Door inner mass optimization using curvilinear laser welding

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Shiloh Industries
Agenda

- What is Curvilinear Laser welding
- Door Inner Case study
- Linear Vs Curvilinear options
- Different material grades
- Formability advantages
- Stamped Door Inner
- Structural Analysis
- Cost and Quality Advantages
- Summary
Why use Laser Welded Blanks

- Different gauges, materials & coatings can be incorporated into one blank
  - Component can be engineered to desired properties
  - Improved energy management
- Consolidation of components
  - Reduction in number of parts
  - Reduced tooling costs
  - Reduced assembly operations and equipment
  - Reduction in variation due to assembly tolerances
- Material utilization
  - Reduction in engineered scrap due to improved blank nesting
- Mass reduction on vehicle
Types of Welded Blanks

Linear

- Thick gauge
- Thin gauge

Multi - Linear

- Thick gauge
- Thin gauge

Curvilinear

- Thick gauge
- Thin gauge

Curvilinear

- Thick gauge
- Thin gauge
Curvilinear Laser Welded Blanks

Rear Door Inner

Window Frame
Door Inner Case Study

Optimization of Current Monolithic I

UPR HNG BRKT
Gauge: 2.50 mm
Mass Usage: 0.45 kg.

Check Load BRKT
Gauge: 1.50 mm
Mass Usage: 0.21 kg.

LWR HNG BRKT
Gauge: 2.50 mm
Mass Usage: 0.42 kg.

FRT DR INR
Gauge: 0.80 mm
Mass Usage: 5.66 kg.

Platform Priority
Optimize cost
Optimize weight

Baseline on vehicle mass Usage = 6.74 kg
Baseline gross steel usage = 12.84 kg
### Linear Laser Welded Option

#### Monolithic Design

![Monolithic Design Image]

#### Linear Laser Welding Design

![Linear Laser Welding Design Image]

<table>
<thead>
<tr>
<th>Part</th>
<th>Gauge In mm</th>
<th>Material Usage in kg</th>
<th>Mass in kg</th>
<th>Gauge In mm</th>
<th>Material Usage in kg</th>
<th>Mass in kg</th>
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</thead>
<tbody>
<tr>
<td>FDI</td>
<td>0.80</td>
<td>10.8</td>
<td>5.66</td>
<td>1.40</td>
<td>5.14</td>
<td>2.73</td>
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<tr>
<td>UPR HNG BRKT</td>
<td>2.50</td>
<td>0.98</td>
<td>0.45</td>
<td>0.80</td>
<td>8.07</td>
<td>4.11</td>
</tr>
<tr>
<td>MDL BRKT</td>
<td>1.50</td>
<td>0.33</td>
<td>0.21</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LWR HNG BRKT</td>
<td>2.50</td>
<td>0.73</td>
<td>0.42</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12.84</strong></td>
<td><strong>6.74</strong></td>
<td>-</td>
<td><strong>13.21</strong></td>
<td><strong>6.84</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Savings in kg</strong></td>
<td>-</td>
<td>-</td>
<td>(0.37)</td>
<td>(0.10)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Mass increase of 0.10 kg on vehicle compared to monolithic
- Material increase of 0.37 kg
- Not a good solution
Curvilinear Laser Welded Option

Monolithic Design

Option 1 – Curvilinear Laser Welding

<table>
<thead>
<tr>
<th>Part</th>
<th>Monolithic Design</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gauge in mm</td>
<td>Material Usage in kg</td>
</tr>
<tr>
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<tr>
<td>LWR HNG BRKT</td>
<td>2.50</td>
<td>0.73</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12.84</strong></td>
<td><strong>6.74</strong></td>
</tr>
<tr>
<td><strong>Savings in kg</strong></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Material savings of 0.35 kg
- Vehicle Mass savings of 0.18 kg
- Total Value Chain Cost Decrease
Curvilinear Laser Welded Option

