A New Testing Method for Edge Cracking Evaluation

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Introduction

The auto industry is increasingly using advanced high-strength steels (AHSS) to improve safety for passengers and provide a lighter structure with a thinner gage AHSS, while maintaining the required strength and toughness. However, stamping of AHSS creates several technical challenges such as increased springback, severe tool wear, inconsistent material properties, and limited local ductility. Edge cracking is an example of reduced local ductility. It occurs more frequently in stamping AHSS than other ductile steels and aluminum alloys. Edge cracking increases scrap rate in the stamping production.

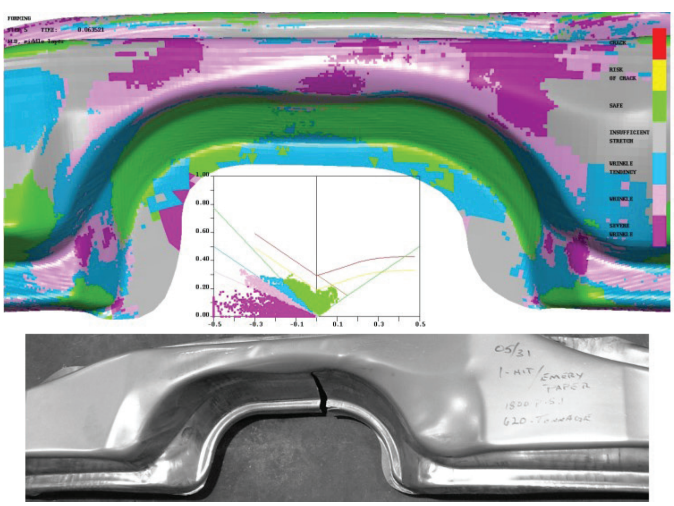

Figure 1. Discrepancy between FE predicted FLD and actual stamping with edge cracking [Chen, M. and Zhou, D.J., "AHSS Forming Simulation for Shear Fracture and Edge Cracking", Great Designs in Steel, Livonia, Michigan, U.S., 2008]

Edge cracking is a defect that can occur in formed parts due to shearing-induced work hardening or other edge conditions. Work hardening creates a localized area that exhibits different mechanical properties than the rest of the blank, making simulation predictions of edge cracking of AHSS challenging. Figure 1 shows an example discrepancy between finite element (FE) predicted safe result under the forming limit diagram (FLD) and actual stamping part with edge cracking.

The current ISO standard for edge cracking evaluation (ISO/TS 16630: 2003E) uses a trim line (a 10-mm diameter round hole) that has limitations in terms of obtaining reliable test results (i.e. maximum hole expansion ratio for the onset of edge cracking through sheet thickness) and correlating the edge cracking test results with edge cracking observed in actual stampings. To address a practical solution for these limitations, EWI recently developed a new edge cracking testing method through an internal development project (IRD). A forming simulation software, PAM-STAMP, was used to design and simulate a complex trim line shape, and then optimize it based on finite element analysis results from simulations. The simulation results were then used to set the guidelines for a new edge cracking test method.

Experimental Validation with the Servo Press

The new test method was performed on a 300-ton AIDA servo press at EWI. Five TRIP780 and five DP980 blanks with the peanut shape trim line (water jet cut) were tested using a universal test die available at EWI. The servo press was programmed to match the simulation motion and force used in the PAM-STAMP simulations. A load analyzer in the servo press monitored the load vs. displacement in real time, determining both the peak load and the location of the forming stroke where peak load occurred (which corresponds to the onset of edge cracking). TRIP780 cracked at the trim hole at around 45 mm draw depth and DP980 failed around 32 mm draw depth. Figure 2 shows one of the TRIP780 panels with the edge cracking failure as well as the load vs. displacement curves with the peak load circled.

DP980 showed less ductility for edge cracking

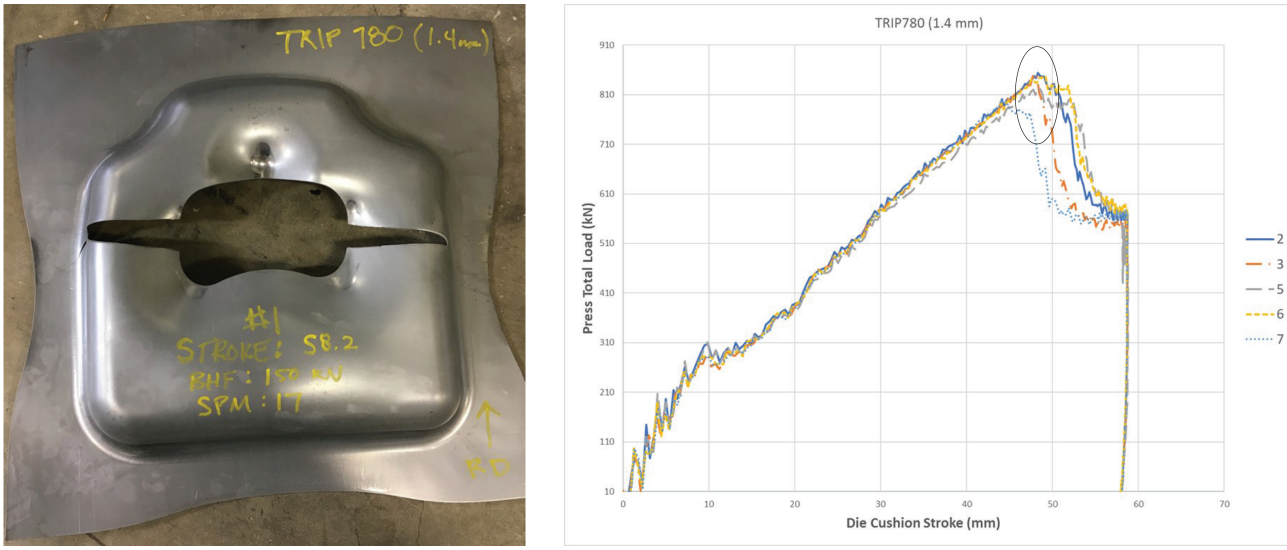

Figure 2. EWI edge cracking test method results; TRIP780 panel (left) and load vs displacement curves with peak load (right).

based on this newly developed method. The servo press load analyzer enables to precisely capture the forming stroke corresponding to the onset of edge cracking in ±2 mm errors in five repetitions. EWI also measured the thinning and major strain on the edge crack area of the tested samples using the 3D optical strain measurement tool, ARGUS. The measured strain data can be practically used for the edge cracking prediction criterion.

Next Steps and Future Applications

Testing with the innovative trim line design is potentially to be a good indicator of edge cracking.

As next steps, EWI forming team will develop a trim die to cut out the peanut shape contour on blank samples under various shear clearances (5~15% of blank thickness) instead of using a water jet cutting. With the trim die, the team will further investigate the effects of cutting speed with the servo press and shear clearance on trim edge quality and edge cracking for AHSS to develop the best practice in trimming of AHSS with a minimum edge cracking in stamping production. The trim die cut is more frequently used for high volume applications in sheet metal forming. Once complete, this method can be used to test customer interested materials.

***Laura Thornton**, Project Engineer in EWI's Forming Center, uses ARGUS strain analysis, stamping tool design in CATIA VD, and part simulation software in her work. In addition, she conducts material research and tests forming limit diagrams on aluminum and steel sheet metal. Laura began her career in automotive manufacturing at Honda of America in Marysville, Ohio, where her work involved strain analysis and Dynaform simulation software. She also analyzed suspect material using tensile and dome testing with digital image correlation and worked closely with production stamping presses.*

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