FULL SET OF INNOVATIVE TOOLS FOR THE PREDICTION OF LASER WELDED BLANK FORMABILITY IN SIMULATION

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• Laser Welded Blanks (LWB) overview
• LWB fracture modes overview
• Forming Limit Curve for LWB
  – Problem of the application of FLC concept to LWB
  – Formability testing
  – Experimental results
  – Numerical modeling
  – Industrial application
• A new model for the prediction of Laser assemblies’ maximum elongation
  – Results comparison between experiments and model
  – Industrial application
• Conclusion
LASER WELDED BLANK OVERVIEW

• Characteristics
  – Various steel grades Laser welded together
    • Different strengths
    • Different gauges
    • Different coatings
  – Single blank prior to the forming process

• Benefits
  – “The best material in the right place”
  – Cost savings
  – Mass savings
  – Crash management
  – Reduction in number of parts
  – Reduced off-cuts
• Applications

- Bumper beam
- Shock tower
- Floor panel
- Front Rail
- Roof reinforcement
- Tailgate
- Wheel house
- Body side inner
- Body side outer
- Door inner
- Fire wall / dash panel
- Cross member
- Pillars
- Side member
- Bumper beam
- Shock tower
- Floor panel
• Market Example: Renault Laguna III 2007, 18 LWB
LWB FRACTURE MODES OVERVIEW

- Two principal fracture modes
  - **Mode 1**
    - Fracture in base material with propagation parallel to weld line
    - This model is related to the interaction between the two materials
    - Already well-known, ArcelorMittal and Noble Forming Limit Curve (FLC) specific model
  - **Mode 2**
    - Fracture in weld seam with propagation in base materials
    - This mode is related to the mechanical properties of the Laser seam
    - A new model for the prediction of Laser assemblies’ maximum elongation has been developed
• Problem of the application of FLC concept to LWB

- Monolithic FLC of weaker material does not predict any rupture
• Formability testing
  – The Nakazima method has been used
  – A carrier blank has been used to compensate the different gauges between the thinner and the thicker sheets
  – The Bragard method is used in order to obtain the FLC points
Experimental results

The experimental set-up has been used for various configurations:
- Same thickness and different grade specimens
- Same grade and different thickness specimens
- Both different thickness and grade specimens

The interaction between weaker and stronger materials plays a determining factor in LWB forming processes:
- Ductile failure by plastic instability process
- A specific Laser Welded Blank FLC model is required to accurately predict the onset of necking

<table>
<thead>
<tr>
<th>LWB</th>
<th>MS(0.8) / HSS(1.2)</th>
<th>MS(0.8) / MS(1.5)</th>
<th>MS(0.8) / HSS(1.2)</th>
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<tbody>
<tr>
<td>( \varepsilon_{10}^C ) Weaker material</td>
<td>0.33</td>
<td>0.33</td>
<td>0.38</td>
</tr>
<tr>
<td>( \varepsilon_{10}^C ) LWB</td>
<td>0.2</td>
<td>0.187</td>
<td>0.29</td>
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• LWB Forming Limit Curve

Welded seam
Necking zone

LWB Forming Limit Curve MS (0.8mm) / HSS (1.2mm)
LWB Forming Limit Curve MS (0.8mm) / MS (1.5mm)
LWB Forming Limit Curve MS (1.2mm) / HSS (1.2mm)
• Numerical modeling
  – Abaqus model

Necking zone
• Necking zone
  – The numerical simulation shows that the fracture occurs in the weaker material next to the Laser seam
  • The plastic instability process is directly related to the interaction between the two materials
  • The deformation during this phase is localized in the necking region of the specimen
INDUSTRIAL APPLICATION 1/2

- LWB fracture prediction

Fracture on real part

LWB FLC allows prediction of rupture by stamping simulation
• LWB fracture prediction
  
  – Thanks to the FLC LWB model, an excessive stretching area near the weld line is identified

Simulation without LWB FLC for material A1 and B1

Simulation with LWB FLC for material A1 and B1

Monolithic FLC for material B1
PREDICTION OF LASER ASSEMBLIES’ MAXIMUM ELONGATION

Thermal history

Thermal analysis
P, V...

Metallurgical analysis
C1, P1, C2, P2 …

Mechanical analysis
UE1, Ts1, t1,
UE2, Ts2, t2…

Plastic instability, fracture criteria

Ductile fracture

Weld line mechanical behaviour

Percentage of various phases

HAZ and FZ geometry

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w w w . a u t o s t e e l . o r g
Various configurations of assembly have been tested with a large variety of thickness and various steel grades such as Dual Phase 600, Dual Phase 780, Dual Phase 980, TRIP 700, TRIP 800, Multiphase 1000…
Fracture prediction of Laser seam

- Major strains are almost parallel to weld seam as shown by simulation
- Uniform elongation obtained during LWB assembly tensile test is 13 %
- Margin = -2.3 %. There is not enough margin to avoid fracture in the Laser seam
CONCLUSIONS

• Laser Welded Blank Forming Limit Curve
  – Weaker material FLC may not predict the onset of necking of LWB though fracture actually occurs in weaker material
  – LWB FLC allows accurate prediction of fracture in the interaction zone in stamping simulations

• Maximum elongation
  – In the cases where crack initiation appears at the weld seam (major strain parallel to weld seam), maximum elongation model for LWB assemblies allows prediction of fracture in stamping simulations

• These two models may be used to analyze stamping simulations of LWB in order to guarantee part feasibility

• They are particularly suitable for AHSS-based LWB solutions