GREAT DESIGNS IN STEEL

INTEGRATED BATTERY OCCUPANT PROTECTION BODY-IN-WHITE CONCEPT USING TAILORED BLANKS

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AGENDA

• Customer Current Challenges
• AMTB BEV Solution Objectives
• ICE to BEV Journey to AMTB BEV
  • Key Architecture Changes
  • Occupant & Battery Protection System
  • Battery Ring – Novel Concept
  • Performance Comparison
  • BIW Weight Breakdown
• Summary
AMTB’S BATTERY RING CONCEPT
AN INNOVATIVE BATTERY AND PASSENGER SAFETY SOLUTION!

How can we help our customers overcome current challenges?

Challenges:
• Tougher crash regulations
• Reducing carbon footprint
• ICE to BEV platform conversion

Decrease CO₂ emissions

Meet new crash regulations

Invest in BEV Solutions

Create modular shared platforms

Laser welded blanks key enabler for meeting these challenges
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Key Solution Development Objectives

• Meet multiple OEM design strategies
  • Dedicated BEV platforms vs integrated ICE and BEV powertrains
  • Regional vs global variants in future body platforms as worldwide safety standards not uniform

• AMTB BEV solution – A novel concept of integrated battery and occupant protection Body-in-White (BIW) concept
  • Integrated battery and passenger safety concept
  • Retain OEM assembly sequence
  • Integrated vehicle assembly
  • Part consolidation concepts
  • Maximize part commonality (~90% plus)
  • Cost and weight effective multi-powertrain BIW architecture

Steel intensive lightweight battery box with minimal weight impact leveraging strength of Laser Welded Blanks

Laser welded blanks maximize the weight and cost effectiveness in BIW solutions for BEVs
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ICE to BEV: AMTB BEV Main architecture Modifications

Main architecture changes

S-in motion® ICE SUV
AMTB BEV SUV

- Tunnel removed and dash panel lower redesigned
- Floor level moved upward in Z direction
- Seat cross-member sections modified
- Battery rings added to provide battery protection

AMTB BEV
- 195” L x 77” W x 70” H
- Wheelbase – 117.3”
- Curb weight: 2282 kg

Both BIWs share a common platform with respect to assembly sequences
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What is a Hot Stamped Battery Ring Concept?

- Key structural reinforcement encompasses battery module to develop an optimized BIW to meet performance standards
- Lightweight - protects the battery pack maximizes battery module volume

Battery Ring Concept with Door Rings = an integrated battery and occupant protection BIW concept
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Side Structure Exploded View Highlights

1. Door Ring Outer
2. Sill Reinforcement
3. Sill Shear plate
4. Door Ring Inner
5. Battery Ring Upper
6. Battery Ring Reinforcement
7. Battery Ring Lower
8. Battery Lower Tray
9. Self Pierce and Clinch Nut
10. Floor Pan
11. Battery top cover
12. Battery Modules

- Optimized side sill structure for battery protection
- Battery pack is extended as far as possible in fore/aft and width
- Side sill structure reinforced and offers good ductility using PHS 1000
- PHS LWB applied for Door ring and the Battery rings

The self pierce and clinch nuts are attached to battery ring upper for the battery pack assembly

Battery Ring Concept with Door Rings = an integrated battery and occupant protection BIW concept
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Load Path Highlights – Front Impact

- **PHS 1000** in tips of front rails and shotguns for energy absorption
- **PHS 1500** in Hinge pillars, A-pillars and Battery rings for anti-intrusion in cabin and battery space

Efficient strategy to manage front crash with deformation of rails and anti-intrusion with Battery rings
Load Path Highlights – Side Impact

- **PHS 1000** in tips of Floor cross members and B-Pillar lower
- **PHS 1500** in Battery Rings and Floor cross members
- **Designed for pole impact anywhere along the side structure for expansive crash/safety requirements**

Battery Rings are integral part of side crash strategy and designed to withstand pole and side impact modes.
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AMTB BEV: 40% higher kinetic energy, 20% lower cabin intrusions → 230% resultant contact force
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Energy absorption – 50th Pole crash

Animation: Plastic strains on Battery rings

1. Before crush
   Sill Section (energy absorption)  Battery Rings (anti-intrusion)

2. Crush initiates in the outer sill

3. Sill area is completely crushed

4. At max. intrusion no impact to battery modules

5. Vehicle rebounds with no damage to battery modules

The hot stamped door ring and battery ring assembly ensure battery module safety
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Internal energy breakdown – Side Impact & 50th Pole

Battery Ring works well managing both anti-intrusion and energy absorption in the side load cases.
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Load Path Highlights – Rear Impact

Animation: Plastic strains on Battery rings

Battery Pack Ring Reinforcement

• Hot stamped Laser welded blank ring battery pack reinforcement application is ideal to manage e-motor crash inertia

