COST MODELING OF LASER-WELDED BLANKS IN AUTOMOTIVE APPLICATIONS

Jeremy Gregory, Rich Roth and Frank Field
Camanoe Associates/MIT

Peter Mould
Tailored Steel Product Alliance
COST MODELING STUDY

- Underwritten by Tailored Steel Products Alliance (TSPA).
- Camanoe Associates:
  Principal developers of the model.
- Input from:
  - Jay Baron (Center for Automotive Research)
  - TSPA Members
  - Auto/Steel Partnership (A/SP)
  - American Iron and Steel Institute (AISI)
TAILORED STEEL PRODUCT ALLIANCE (TSPA)

- Alliance of:
  - Tailored steel blank manufacturers
  - Equipment Suppliers
  - N.A. Steel Companies
- Organized by AISI
- Started in January 2006
- Cost sharing
- Purpose:
  - Promote the use of tailored steel products in automotive applications.
- Typical Projects:
  - Market applications/trends and growth
  - Understand and share benefits and limitations
  - Develop a COST MODEL for comparing conventional stamping with laser welded blanks.
Tailored Blank Manufacturers

Noble Metal Processing, Inc.
Nova-Hyfo
Powerlasers
ProCoil Company, LLC
Shiloh Industries, Inc.
Tailor Steel America
TWB Company, LLC

Equipment Suppliers

Soutec Soudronic
VIL/Wayne Trail Technologies

N.A. Steel Companies

AK Steel Corporation
Dofasco, Inc.
Mittal Steel U.S.A.
Nucor Corporation
Severstal North America, Inc.
United States Steel Corporation
Genesis of Cost Modeling Project

COST MODELING
- Targeted as the No. 1 project for TSPA in 2006
- Drivers and needs:
  • Identify and compare ALL costs in stamping of conventional, monolithic parts and laser-welded blanks.
  • Basis for a COST-BENEFIT analyses in specific applications.
  • User-friendly.
  • Flexible to allow input variations.
  • Independent analysis, proven and accepted methodology.

CAMANOE ASSOCIATES/MIT
Experience in cost modeling for:
- Ultra Light Steel Auto Body (ULSAB)
- Light Weight Front End Structure (LWFES)
A/SP study
Study Objectives

• Analyze three case studies (TSP & baseline): compare fabrication costs & cost drivers
  – Rail
  – Body side inner
  – Door inner (not presented here)

• Model capable of two cost methodologies
  – Direct Cost Estimation
  – Variable Burden Rate (not presented here)
Outline

- Cost modeling methodology
- Rail Case Study
- Body Side Inner Case Study
- Observations
Direct Cost Estimation Methodology: Process-Based Cost Modeling

• Cost model uses manufacturing requirements → costs
  – Processing requirements
    • Cycle times, equipment specifications
  – Resource requirements
    • Number of tools, equipment, and laborers

• How do technology changes impact manufacturing cost?
TSPA Cost Analysis Methodology - DCE

• Blanking, Stamping, Rollforming, & Assembly
  – PBCM Methodology
• Welding
  – Cost input ($/weld length), includes:
    • Welding, inventory, defects, admin, shipping, material premium, other

• Cost Breakdown
  – **Variable**: Material, Labor, Other (Process Material, Energy)
  – **Fixed**: Equipment, Tooling, Other (Building, Maintenance, Overhead)
  – Welding
Outline

• Cost modeling methodology
• Rail Case Study
• Body Side Inner Case Study
• Observations
Rail Baseline Design

13 Pieces
Rail LWB Design

Bumper Beam

Inner Front Rail

Inner Rail Reinforcement

Outer Front Rail

Rail Extension Reinforcement

Rail Extension

5 Pieces
# Rail Design Content

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>LWB</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Parts</td>
<td>Weight (kg)</td>
<td># of Parts</td>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Stampings</td>
<td>24</td>
<td>26.8</td>
<td>4</td>
<td>4.5</td>
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<tr>
<td>Tailored Blanks</td>
<td>2</td>
<td>5.4</td>
<td>6</td>
<td>18.9</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>26</strong></td>
<td><strong>32.2</strong></td>
<td><strong>10</strong></td>
<td><strong>23.4</strong></td>
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</tbody>
</table>

# of Spot Welds: 562 (Baseline) 320 (LWB)

Includes left & right assemblies

LWB Design has more HS Steels
Unit Cost Breakdown: Processes

<table>
<thead>
<tr>
<th>Assembly</th>
<th>LWB Stamp^</th>
<th>Ord. Stamp*</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>$203</td>
<td>$155</td>
<td>$127</td>
<td>$105</td>
</tr>
</tbody>
</table>

