AS) are subjected to resistance spot welding (RSW) with the goal of welding setting optimization, failure characterization, and damage process modeling under different loading conditions.

So far, a unified set of welding settings has been determined for obtaining expulsion-free spot welds with optimized mechanical properties based on developed 3D processing maps and numerical strength models. The failure behavior of the spot welds has been investigated under normal and shear loading conditions by identifying failure modes in macro-scale and microstructural analysis. One of the notable findings is that failure can occur by local shear band formation at fusion zone\heat-affected zone (HAZ) interface under shear loading which is in contrast with typical failure behavior of spot welds in other high-strength steels in which failure occurs due to martensite tempering at coarse-grain HAZ (known as HAZ softening). Preliminary simulation results obtained from fine-meshed FEM models can also predict the overall damage process and fracture surface of spot weld nugget. Recently, the HAZ characterization results has been implemented to FEM models to obtain a hardness-dependent failure model.