Efficient strategy to manage front crash with deformation of rails and anti-intrusion with Battery rings
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Analysis Summary

Meets Performance targets

IIHS Roof Strength

Side Impact

Full Frontal
40% ODB
Small Offset

50th Pole
5th Pole

Validated Side/Pole Impact loadcase in multiple locations

Rear Impact

5th Pole
50th Pole

Side Impact

IIHS Small Overlap

Front 100%

IIHS Moderate overlap

5th Pole
50th Pole

Side Pole 50 pctl

Side Crash MDB

FMVSS 301 Rear crash

Side Pole 5 pctl

Crush Test

Underfloor Intrusion

Shock Test

Drop Test

Modal Analysis

Hot Stamped Laser Welded Door Ring & Battery Rings are optimized for battery and occupant protection
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Stiffness – Static bending and torsion

- Bending Stiffness BIW only: 10.59 kN/mm
- Bending Stiffness BIW + Battery pack: 15.41 kN/mm
- Torsional Stiffness BIW only: 20.10 kNm/deg
- Torsional Stiffness BIW + Battery pack: 30.20 kNm/deg

BIW and Battery structure is optimized for bending and torsional stiffness
Why Laser Welded Blanks? For Gauge and Grade Optimization

- Benefit of Laser Welded Blanks
  - Weld line location optimization
  - Gauge optimization
  - Material grade optimization
- Strength and elongation optimized
  - Based on performance
    - Higher strength for anti-intrusion can apply PHS 1500 and PHS 2000
    - Higher elongation and crash ductility for energy absorption can apply PHS 1000

ArcelorMittal Tailored Blanks can support with co-engineering for design optimization
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Why Laser Welded Blanks? For Gauge and Grade Optimization

Part Consolidation → Cost Savings!

Scrap Reduction → Cost Savings!

Battery Ring Upper
Material Utilization: 80%

Battery Ring Lower
Material Utilization: 82%

Potential to consolidate 6-10 parts → 2 parts
- Reduced stamping die investment
- Reduced assembly complexity → tighter tolerances
- Hot stamped material (PHS 1500 & PHS 1000) facilitates designing complex shapes
- Added cost reduction by avoiding the use of Aluminum extrusions or roll formed or steel stamped reinforcements (typically added in the sill area of side structure)

Hot Stamped Laser Welded Battery rings offer part consolidation and material utilization improvement
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Laser welded blanks (LWBs): efficient Multi-powertrain solution for BEV

BIW + Battery pack material breakdown

- PHS 1500
- PHS 1000
- AHSS > 1500MPa
- AHSS > 900 MPa
- AHSS > 780 MPa
- AHSS > 590 MPa
- HSS > 300 MPa
- Mild Steels

25 LWBs Possible consolidating 70-80 individual parts in assembly

LWB intensive concept is lighter, and designed for part integration and cost savings
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AMTB BEV Weight Optimization Breakdown

HS LWB Battery rings maximize the weight reduction while ensuring passenger and battery safety
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Hot Stamped Battery Pack Ring Concept

What is a Hot Stamped Battery Pack Ring Reinforcement?
- Novel concept uses Press Hardened Steel
- Key structural battery rings encompasses battery modules to develop an optimized BIW to meet performance standards
- Lightweight and protects the battery pack while maximizing battery module volume

Hot Stamped Battery Pack Ring Reinforcements
- Upper Structural reinforcement part of Body BIW
  - First layer for “Ring concept reinforcement”
  - Attaches via spot welds to inner side sills, front-rear underbody crossmember and floor tub (OEM design dependent)
- Lower Structural reinforcement part of Battery Pack
  - Second layer for “Ring concept reinforcement”
  - Bolted to Body BIW through upper & floor (OEM design dependent)

HS LWB Battery rings maximize the weight reduction while ensuring passenger and battery safety
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Summary

➢ AMTB’s hot stamped laser welded blanks (HS LWB) technology
  o Allows our customers to optimize cost, weight and performance
➢ HS LWB Door Rings provide the optimal balance of weight, cost and performance
  o Multiple OEMs have applied the door ring solution to vehicles
  o AMTB has developed many cost optimization solutions for Door Rings
  o Co-engineering with our customers allows us to innovate and find new ways to cost optimize, maximize weight savings, improve material utilization
➢ Battery ring design results in **15 kg** weight reduction
➢ LWB technology - Part consolidation, high part commonality
  o Different BEV modular architectures also possible with common battery pack structure
➢ Battery Rings are active in the load path for both occupant safety and battery pack protection – an integrated innovative solution leading to lightweight designs

Door Rings + Battery Rings are an innovative solution for optimized weight, cost and performance
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