$0 $50 $100 $150 $200 $250

Total Unit Cost (L&R Assemblies)

50k = 50,000/yr
275k = 275,000/yr
Base = Baseline
LWB = LWB

*Ord. Stamp = Ordinary Stamping (including blanking)
^LWB Stamp = LWB Stamping (including blanking & welding)
Unit Cost Breakdown: Factors

Total Unit Cost (L&R Assemblies)

- Base 50k: $203
- LWB 50k: $155
- Base 275k: $127
- LWB 275k: $105

Welding
- Other*
- Tooling
- Equipment
- Labor
- Material

*“Other” includes process materials, energy, building, maintenance, and overhead
Unit Cost Production Volume Sensitivity

Total Unit Cost (L&R Assemblies)

- Base
- LWB

Annual Production Volume (x 1,000)
Conclusions from Rail Case Study

- LWB design is less expensive than baseline
- Use of HS Steels and LWBs improves LWB design
  - Less material and weight
  - Fewer parts
- More expensive HS Steels negate cost savings from weight reduction in LWB design...
- ...but parts consolidation significantly decreases LWB assembly costs
• Cost modeling methodology
• Rail Case Study
• **Body Side Inner Case Study**
• Observations
Body Side Inner Baseline Design

5 Parts: FBHP, Rocker, Center Pillar, Wheelhouse, Roof Rail
Body Side Inner LWB Design

6 Welded Blanks: FBHP, Rocker, Center Pillar, Wheelhouse, Front Roof Rail, Rear Roof Rail
# Body Side Inner Design Content

## Baseline

<table>
<thead>
<tr>
<th># of Parts</th>
<th>Weight (kg)</th>
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<tbody>
<tr>
<td>Stampings</td>
<td>8</td>
</tr>
<tr>
<td>Tailored Blanks</td>
<td>--</td>
</tr>
<tr>
<td>Rollformings</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

## LWB

<table>
<thead>
<tr>
<th># of Parts</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stampings</td>
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</tr>
<tr>
<td>Tailored Blanks</td>
<td>2</td>
</tr>
<tr>
<td>Rollformings</td>
<td>--</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

# of Spot Welds | 116

Includes left & right assemblies

Same materials in both designs

[www.autosteel.org](http://www.autosteel.org)
Unit Cost Breakdown: Processes

**Assembly**
- Base 50k: $171
- LWB 50k: $129
- Base 275k: $120
- LWB 275k: $95

**Rollforming**
- Base 50k
- LWB 50k
- Base 275k
- LWB 275k

**Ordinary Stamping (including blanking)**
- *Ord. Stamp =* Ordinary Stamping (including blanking)

**LWB Stamping (including blanking & welding)**
- ^LWB Stamp = LWB Stamping (including blanking & welding)

50k = 50,000/yr
275k = 275,000/yr
Base = Baseline
LWB = LWB
Unit Cost Breakdown: Factors

Total Unit Cost (L&R Assemblies)

- **Base 50k**: $171
- **LWB 50k**: $129
- **Base 275k**: $120
- **LWB 275k**: $95

**Welding**, **Other**, **Tooling**, **Equipment**, **Labor**, **Material**

**Other** includes process materials, energy, building, maintenance, and overhead.
Unit Cost Production Volume Sensitivity

Total Unit Cost (L&R Assemblies)

Annual Production Volume (x 1,000)
Conclusions from Body Side Inner Case Study

- LWB design is less expensive than baseline
- Cost drivers
  - Material: LWB is 33% lighter; less material costs
  - Tooling: 1 tool for LWB design (per side) vs. 4 tools for baseline (per side)
  - Forming time: 1 part for LWB design (per side) vs. 5 parts for baseline (per side)
  - Assembly: None required for LWB design
Outline

• Cost modeling methodology
• Rail Case Study
• Body Side Inner Case Study
• Observations
• LWB Designs are less expensive than baseline counterparts for assemblies studied here
  – Door case study has similar results
• Keys to cost-effective LWB designs
  – Reduce mass (less material cost)
  – Reduce parts (less forming time, tooling, and assembly)

To a certain extent, this can come at the expense of more costly materials (e.g., HS Steels) and production processes (e.g., blank welding)
Contact Information

Jeremy Gregory, Camanoe Associates
jgregory@mit.edu

Peter Mould, TSPA
prmould@comcast.net
Backup Slides
Welding Cost Breakdown

Average Cost Contribution to Piece Cost

90% of the piece cost is: welding + blanking + inventory + defects


Note that blanking costs excluded from welding costs in this analysis – they were calculated separately.