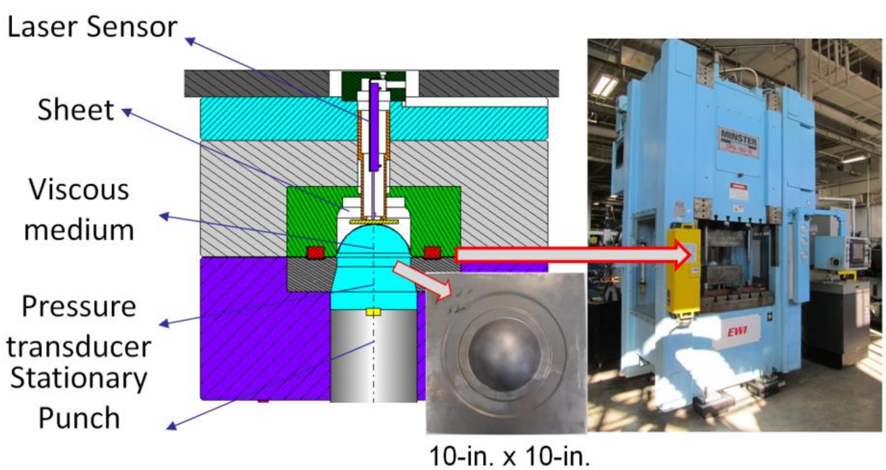
Determination of Material Formability Data of Newly Emerging Sheet Materials

Forming new lightweight materials such as aluminum, titanium, and magnesium alloys, as well as advanced high-strength steels with thinner gauges, requires increased control of material quality and properties, and more expensive forming dies and coatings. A more rigid tool structure and a larger capacity forming press are often needed to handle the increased strength and low formability, as well. The scrap rate tends to be higher than with conventional materials due to more frequent failures like severe springback, trimmed edge-cracks, necking, and bending fractures.

Emerging high-strength materials are increasingly used or considered for new product designs to improve performance and reduce manufacturing costs. The forming industry continuously looks for reliable material properties and formability specifications to maintain or improve their production results with these less-familiar materials.

To meet industry needs, EWI recently conducted an Internal Develop Research (IRD) project to establish formability testing capabilities. We established the viscous pressure bulge (VPB) and limiting dome height (LDH) testing capabilities from the IRD project. The biaxial bulge testing method, originally developed a decade ago by The Ohio State University's Center for Precision Forming (our key university partner), has been extensively used to provide more accurate stress-strain data for the stamping industry. EWI acquired this test tooling from OSU-CPF and improved the testing procedure and measurement tool during our IRD project. Figure 1 illustrates the VPB testing procedure. A 10-in. x 10-in. square specimen is plastically formed into a bulged dome using a pressurized viscous medium that produces negligible frictional effects when compared with a solid dome punch. During the test, the pressure and the dome height are measured until the fracture occurs at the apex of bulged dome. The measured data is converted to the true stress-strain curve using a developed excel macro program. The testing procedure is fairly simple and easy. The online video is available at https://www.youtube.com/watch?v=6c8x8tlVMUM.



10-in. x 10-in.

Figure 1: VPB testing for sheet material at EWI's 160-Ton hydraulic press

The enhanced VPB testing method was validated with eight different sheet materials as listed in Figure 2. As shown, VPB testing offers the stress-strain data over a much larger range than standard tensile testing. For instance, tensile tests generate data only up to 13-14% of total elongation for 980YL material which is usually extrapolated in various ways to cover higher strain range data for sheet forming. The VPB test offers data up to 38% strain, which is usually sufficient for sheet forming application. This significant improvement enables design engineers to apply real stress-strain data to parts and processes, especially when using computer simulation tools that require reliable input data of material properties.