Monolithic Design

Option 2 – Curvilinear Laser Welding

<table>
<thead>
<tr>
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<th>Monolithic Design</th>
<th>Option 2</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Gauge In mm</td>
<td>Material Usage in kg</td>
</tr>
<tr>
<td>FDI</td>
<td>0.80</td>
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</tr>
<tr>
<td>UPR HNG BRKT</td>
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<tr>
<td>LWR HNG BRKT</td>
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<td>0.73</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12.84</td>
<td>6.74</td>
</tr>
<tr>
<td><strong>Savings in kg</strong></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Material savings of 0.80 kg
- Vehicle Mass savings of 0.48 kg
- Total Value Chain Cost Decrease
Formability with Different Material Grades

Thick Gauge Material

CR4

1.4/0.8 mm
Thinning near weld line:
Max (18.4%)

180 BH

1.4/0.8 mm
Thinning near weld line:
Max. (18.7%)

270 BH

1.2/0.8 mm
Thinning near weld line:
Max. (20.3%)
Formability Advantage

Original Straight Line Formability Issues

Blank

Final Form

Thinning

Solution#1: Straight

Solution#2: Curvilinear

Mass Savings: 0.47kg (from Solution #1)

Thinning Near Weld: 39.3%  33.6%  16.3%  16.6%
Formability with Different Material Grades

<table>
<thead>
<tr>
<th></th>
<th>CR4</th>
<th>180 BH</th>
<th>270 BH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass on vehicle</td>
<td>8.15 kg</td>
<td>7.43 kg</td>
<td>7.17 kg</td>
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<tr>
<td>Mass savings</td>
<td>0.00</td>
<td>0.72 kg</td>
<td>0.98 kg</td>
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</tbody>
</table>
Stamped Door Inner

1.2 mm 270 BH
## Structural Analysis

**Curvilinear Laser Welded Blank Option**

<table>
<thead>
<tr>
<th></th>
<th>Monolithic</th>
<th>Curvilinear Option 1</th>
<th>Curvilinear Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check load strain</td>
<td>Baseline</td>
<td>↓</td>
<td>←</td>
</tr>
<tr>
<td>Vertical rigidity - Deflection</td>
<td>Baseline</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Vertical rigidity - Set</td>
<td>Baseline</td>
<td>↓</td>
<td>←</td>
</tr>
<tr>
<td>Upper frame stiffness</td>
<td>Baseline</td>
<td>←</td>
<td>←</td>
</tr>
</tbody>
</table>
Cost & Quality Advantages

- Eliminate 23 spot welds and processing time
- Eliminate 3 stamped parts and its stamping dies
- Eliminate Assembly equipment & labor
- Eliminate floor space required for 3 stamped parts
- Eliminate transportation & inventory of stamped parts

- Better dimensional control for door assembly

- Heavier gauge covers more area than the localized brackets improving stiffness
## Optimized Door Inner Cost Estimates

<table>
<thead>
<tr>
<th>Manufacturing Operations</th>
<th>Baseline Design</th>
<th>Curvilinear EWB Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanking</td>
<td>✓</td>
<td>🔄</td>
</tr>
<tr>
<td>Laser Welding</td>
<td>🔄</td>
<td>🔄</td>
</tr>
<tr>
<td>Stamping 1</td>
<td>✓</td>
<td>🔄</td>
</tr>
<tr>
<td>Stamping 2</td>
<td>✓</td>
<td>🔄</td>
</tr>
<tr>
<td>Stamping 3</td>
<td>✓</td>
<td>🔄</td>
</tr>
<tr>
<td>Freight/Packaging/Inventory</td>
<td>✓</td>
<td>🔄</td>
</tr>
<tr>
<td>Assembly/Spot Welding</td>
<td>✓</td>
<td>🔄</td>
</tr>
</tbody>
</table>

- ≈ 5.2 % lower Costs
- 0.48 kg Mass Reduction
Summary

- Curvilinear laser welding enables optimize door inner
  - Mass savings
  - Material savings
- Consolidation of hinge brackets
  - Improves dimensional control
  - Improves fit and finish
  - Reduction in secondary processing (Stamping/welding)
- Cost savings
Thank you
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