Practical Evaluations of Formability and Reliable Predictions of Failure

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Background

- Stamping industry more often experiences a gap between material specs and stamping results with recently developed sheet materials (AHSS, Aluminum alloys, Ti alloys and SS)

- ASTM standard formability tests are not sufficient:
  - to evaluate the material formability
  - to provide the material data for predicting local failures in stamping AHSS and aluminum alloys

- To obtain practical knowledge of forming process and tooling design for these new emerging materials, industry looks for:
  - practical testing methods to evaluate formability
  - more accurate prediction capability with reliable failure criteria
  - knowledge transfer for the industry use with their available software
OSU-CPF has been working on fundamental aspects of formability and failure with AHSS and aluminum alloys.

EWI recently conducted multiple industry sponsored projects of failure predictions in draw bending, deep drawing, stamping and hole-flanging with AHSS and stainless steels.

EWI-FC and OSU-CPF are currently collaborating through an Internal Research Project (IRD) on formability and friction evaluations with AHSS and aluminum alloys.
Research Goal

- Develop practical **formability evaluation methodology** and reliable **failure criteria** enabling us to
  - **Evaluate** the material formability at major forming modes (i.e. bending, stretching, drawing, and hole-flanging)
  - **Predict** the failures of materials at different forming modes
  - **Build** the web-based database of material formability and failure models

[Diagrams showing bending, stretch forming, deep drawing, and hole flanging modes.]

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Available Resources for Evaluating Sheet Formability

- Uniaxial tensile test
- Biaxial bulge test
- Limiting dome height test
- Round cup draw test
- Rectangular pan draw test

Deep Drawn Sample (6-in. bottom dia. x 3.5-in. depth)

Rectangular Drawn Sample (20- × 18- × 2-in. depth)

160-Ton Hydraulic Press (w/ 100-ton CNC controlled cushion system)

Biaxial Bulge Tested Sample (12 × 12 in.)

LDH Tested Sample (14 in. diameter)
Prediction Capabilities

Process Simulations

- Sheet Metal Forming
  - Springback
  - Failures (necking and wrinkling)
  - Temperatures of the part and die

- Forming simulation software
  - Forming simulation software
  - PAM-STAMP
  - LS-DYNA
  - DEFORM

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Recommended Scope of Work

- **Task 1 – Surveying the materials and failure modes**
  - Survey of sheet materials that are interested by industry partners (ex. Al, AHSS, Stainless steels, Titanium, and TWB)
  - Survey of failure modes/types experienced at industry partners (ex. failures in bending, drawing, hole flanging, stretch forming)

- **Task 2 – Determination of basic material properties**
  - Obtain basic elastic and plastic properties (elastic modulus, hardening parameters and anisotropy) using uniaxial tensile and biaxial bulge testing methods

- **Task 3 – Establishing failure models**
  - Maximum plastic strain criteria
  - FLD based failure criteria
  - Thickness reduction ratio criteria
  - Equivalent strain limit criteria (e.g. Damage based criteria)
Recommended Scope of Work

◆ Task 4 – Evaluation of formability in bending
  -- Stretch-bending with a rectangular pan draw die at different blank holder forces (BHF)
  -- Validation of failure criteria with FEM predictions

◆ Task 5 – Evaluation of formability in pure-stretching
  -- Biaxial bulge or limiting dome height tests
  -- Validation of failure criteria with FEM predictions

◆ Task 6 – Evaluation of formability in drawing
  -- Round cup draw tests at different BHF's
  -- Rectangular pan draw tests at different BHF's
  -- Validation of failure criteria with FEM predictions
Recommended Scope of Work

❖ Task 7 – Evaluation of formability of sheet with a punched hole or trimmed notches
  – Hole-tensile and notch-tensile test
  – Hole expansion test
  – Validation of failure criteria with FEM predictions

❖ Task 8 – Establishing the formability database
  – Develop a web-based database for the formability of selected materials (available only for sponsored industry partners)

❖ Task 9 – Recommendations of failure prediction models for the industry applications
  – Reporting the failure model parameters for studied materials
  – Implementing the validated failure models in commercial FEM software (ex. PAM-STAMP, DEFORM and LS-DYNA)
Deliverables & Performance Period

- **Deliverables:**
  - Reporting (monthly basis, at the end of each task and a final)
  - Basic material properties
  - Experimental data
  - Failure criteria and simulation results
  - Permission to access the material formability database

- **Performance period: 12-months**

- The final project scope including budget and materials will be determined with the inputs of industry partners.

If you are interested to know more information or participate in this JIP topic, please free to contact Hyunok Kim (hkim@ewi.org / 614.688.5239) at EWI-FC.
Questions & Contact

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