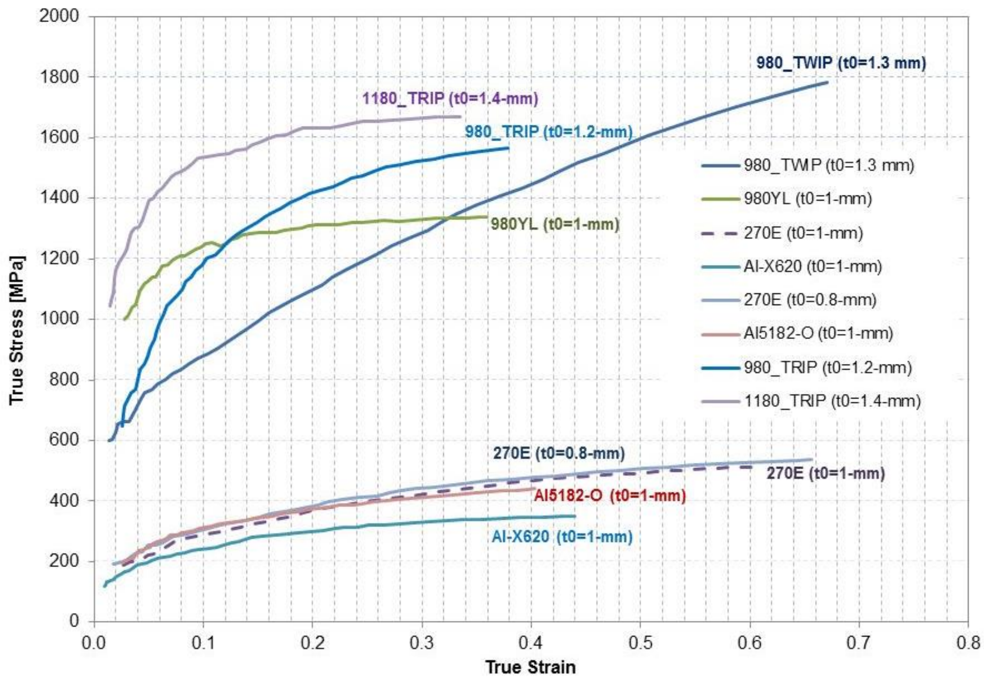


Figure 2: The stress-strain data obtained from the VPB test

EWI also successfully demonstrated a conventional method to develop a forming limit diagram (FLD) of two selected sheet materials. This capability was upgraded recently using a digital-image correlation (DIC) tool, the ARGUS system. This new equipment reduces measurement error by replacing numerous manual measurements of the tested circle grid specimens by taking multiple pictures and processing those images using ARGUS software. Figure 3 shows a tested sample and the distribution of a major strain that was measured by the ARGUS system. A new ISO standard FLD testing with a DIC (ISO 12004-2:2008) is now available at EWI. These new services, developed for formability testing, will be beneficial for industries manufacturing sheet metal products such as aircraft, automotive, electronics, and consumer products.

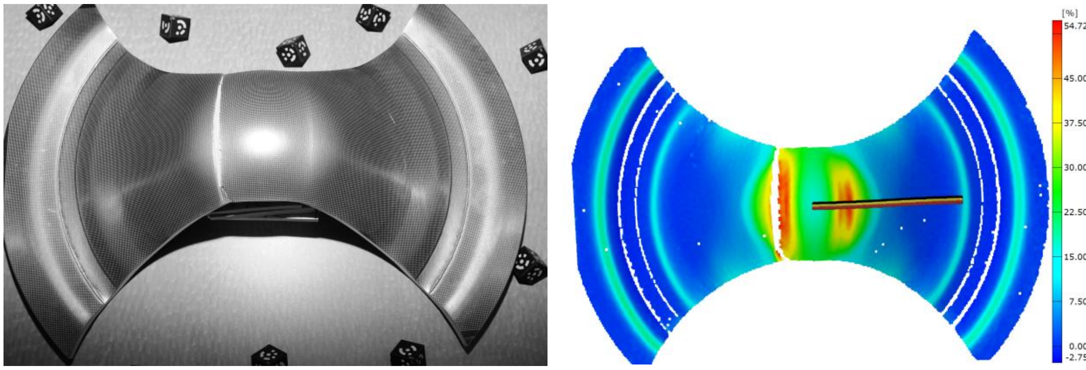


Figure 3: A tested sample for FLD analysis (left) and the measured stain distribution using the ARGUS system (right)