Introduction to Martinrea

A2Mac1 Engine Cradle Benchmarking Study

Optimized Engine Cradle
- Baseline Design
- Ideas Considered
- CAE Validation
- Final Optimized Design
- Mass and Cost Comparison
- Manufacturing Feasibility

Summary / Conclusions
Leading Tier One automotive supplier in metal forming, fluid management systems and aluminum parts

One of the fastest growing automotive parts suppliers in the past 15 years ($0 to ~$4.0 billion in sales)

Headquartered in Canada and operating 44 manufacturing facilities with over 9 million square feet of manufacturing space and 15,000 motivated employees in 9 countries: Canada, United States, Mexico, Brazil, Germany, Slovakia, Spain, China, and Japan.

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ENGINE CRADLE BENCHMARKING – SIZES

Hyundai Elantra
Mass = 14.6 kg
SMALL

Subaru Outback
Mass = 27.0 kg
LARGE
ENGINE CRADLE BENCHMARKING - MATERIALS

Aluminum
BMW 5 Series
Mass = 16.8 kg

Hybrid
Audi Q7
Mass = 21.4 kg

Steel
Chrysler Pacifica
Mass = 27.8 kg
CRADLE VS VEHICLE WEIGHT

- Steel
- Hybrid Aluminum/Steel
- Aluminum

Audi A7
BMW 3 Series
Hyundai Genesis
Kia Stinger
ENGINE CRADLE BENCHMARKING – NEW ‘MEDIUM’ SIZE

- 2013 BMW 3 Series
- 2015 Hyundai Genesis
- 2018 Kia Stinger
- 2018 Audi A7
**MEDIUM SIZE ENGINE CRADLE OBSERVATIONS**

- **Audi A7**
  - Large steel X-brace
  - 2 hydroformed tubes

- **BMW 3-Series**
  - 6 tubes configuration
  - 3 hydroformed

- **Hyundai/Kia**
  - Heavy use of lightening holes

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*Images of engine cradles for Audi A7, BMW 3-Series, and Hyundai/Kia models are shown.*
ENGINE CRADLE BENCHMARKING - SIZES

Small
Hyundai Elantra
Mass = 14.6 kg

Medium
Kia Stinger
Mass = 19.6 kg

Large
Chevy Malibu
Mass = 28.5 kg
MURANO & SORENTO CRADLE COMPARISON

2015 Nissan Murano Large Engine Cradle
Weight: 37 kg

2017 Kia Sorento Small Engine Cradle
Weight: 18 kg
ENGINE CRADLE BENCHMARKING CONCLUSIONS

- 3 Sizes: Small, Medium and Large
- 3 Material Configurations: Steel, Aluminum and Hybrid
- Potential mass reduction enablers: Tubes, X-braces, and Lightening Holes
- Aluminum mainly used for large engine cradles

### CRADLE VS VEHICLE WEIGHT

<table>
<thead>
<tr>
<th>Engine Cradle Mass (kg)</th>
<th>Vehicle Weight (kg)</th>
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<tr>
<td>29.4</td>
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<td>20.7</td>
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<td>16.9</td>
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<td>20.0</td>
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<td>16.8</td>
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</table>

- Large Steel Cradles: 29.4 kg
- Medium Steel Cradles: 20.7 kg
- Small Steel Cradles: 16.9 kg
- Hybrid Al/Steel Cradles: 20.0 kg
- Large Aluminum Cradles: 16.8 kg
OPTIMIZED ENGINE CRADLE – BASELINE DESIGN

- Upper/Lower Side Members LH/RH: 2.1 mm HSLA
- Upper/Lower Rear Cross Members: 2.1 mm HSLA
- Body Locator Brackets LH/RH: 4.0 mm HSLA
- Upper/Lower Crush Cans LH/RH: 2.0 mm HSLA
- Upper/Lower Front Cross Members: 2.1 mm HSLA
- Side Deflector Upper LH/RH: 2.5 mm HSLA
- Side Deflector Lower LH/RH: 2.1 mm HSLA
- Drivetrain Bracket: 2.3 mm HSLA
- Stabiliser Bar Rnfs: 2.1 mm HSLA
- Stabiliser Bar Mounts: 3.1 mm HSLA
- Side Deflector Upper LH/RH: 2.5 mm HSLA
- Side Deflector Lower LH/RH: 2.1 mm HSLA
OPTIMIZED ENGINE CRADLE – IDEAS CONSIDERED

1. Lap Weld to Butt Weld

2. Gauge Optimization

3. 1180 3rd Gen for Strength Driven Parts

4. Tailored Blank Rings

5. Light Front Cross Member
1. Lightening Holes

2. Hydroformed Tubes

3. ‘X’ Braces
OPTIMIZED ENGINE CRADLE – CAE VALIDATION

Strength

Pole Barrier

PROPOSAL

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<th>Load Location/Direction</th>
<th>Baseline Design (%)</th>
<th>Optimized Design Percent Improvement (%)</th>
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Updated Components

- **Stabiliser Bar Rnfs**: 3.1 mm HSLA
- **Rear Cross Mbr Upper**: 2.2 mm HSLA
- **Stabiliser Bar Mounts**: 1.8 mm HSLA
- **Body Locator Bracket LH/RH**: 3.0 mm HR CP800
- **Tailored Blank Side Members**

**Upper/Lower Front Cross Members**: 1.0 mm HSLA GI

**Upper/Lower Crush Cans LH/RH**: 1.1 mm HSLA GI

**Side Deflector Upper LH/RH**: 1.8 mm 1180 3rd Gen GI

**Side Deflector Lower LH/RH**: 1.1 mm 1180 3rd Gen GI

**Side Member Upper**: 1.6 mm 1180 3rd Gen GI/2.8 mm HSLA

**Side Member Lower**: 1.1 mm 1180 3rd Gen GI/2.3 mm HSLA

**Drivetrain Bracket**: 2.2 mm HSLA

**Rear Cross Mbr Lower**: 1.9 mm HSLA GI

**Side Member Upper**: 1.6 mm 1180 3rd Gen GI/2.8 mm HSLA

**Side Member Lower**: 1.1 mm 1180 3rd Gen GI/2.3 mm HSLA
## OPTIMIZED ENGINE CRADLE – EBOM MASS COMPARISON

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<tr>
<th>Component</th>
<th>Mass (kg)</th>
<th>Opt Mass (kg)</th>
<th>Mass Save (kg)</th>
<th>Part Count</th>
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<td>Side Rail Lower (lh/rh)</td>
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<td>Rear Cross Member Upper</td>
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<td>Rear Cross Member Lower</td>
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<td>Front Cross Member Upper</td>
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<td>Front Cross Member Lower</td>
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<td>Stab Bar Mounts (lh/rh)</td>
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<td>Stab Bar Reinforcements (lh/rh)</td>
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<td>Drive Train Bracket</td>
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<td>Triangle Bracket</td>
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<td>Side Deflector Upper (lh/rh)</td>
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<td>Side Deflector Lower (lh/rh)</td>
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<td>Upper Crush Can (lh/rh)</td>
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<td>Lower Crush Can (lh/rh)</td>
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<td>Steering Brackets (lh/rh)</td>
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<td>Body Mount Sleeves (4)</td>
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<td>Side Rail Inside Bracket (lh/rh)</td>
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<td>Rear Body Locator Brackets (lh/rh)</td>
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OPTIMIZED ENGINE CRADLE – MASS/COST COMPARISON

Mass Savings: 15%
Estimated Cost Increase: 11.3%
Cost/kg Saved: $3.36

Total Material Utilization:
Upper/Lower Front Cross Members: 1.70 kg
Upper/Lower Side Deflectors: 0.73 kg
Upper/Lower Crush Cans: 0.54 kg
Other: 0.84 kg
Total: 25.33 kg

Total Material Utilization:
Upper/Lower Front Cross Members: 0.54 kg
Upper/Lower Side Deflectors: 0.73 kg
Upper/Lower Crush Cans: 0.84 kg
Other: 1.70 kg
Total: 21.52 kg

Material Utilization:
Original: 41.7 kg
Optimized: 37.6 kg
1180 3rd GEN SIDE MEMBERS MANUFACTURING

Side Member Upper
1.6 mm 1180 3rdGen Gl

Side Member Lower
1.1 mm 1180 3rdGen Gl
1) Benchmarking Study Recap

2) An optimized Engine Cradle was developed with a 15% mass savings versus the baseline design meeting the same packaging requirements

3) Most of this mass savings was achieved with gauge optimization and 1180 3rd Gen application for Side Deflectors and tailored blank Side Members

4) The optimized steel cradle in this study was estimated to have an 11.3% cost premium over the baseline design due to additional material cost and the addition of 4 tailored blanks. This translates to $3.36 / kg saved.

5) Next Steps: Prototype Cradle Assemblies & Corrosion Testing

6) Come to Martinrea for ‘Great Designs in Steel’!!!
Thank You!

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